Macmillan

Queensland Senior Physical Education

3RD EDITION

Glenn Amezdroz Sue Dickens Geoff Hosford Tania Stewart Damien Davis

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Introduction

The third edition of *Queensland Senior Physical Education* has been comprehensively updated. It provides practical support to Queensland students and teachers of Physical Education. Like past editions, this edition adopts a fully integrated approach to the latest Queensland Studies Authority syllabus, focusing on learning in, about and through the medium of physical activity. The book features:

- coverage of all prescribed core content, clearly linked with specific syllabus requirements
- extension subject matter (where relevant), to support syllabus requirements
- enough information to enable students to complete the various syllabus requirements throughout the course of study
- the latest research and theories within skill acquisition, biomechanics, sport psychology, exercise physiology and training methodologies, as well as a comprehensive examination of sociological issues surrounding access and equity to exercise, sport and physical activity, based on Figueroa's framework
- a vast selection of relevant photographs, real-life examples, diagrams and articles to ensure students develop the ability and confidence to make independent decisions based on their own research, personal experiences and learning
- an extensive range of personalised learning experiences, including stimulus questions, essays, research activities and multimodal tasks, which can be used to reinforce students' learning and develop a range of assessment tasks.

With extensive and current teaching experience in Physical Education, authors Glenn Amezdroz (All Hallows' School), Sue Dickens (University of Queensland), Geoff Hosford (RMIT University), Tania Stewart (St. Andrew's Lutheran College) and Damien Davis (Davis Enterprises) have provided students and teachers with a top-notch resource. Using the knowledge, research skills and expertise gained through respected careers, the authors have created a textbook that makes the study of Physical Education a challenging, rewarding and motivating experience.

About the authors

Glenn Amezdroz is a highly experienced and respected Physical Educator, based at All Hallows' School in Brisbane as Head of Department, Health and Physical Education. Glenn has undertaken extensive research on Figueroa as part of his contribution to Focus Area C in Macmillan's *Queensland Senior Physical Education (3rd edition)*. He is a much sought after mentor and speaker and advises the QSA regularly in Physical Education.

Damien Davis has been a prolific author in Physical Education over several decades. An accomplished teacher, Damien taught Physical Education in Queensland and Victoria before establishing a second career in business. Damien has contributed to Focus Area B in Macmillan's *Queensland Senior Physical Education (3rd edition)*.

Sue Dickens joined the University of Queensland's School of Human Movement Studies in 2000 in a newly a created position to facilitate development of educational resources for the Postgraduate Programs in Sports Coaching. This followed a decade of experience as a Health and Physical Education Teacher in Queensland schools. The Postgraduate Programs in Sports Coaching are a joint venture between the Australian Sports Commission (ASC), the Australian Institute of Sport (AIS), and the School of Human Movement Studies at The University of Queensland. Sue has published widely in skill acquisition and coaching in the context of physical education coursework – and contributed to Focus Area A in *Queensland Senior Physical Education (3rd edition)*.

Geoffrey Hosford, a director and biomechanist with Accident Analysis, is a graduate of Loughborough University, U.K., and the University of Western Australia. He has lectured in human movement and biomechanics at Deakin University and t RMIT University in the School of Medical Sciences. Geoff has written and published widely in biomechanics in the context of physical education coursework – and contributed to Focus Area A in *Queensland Senior Physical Education (3rd edition)*.

Tania Stewart is very well respected and experienced Physical Educator currently based at St Andrew's Lutheran College as Head of Department, Health and Physical Education. Tania's creative approach to assessment has made her a highly sought after consultant in this area – including with the QSA. Tania has contributed to Focus Area B in Macmillan's *Queensland Senior Physical Education (3rd edition)*.

Author acknowledgments

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from Tania: Thank you to Glenn Amezdroz for trusting me to contribute to the text book. I have used this text for many years and it is a privilege to now be involved in the writing process.

Syllabus mapping grid

Core subject matter	Extension subject matter
Focus Area A Learning physical skills	
Chapter 1 Motor skills	
• Classification of skills • Stages of skill learning and implications on practice • Factors affecting skill acquisition • Performance curves.	• Analysing and classifying physical skills.
Chapter 2 The motor learning process	
• Learning and memory • Different forms of memory • Types of practice • Implications of the type of practice on learning • Learning styles (including VARK).	
Chapter 3 Processing information, reaction time and feedback	
• Information processing model • Reaction time and anticipation • Factors influencing reaction time including signal detection; visual training and selective attention • Psychological refractory period • Feedback and learning • Types of feedback.	• Feedback mechanisms • Information processing.
Chapter 4 Performance-enhancing psychological skills	
• Performance enhancing psychological skills including: imagery, concentration, self talk and performance routines • Motivation • Nideffer's model of attentional focus • Psychology of injury.	• Goal setting • Imagery and visualisation.

Core subject matter	Extension subject matter
Chapter 5 Motivation, arousal and anxiety	
• Motivation • Arousal • Inverted U-hypothesis • Psychological recovery and relaxation techniques.	• Anxiety.
Chapter 6 Team cohesion, goal setting and coaching styles	
• Team cohesion • How to develop a cohesive team • Coaching styles—productive and reproductive styles • Characteristics of effective coaches.	• Coaching styles • Goal setting.
Chapter 7 Force	
• Linear and turning forces • Action and reaction forces • Impact forces.	• Balancing forces—application of mass, centre of gravity, rotational inertia and action/reaction to the balance principle.
Chapter 8 Momentum	
• Linear and rotational momentum • Impulse • Accuracy • Inertia and rotational inertia.	• Summing momenta—application of stabilisation, sequential body motion, optimum stretch and range of motion.
Chapter 9 Air and water forces	
• Projectile motion • Movement in air • Movement in water.	• Fluid forces—application in the air (spin, swerve, angle of approach and rebound) and in the water (buoyancy, resistance and propulsion).

Core subject matter	Extension subject matter
Chapter 10 Application of biomechanical knowledge	
• Sport biomechanics • Occupational biomechanics • Forensic biomechanics.	• Analysing performance • Work productivity, health and safety • Accident investigation: sport, recreational and industrial accidents.
Focus Area B Process and effects of training and exercise	
Chapter 11 Energy systems	
• The three energy systems • Limitations • Percentage use of energy systems in physical activities.	
Chapter 12 Fitness	
• Types of fitness • Components of types of fitness.	• Measurement and evaluation of physical performance capacities (i.e. fitness testing).
Chapter 13 Games analysis	
• Planning and designing a training program.	• Measurement and evaluation of physical performance capacities (i.e. fitness testing).
Chapter 14 Exercise physiology principles	
• Training principles • Training methods.	
Chapter 15 Training program design, evaluation and modification	
• Planning and designing a training program • Evaluating training programs • Immediate and long-term effects of training.	• Evaluation and modification of training programs and programming for special and individual needs.
Chapter 16 Training limitations	
• Immediate and long-term effects of training.	• Injury prevention, management and rehabilitation practice.

Core subject matter	Extension subject matter
Focus Area C Equity and access to exercise, sport and physical activity in Australian society	
Chapter 17 Access and equity: Figueroa's framework	
• Equity and access • Figueroa's framework.	
Chapter 18 Access and equity at the individual level	
• Genetic predispositions and the satisfaction of personal preferences and human needs through physical activity • The role of self-concept, personal beliefs, values and attitudes.	
Chapter 19 Factors affecting access and equity at the interpersonal level	
• The role of parents, peers, coaches, teachers and media on socialisation, opportunities and decisions about physical activity.	• The social construction of gender and its impact on access to sport.
Chapter 20 Factors affecting access and equity at the institutional level	
• The impact of institutions such as families, schools, sporting clubs, religions and politics on access to physical activity.	• Sporting authorities as institutions affecting access to sport and physical activity.
Chapter 21 Factors affecting access and equity at the structural level	
• Government and media influence on the distribution of sporting resources and rewards • The impact of inequitable distribution of resources and rewards.	
Chapter 22 Factors affecting access and equity at the cultural level	
• Cultural influences on body image, the social construction of gender and physical activity • Sport as a microcosm of society.	• Naturalistic and constructionist views of body image and body regulation • Media influence on the evolution of culture • Nationalism and the impact on participation in sport • The influence of dominant culture and related versions of history • Common assumptions about sport and exercise in Australia.

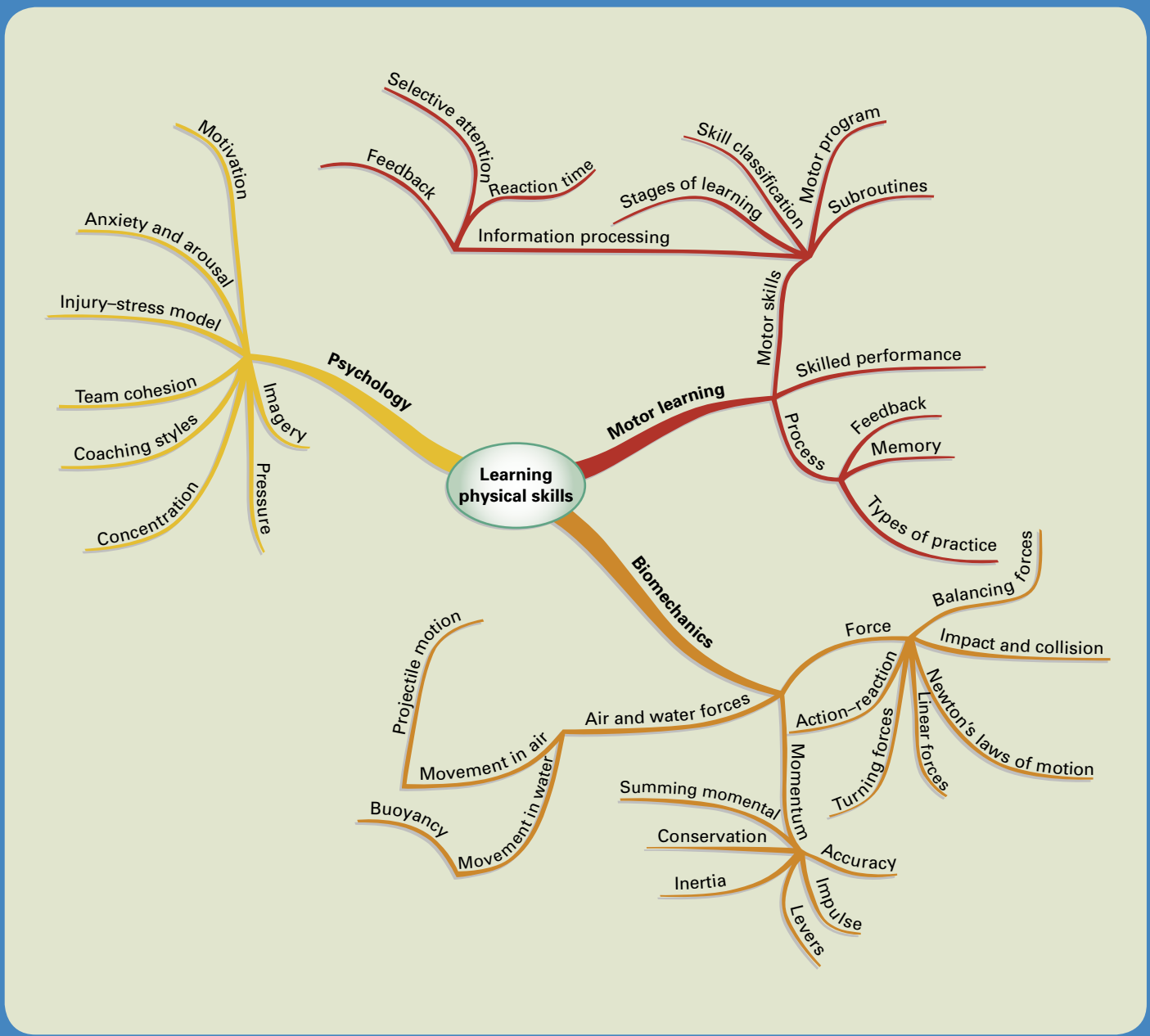
Focus Area A

Learning physical skills

HOW ARE SKILLS LEARNT, IMPLEMENTED, MAINTAINED AND ENHANCED?

For students to be intelligent performers, they must be able to do more than just reproduce physical responses. They need to know and understand how physical responses can be improved, and to appreciate the qualities of physical responses. Students need to be able to apply motor learning theory, psychological strategies and biomechanical principles to maximise their own and their team's performance potential. As self-directed learners, students need to reflect on these qualities and adjust their learning experiences to accommodate this greater understanding.

Source: *Physical Education 2010 Senior Syllabus*, published by Queensland Studies Authority


Learning physical skills
Psychology
Motivation
Anxiety and arousal
Injury–stress model
Team cohesion
Coaching styles
Concentration
Imagery
Pressure
Motor learning
Motor skills
Information processing
Selective attention
Reaction time
Feedback
Stages of learning
Skill classification
Motor program
Subroutines
Skilled performance
Process
Feedback
Memory
Types of practice
Biomechanics
Force
Balancing forces
Impact and collision
Action–reaction
Newton's laws of motion
Linear forces
Turning forces
Momentum
Summing momental
Conservation
Inertia
Accuracy
Impulse
Levers
Air and water forces
Projectile motion
Movement in air
Movement in water
Buoyancy

Motor learning

HOW DOES AN UNDERSTANDING OF MOTOR LEARNING HELP TO IMPROVE TEAM AND INDIVIDUAL PERFORMANCE IN PHYSICAL ACTIVITIES?

chapter 1

Motor skills

Skill acquisition is a sub-discipline of the exercise and sport sciences. It is primarily concerned with acquiring, developing and enhancing skilled performance. A number of theories have been developed to explain the different stages of learning and the ways in which movements are learnt. This knowledge has applications for teachers, athletes and coaches in developing the appropriate structure to enhance the learning environment.

What is a motor skill?

A **motor** or **movement skill** is an activity that involves voluntary muscular movement with the correct degree of muscular control, to complete a reasonably complex predetermined task. Just how well the skill is completed will depend on a number of factors, such as how often the movement has been practised, how much is learnt through that practice, and how well that learning is applied to make the movement more efficient.

A **motor skill** involves a muscular movement to complete a predetermined task.

Examples of motor skills include:

- catching a cricket ball
- performing a handstand
- running a race
- shooting a goal in netball.

Compare the complexity of throwing a ball at a target with your right arm and throwing with your left. If you are right handed, you will have practised this movement many times and the result is a smooth, coordinated movement. When you compare this with the throwing action of your left hand, you begin to realise that a seemingly effortless motor skill such as throwing requires practice and learning before it becomes proficient.

Characteristics of skilled performers

Skilled performers have a highly developed capacity for information processing, which allows them to exhibit some of the following characteristics. They:

- anticipate their opponents
- perform consistently
- work physiologically economically

- time their movements perfectly
- appear to have 'all the time in the world'
- react quickly with precision
- adapt their skills to suit the performance
- read the patterns of play extremely well
- have responses that are ideal for the performance of the task.

Skilled performance

A skilled performance involves:

- a predetermined goal
- a complex sequence of movement
- organisation of time, space and muscular control
- learning through practice.

There is more to being an expert performer than simply acquiring advanced motor skills. A skilled performer not only performs the motor skills but can also assess the game situation and provide an exact response. This ability is often lacking in a beginner. A skilled performance depends on the performer's ability to:

- think
- interpret the conditions of their environment
- select an appropriate response or action.

What is a motor program?

To perform a reasonably complex motor skill successfully, you need to be able to break down the skill into its component parts. These parts are called subroutines.

A skilled movement results when all the subroutines are performed in the correct sequence with the correct timing. Examples of subroutines for tennis and swimming are shown in figure 1.1. A motor skill may be seen as a whole plan that specifies the timing and sequence of the total movement. This whole plan is known as a **motor program**.

A **motor program** is the set of instructions held in memory that is sent to muscles and results in movement.

Figure 1.1 The breakdown of a skill

Motor program	Subroutines
Tennis serve	Grip Backward swing Point of contact Follow through Stance Ball toss Angle of racquet head
Swimming backstroke	Arm entry Path of hand Breathing Upper body rotation Leg kick Head position

Learning experience

Demonstrate an understanding of motor programs by describing the sequence of movements for the changing of gears in a manual car in the correct order.

Classification of skills

This section discusses the common characteristics of motor skills and the different classification systems. This analysis helps to determine how particular movements are best learnt, controlled and analysed.

Figure 1.2
The tennis serve is a closed skill.

Fine and gross motor skills

This classification method distinguishes motor skills by the size of the muscles involved in the movement. Gross motor skills involve movements of large parts of the body or of the whole body. They also require less precision, e.g. doing a somersault or tackling in football.

Fine motor skills require greater precision in the control of small muscles, such as in writing, threading a needle, throwing a dart, drawing and sewing.

Open and closed motor skills

This classification is based on the stability of the environment. The environment can be either the object (e.g. ball) or the context (e.g. court surface or wind conditions).

A closed motor skill is performed in a highly predictable environment in which the performer is in full control of the timing of the movements. The performer can commence the action when they are ready.

In such an environment, the performer goes through a pre-learnt motor program without having to consider environmental changes, such as the

Figure 1.3 Surfing and rugby league skills are physical activities involving open skills.

position of the opponents. Examples include hitting a ball off a tee, diving, gymnastics, a free throw in basketball and a shot put.

An open skill is performed in an unpredictable environment in which the object or context is changing. Team games such as netball, football and rugby involve open motor skills. The location of defenders and the flight path of the ball are factors to which the performer must respond. In most cases, the decision-making process leading to the performance of open skills occurs in a short space of time, sometimes milliseconds.

Motor skills are not always classified neatly as open or closed and frequently fall into the continuum between the two (see figure 1.4).

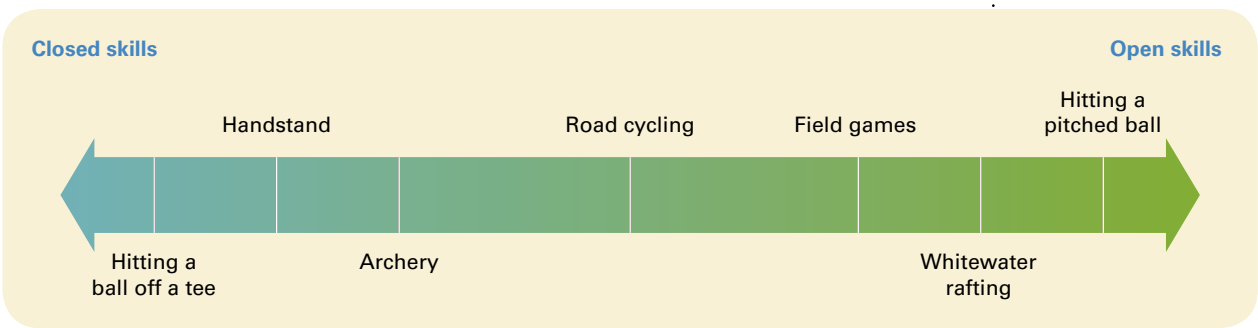


Figure 1.4 The continuum for closed and open motor skills

Learning experience

Which of the following practice sessions focuses on learning in a closed environment?

1. A softball coach hits balls to a fielder at second base.
2. A tennis ball machine shoots successive balls to a player's forehand.
3. A volleyball player receives an opponent's serve in position 6.
4. A basketball player practises a free throw.
5. A swimmer practises starts off the blocks.
6. A hockey player practises shooting for goal with two defenders.

Discrete, continuous and serial skills

This classification is based on whether the movement has a specific beginning and ending.

A discrete motor skill is one that has a distinct beginning and ending. Examples include throwing a ball, kicking a football and swinging a bat.

If discrete skills are linked together in a movement sequence they are called serial motor skills. Examples include a gymnastics routine and dribbling a basketball.

Motor skills that bring together discrete tasks in a repetitive movement are called continuous motor skills. Examples of continuous skills are walking, running and swimming.

Figure 1.5
Swinging a golf club is a discrete motor skill.

Figure 1.6
Dribbling a soccer ball is a serial motor skill.

Figure 1.7
Swimming is a continuous motor skill.

Learning how to dribble in basketball

When learning how to dribble in basketball, the students should practise stationary dribbling by themselves. At this time the environment should remain stable, since most of the attention of the students will be directed towards visually monitoring the task. As students become more competent at this skill level, the teacher can introduce additional factors.

The teacher can direct the students to vary the height of the bounce and other simple modifications of the basic task. This can be followed by dribbling and travelling, dribbling in specific floor patterns or changing the speed of the dribble and travel.

Obstacles, such as cones or chairs, can be added to shift the focus of attention from the ball and relate the skill to stationary objects. Other players can be introduced as opposition with a gradual increase in the degree of pressure, from passive opposition to partial and then finally full opposition.

Eventually, dribbling can be integrated with other skills and more complex game situations. Application of the skill in realistic game settings will require good technique, modifications of the basic pattern, awareness of the environment, and the use of strategies and tactics.

Initial experiences in learning a skill should occur under relatively constant conditions or simple drill. However, in order to develop a level of competency in 'open skills' the teacher should provide progressive degrees of variable situations. Variable situations allow for adaptations of the initial motor pattern which provides a sound basis for performance of the skill in actual game situations.

Source: Doherty, D & Turkington, D, 1986, 'A model for the sequential development of sports skills', *CAHPER Journal*, vol. 52(2), pp.16–19

Learning experience

Refer to the article titled 'Learning how to dribble in basketball'. Pay particular attention to how the authors develop a progressive structure for the learning of the basketball dribble. Select an open skill from a sport you are learning. List the progressive learning steps that would assist a beginner in learning this skill.

Note: The key to this task is to increase the degree of variability of the drills from closed to open environments.

Motor learning

Motor learning is 'a change in the capability of a person to perform a skill as a result of practice or experience that must be inferred from a relatively permanent improvement in performance' (Magill 2004).

Motor learning is a change in the capability of a person to perform a skill as a result of practice or experience.

There are four key aspects of motor learning:

1 Motor learning is a process of acquiring capability.
2 Motor learning occurs as a result of practice or experience and not as a result of aging or the environment.
3 Motor learning cannot be directly observed but is presumed to have occurred through changes in performance.
4 Motor learning is a fairly permanent change in capability.

Motor learning involves the modification of neural circuits involved in the planning and execution of a movement. Learning a motor skill involves a reorganisation of basic movement patterns, resulting in a permanent change in the way large muscle groups behave.

The only way to be certain that learning has occurred is to observe improvement over a period of time. The observable changes in control and coordination of motor behaviour will have resulted from practice. Many different changes can be observed. These include:

- a more efficient movement as a result of improved efficiency in activating neurons
- a greater production of force in the movement
- the discovery of a sequence of movement actions in performing the task
- the development of individual control over the muscle.

You may have heard the saying 'I'm on a steep learning curve', referring to a person's ability to learn a new skill having had no prior experience. Similarly, in motor learning, a 'performance curve' is used to measure observable changes in performance. Learning curves plot the time it takes to learn a task as a function of practice. The *x*-axis indicates the time period over which the performance is measured (minutes, days) and the *y*-axis indicates the performance measure (number of shots, errors, trials).

The learning of a task will usually follow one of the following four graphical trends.

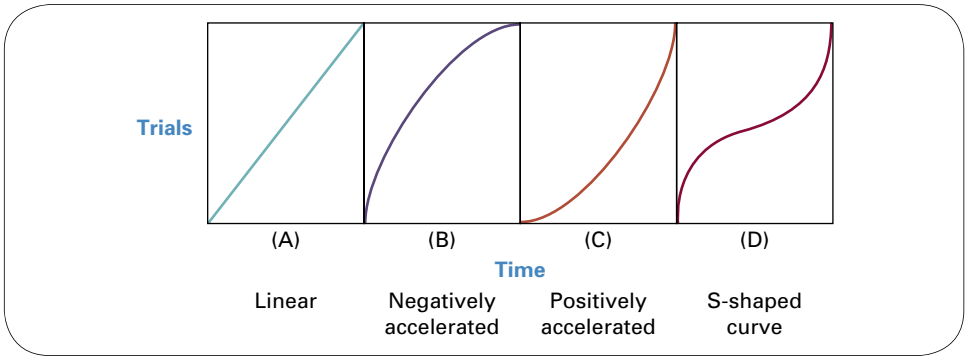


Figure 1.8
Performance curves showing four trends of motor learning

Each graph indicates a trend in performance:

- Graph A is a linear curve highlighting that as practice continues the performer improved proportionally.
- Graph B is a negatively accelerated curve showing that the performer improved rapidly at the start of practice and smaller improvements occurred later in practice.
- Graph C is a positively accelerated curve indicating small improvements in performance early in practice but then substantial changes in performance late in practice.
- Graph D is an S-shaped curve indicating a combination of graphs A, B and C.

Learning experience

Figure 1.9 illustrates a hypothetical study that shows the results of a test of performers' abilities to hit a golf ball the longest distance off a tee in a computer simulated game. The results are for adults and children aged 10 years.

1. Compare results for the adults with those for the children. Hypothesise why you consider the differences to be so apparent.
2. Explain the differences in terms of stages of learning of both adults and children.
3. What isn't the graph indicating about the learning that has taken place?
4. Are the performance indicators valid measures of learning?
5. What recommendations would you have for the next research trial investigating performance in a golf simulation?
6. Can you extrapolate from this graph to determine which group's performance improved more? Consider:
   - the performance indicator of golf skill
   - the observable products of skill learning
   - how many trials and how often performance would be assessed.

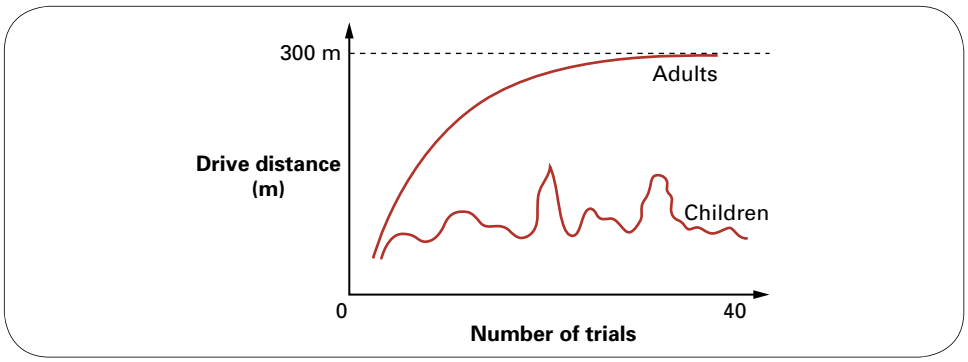


Figure 1.9
Performance curves—indicators of skill learning

Stages of skill learning

Consider a skill in which you are very proficient. Try to recall when you first learnt this skill and the difficulty you had with all the components. You may have had difficulty with timing, where each body part is supposed to go and in what order. Learning an unfamiliar skill took a lot of effort and you tired quickly. You were probably pre-occupied with the skill itself and had little concern for other tactical or environment factors. Take, for example, learning to drive a manual car. The skills required to change gears in a particular sequence *and* use the steering combine to make driving a complex task for the novice. Now compare the skilled driver who doesn't have to think about the individual components of changing gears but transfers full attention to other details, such as changing lanes, merging traffic and cars approaching from behind.

A widely used theory on the process of learning motor skills was presented in 1967 by Paul Fitts and Michael Posner. This theory continues to be referred to by sport researchers today. It proposes that everyone goes through distinct stages when learning a motor skill.

The **Fitts and Posner model** proposes three stages of learning a motor skill:

1 the cognitive stage (understanding)
2 the associative stage (practice)
3 the autonomous stage (automatic reference).

The **Fitts and Posner model** describes the different stages of learning a motor skill.

Cognitive stage (understanding)

During the **cognitive stage**, you learn what is needed to perform a skill. As the cognitive stage is exploratory, the beginner will invariably make a large number of errors when trying to perform the required action. Cognitive stage learners:

- make frequent errors
- get a general idea of the skill
- devote a lot of attention to decisions about step-by-step procedures

The **cognitive stage** is the first stage in the Fitts and Posner Model of motor learning and is characterised by frequent errors in performance.

Figure 1.10
A tennis coach working with a beginner

- have a high attentional demand (i.e. you always have to think about what you are doing)
- rarely have two consecutives trials the same
- tend to perform the skill slowly
- watch for feedback from the previous trial for clues on how to improve performance.

What coaches see

Typically, during this stage of motor learning, coaches will be able to observe the following behaviours:

- Movements are poorly timed.
- There are extraneous movements unnecessary to the task.
- There are rapid and relatively large gains in performance.
- There is self talk about what to do next.
- There is frustration at not being able to master a skill in a short time span.
- There might be possible lack of motivation if the task is perceived as being too difficult.

Implications for practice

The best way to learn in the cognitive stage is to have the skill demonstrated so that you can form a rough mental plan. The neurons in the motor-control section of the brain respond when an action is observed (and performed). This could be in the form of a demonstration given by the teacher/coach or watching a video of the performance. Alternatively you could read about the skill, but this is less effective than seeing the skill performed.

Research has found that demonstration of a skill followed by time for the learner to practise and then a further demonstration to consolidate learning is the best method of practice.

Watching others learn the movement is also a way of improving performance. The learner identifies the errors of the observed performer and this visual feedback assists in correcting their own performance.

Key points for instructional support

Coaches can help cognitive learners by:

- providing accurate demonstrations
- allowing time for practice and by re-demonstrating the skill
- relating the skill to other skills previously learnt—transfer of learning
- giving clear instructions—don't overload the learner with information
- allowing the learner to experience the 'feel' of the whole movement
- using short cue words to assist in simplifying the key components of the skill (e.g. 'snap' the wrist)
- not providing instructions on what *not* to do.

The associative stage (refining practice)

The **associative stage** is the second stage in Fitts and Posner's model of motor learning. It is characterised by practice.

Once learners have a clear understanding of what is required, they must practise to become familiar with the sequencing and timing of the movement. The **associative stage** is concerned with the practice of the motor

skill. The amount of practice will depend on the complexity of the task, the player's ability, their past experience and motivation. Demonstrations and feedback are important in this stage. Feedback is particularly important, but it should not be specifically about what has happened but, more importantly, about what to do next. At this stage, learners typically:

- refine the accuracy and consistency of the motor skill
- reduce the degree of error
- recognise when there is an error
- know 'how to do' rather than just 'what to do'
- develop capability to better anticipate and time movements
- require feedback on technical aspects that take performance to the next level.

What coaches see

Typically, during this stage of motor learning, coaches will be able to observe the following behaviours:

- Movements become quicker and smoother.
- Performance becomes more efficient.
- Improvements are less dramatic.
- Self talk is reduced or stopped.
- Performance becomes more consistent.
- Performers can critique their own practice.

Key points for instructional support

Instructions, demonstrations and feedback are less important unless they are targeted at specific aspects of the skill. Practice should approximate that used in performance/competition, and can be modified gradually to keep the skill at a challenging level.

Autonomous stage (automatic)

Some performers may only reach the **autonomous stage** after many years of practice; others may never reach this stage. The autonomous stage is characterised by performances that are 'automatic' and occur without thinking.

The **autonomous stage** is the final stage in the Fitts and Posner model of learning. It is characterised by automatic movement.

At this stage:

- the learner is performing the skill without thinking
- the sequencing and timing of the subroutines is automatic.

What coaches see

Typically, during this stage of motor learning, coaches will be able to observe the following behaviours:

- The movements are effortless.
- The performer can often carry out another task at the same time.
- The consistency of performance is high.
- The speed and efficiency of the performance is high.
- There is little or a reduced amount of 'thinking' involved.

- The performer can detect their own errors and make adjustments.
- The performer can process additional information without it having a detrimental effect on performance.
- Improvements are only subtle variations.

Implications for practice

Performers at the autonomous stage have better response times than novices. This is because they don't have to process individual bits of information but, instead, they process larger chunks of information that occurs without their attention. However, at the other end of the practice spectrum, when 'expert' performers are asked to focus on the individual mechanics of a movement skill, their performance actually diminishes. Refocusing on individual components of the task results in the performer interrupting the normal efficient automated process. This is sometimes evidenced in soccer goal shoot-outs in which the performer over-analyses the soccer kick and fails dismally in the execution. This is called 'paralysis by analysis'. To avoid this occurring, coaches should provide performers with an alternate focus when under pressure. For instance, cue words and metaphors are helpful in re-directing attention towards tactics or on opponent's positioning so as to minimise the focus on execution of the skill. Metaphors for performance such as 'high and long' provide a focus but are not specifically technical.

Another consideration for training is that performers at the autonomous stage are frequently not the best teachers of complex skills that they themselves excel in. This is because they are not aware of 'how' they perform the task because it is such an automated response. You will find that the best coaches were not always the best players in their sport. The implication for practice is to avoid pairing 'expert' players with novices, as they may miss the steps that are necessary for those who are just learning.

Relearning a skill

Once a player reaches the autonomous stage of learning a motor skill, it would be assumed that they have reached the pinnacle of performance. However, expert performers too can have 'bad habits'. For expert performers, modifying bad habits is a frustrating task from a skill-acquisition perspective. Learners need to 'unwire' the learnt skill and 'rewire' a new motor program. The autonomous stage of learning enables the old skill to be performed subconsciously and its execution seems correct. To the athlete it 'feels' right, but they are also aware that it is executed incorrectly. When the athlete tries to adapt to the 'new' technique, it feels wrong. This is a common complaint of athletes when learning a modified or more efficient skill, and they must persevere during this stage of learning. The new technique not only feels wrong, but also it is not as efficient as the old method and has a high rate of errors. Commonly, athletes will revert back to old habits when their performance suffers as a result of the new skill not being at the autonomous stage. This transition to a new technique requires great perseverance from an athlete and even greater feedback from the coach.

SNAPSHOT

Performers who reach the autonomous stage must repeatedly go back to the associative stage to maintain the skill as autonomous. Effective coaches always ensure that players include basic skill practice in every training session, even at the elite level. Some athletes even find it necessary to go back to the cognitive stage in order to change the technique of a current motor skill.

Early in his career, Tiger Woods found himself in this exact position when his swing technique put too much strain on his left knee. He underwent surgery to remedy the ligament strain and consequently had to modify his swing to reduce the probability of further injury. It took nearly two years for him to rebuild his swing, which involved modification of his stance, an increase in strength and reduced rotation at his hips.

More is not always better

VG DENNY

While feedback is extremely beneficial in skill acquisition, more is not necessarily better. In fact, asking learners to rate their own performance before providing augmented feedback may actually enhance the feedback's effectiveness and help players not become so dependent on the coach providing all the feedback. There are numerous ways to decrease the amount of feedback provided, helping players become independent learners. For example, having players perform several attempts of a skill before providing augmented feedback (called summary feedback) can allow them to engage in a cognitive/kinesthetic skill analysis before hearing from the coach. A method called self-selected feedback suggests players only receive feedback from the coach when the players request feedback. Another approach of providing less rather than more feedback is termed 'bandwidth feedback', which entails establishing an acceptable range or criterion of performance error, and only providing feedback once the player is outside that range. These approaches for reducing feedback delivery are helpful for coaches and players since it is a systematic reduction of feedback based on individual skill slevels. So while feedback is essential for skill learning, more is not always better.

Source: from VG Denny, 'Part II: Applying Motor Learning Principles', *Coaching Volleyball*, June/July 2010, p. 24

Learning experience

LEARNING A SKILL

Reflect on how you learn a skill. Do you rely on the teacher/coach to always provide feedback before knowing what to try next? Consider the following questioning–feedback technique. Ask yourself the following four questions during practice:

1. What are you working on? Being able to focus on one part of a skill is important. Breaking a skill into subroutines can assist. This also provides a focus and maintains motivation.
2. Did you do what you wanted to do? If you are not performing the skill to the standard that you expect, your coach or peers might intervene with an alternative strategy.

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Proprioception is the ability of the body to sense stimuli from within the body, e.g. knowing that your hand is in the air when your eyes are closed.

3 How did it feel? Being able to direct attention to the **proprioceptive** sensory information is a very important skill. This is the information that athletes rely on in the autonomous stage of learning. Being able to retrieve the 'feel' of a skill should become part of every practice.

4 What are you going to try next? Placing the emphasis on the learner for their own learning is an important step in the process. Practising with a key focus and making every trial count is more effective than simply practising.

You will feel much more empowered and motivated to perform when you take control of your own learning process. You should work together with your coach/teacher rather than rely solely on them for performance feedback.

Learning experience

TENNIS BALL THROW TO TARGET USING NON-DOMINANT HAND

Aim

To demonstrate that motor learning results from practice.
To experience stages of learning in a motor task.

Equipment

- 5 tennis balls per group
- target (50 cm × 50 cm) to be hung on wall as shown in diagram

Procedure

1 Divide class into groups of 4.
2 Distribute 4 score sheets to each group.
3 Place target on wall as illustrated. Make a mark on the ground 5 m from wall and parallel to wall.
4 NO practice is allowed prior to Trial 1.
5 Stand behind the line marked on the ground, with 5 tennis balls in a basket. With the tennis ball in your non dominant hand, attempt to bounce the ball off the ground to land in the target on the wall. Each trial consists of 5 attempts.
6 You score one point for a ball landing in the target area. Score after each trial and record on your score sheet.
7 You will complete 10 trials, i.e. a total of 50 throws.
8 Complete a performance graph of your practice (see figure 1.12 for an example).
9 Calculate the class average for each trial and plot on your graph.

Results

1 Identify the trends in performance from the performance curve.
2 Explain the performance improvements in terms of stages of learning.
3 Evaluate whether you consider learning to have occurred.

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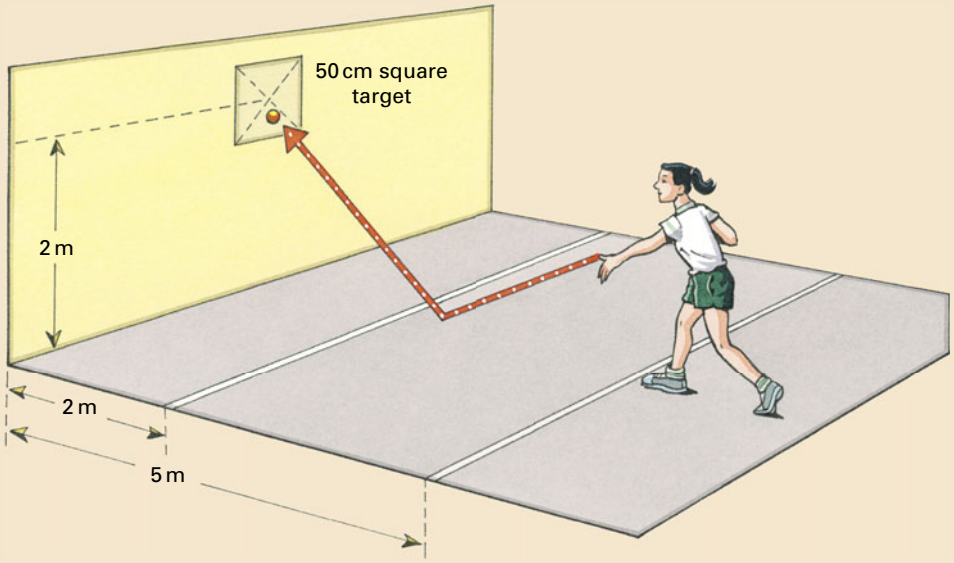

Figure 1.11 Throwing and bouncing a tennis ball using the non-dominant hand

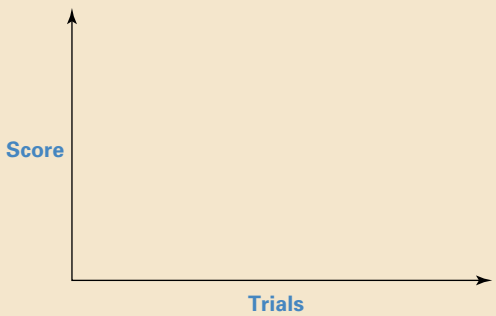

Figure 1.12 Scoresheet and performance curve

Factors affecting skill acquisition

Naturally gifted athletes who can excel at any sport are frustrating to those who have slogged it out at training sessions for years to get to the same level. So what factors influence a performer's ability to perform complex motor skills?

Ability to process information

The learning of a new skill depends greatly on the performer's ability to relay information (stimuli) from the environment, to the muscles via the brain. Your ability to process information depends on your genetic inheritance, the quality of the instruction or training you receive and your previous experience.

Age and maturity

People mature at different rates and therefore chronological age is not always a good indicator of maturity. Lleyton Hewitt was only 16 when he won the

Australian Men's Hardcourt Championship in 1998, becoming the second youngest player in history to win a major championship. However, research indicates that the 'relative-age effect' is an influencing factor as to whether someone will reach elite level.

Relative-age effect is a term used to describe the trend of players born in the early months of the year being disproportionally represented at elite level sport.

The **relative-age effect** is the predisposition of players who are older than their peers but still in the same age group (e.g. 10 years and 9 months compared to 10 years and 1 month) to be more likely to be represented in an elite level of sport. Lleyton Hewitt was born in February. Tiger Woods was born in December.

Research from Canada identified the month of birth of junior players in high-level sports teams (see figure 1.13). Players born in the months of January to April are over-represented in junior sports teams.

Reasons for relative-age effect

There is opportunity for a greater range of skill difference to be observable between a player who is 10 years and 9 months old and one who is 10 years and 1 month old. Eight months can make a significant difference in the skill acquisition of juniors:

- Older players are seen as more talented and hence are more likely to be selected for teams on the basis of ability.
- More talented players are more likely to be streamed into teams with similarly skilled players and hence receive a higher level of competition.
- Coaches allocate more time and attention to those players they deem to be more talented.

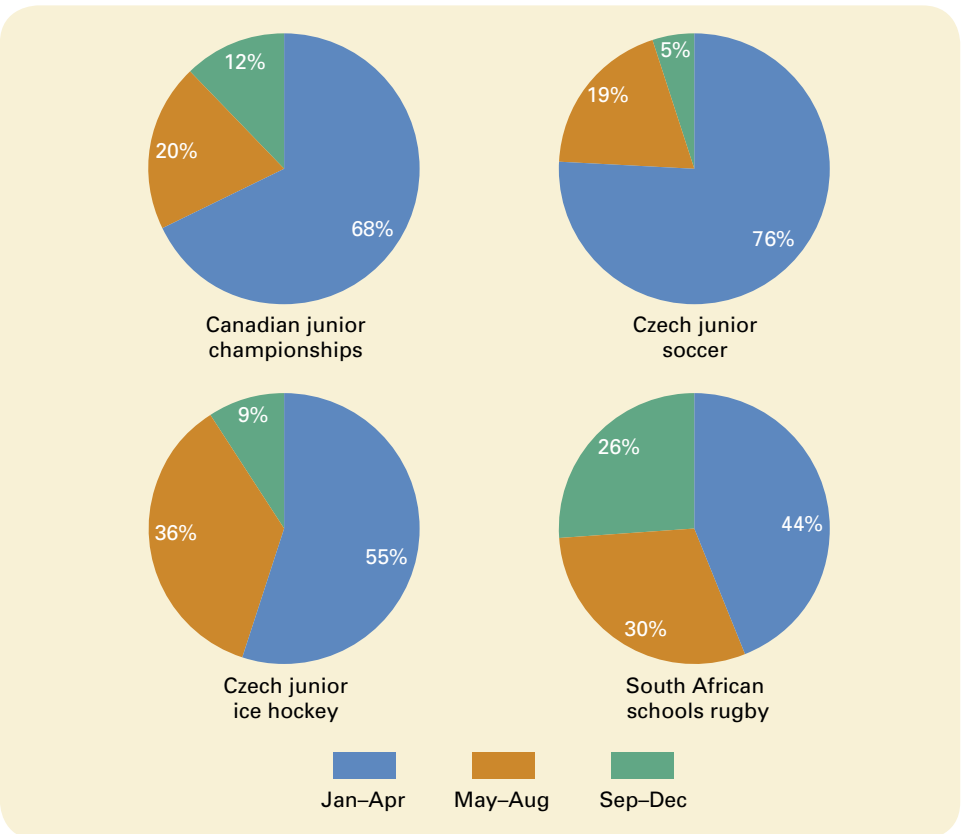

Figure 1.13 Research from Canada shows the relative-age effects of junior sporting teams.

Source: <http://www.sportsscientists.com/search?q=matthew+effect>

- Players deemed to be more talented receive more rewards and are more likely to stay in the sport as a result.
- Players gain confidence as a result of 'being better' than their peers. Confidence encourages future participation in their chosen sport.

Children have a lowered capacity to process, store and remember information than do adults. They also have a lowered level of motor control. If given tasks that are beyond their information-processing ability, children become frustrated and lose motivation. On the other hand, if given tasks that are too simple, they easily become bored.

In any sporting activity, performers seem to be at their peak at a particular age. For example, female gymnasts and swimmers generally perform best in their teens and twenties, whereas marathon runners and weightlifters tend to perform best in their late twenties and early thirties. Motor performance generally declines after the age of 30.

Learning experience

Consider the relative-age effect in sports shown in figure 1.13. Consider why in some sports the age effect might not be a significant impact.

Conduct a survey of your sporting club or playing team members' month of birth and compare against their team rankings. Create a suitable means for displaying this data. Identify any trends in this data and suggest possible reasons for this trend.

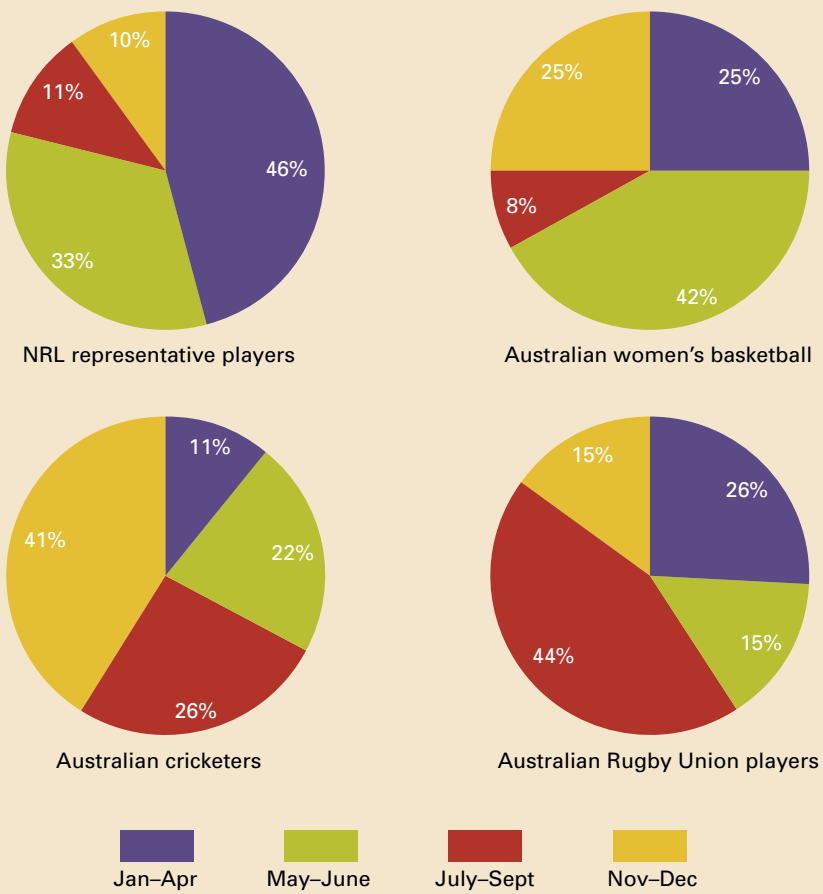

Figure 1.14
Four pie charts on age effect in Australian teams—relative age effect in various Australian representative teams (2003–2005)

Learning experience

Given the evidence for the relative-age effect, discuss the impact of introducing a weight or height classification for youth sports instead of age rankings in an attempt to make for a fairer competition.

Gender

Differences in physiology, rather than differences in ability to learn skills, explain why males perform better in strength and power activities and females perform better in endurance events. Events that depend on explosive power (e.g. high jump and long jump) show the greatest difference between males and females. However, women hold the majority of records in endurance swimming, possibly because of their ability to utilise fat as an energy source. Susie Moroney broke many long-distance swimming records, some previously held by men. Females are tending to break world sports records at a faster rate then males. The reason for this may not be physiological, but rather due to improved access to skilled training and selection processes, as well as increased opportunities for involvement in sport.

Heredity

For many years, the question 'Are great athletes born or made?' has been asked. No-one can claim that anyone's ability or performance is caused solely by genetic factors (body type or proportion of fast-twitch fibres) or solely by environmental factors (role models, quality coaches or access to facilities). Genetics and the environment both contribute to the making of an expert performer. The relative contributions that each makes to the development of a person's sporting ability may vary. For example, a basketball player who isn't as tall as others on the court makes up for it by being fast and developing anticipatory skills to intercept plays, whereas a player who has inherited favourable physical characteristics may not be motivated to achieve their potential.

Physical characteristics

Skill acquisition can be influenced very much by physical characteristics, such as:

- **somatotype**
- height and weight
- strength
- flexibility
- endurance
- vision
- **kinaesthetic sense**.

A **somatotype** is a classification of body types according to physique. There are three somatotypes: ectomorph, mesomorph and endomorph.

A **kinaesthetic sense** is the ability to sense the position, movement and weight of the body by receptors in the muscles, joints and tendons.

A short player will never have the opportunity to slam dunk a basketball or block a volleyball. In rugby, physically strong players play in the forwards, while those with agility and speed are positioned on the wings.

Personality

Having physical attributes alone does not ensure reaching the top. Skill learning depends on your level of competitiveness, keenness, aggression and confidence as well as your ability to relate to others. Athletes tend to be:

- more outgoing and socially confident
- more socially aggressive, dominant and leading
- better socially adjusted
- held in high esteem by others
- less anxious and more emotionally stable than non-athletes.

The personality traits of champions only tend to emerge in adulthood, so predictions of the future success of children are limiting.

Motivation

To achieve maximal learning, the learner must be highly motivated. Motivation is linked to personality and depends on:

- your reasons for participating
- what you hope to achieve
- the degree of enjoyment that participation brings
- your preparedness to learn.

Conversely, your level of motivation has an impact on:

- the type of activity you prefer
- your persistence at an activity
- how much effort you put into training.

Geographical location

Australians are more likely to take up swimming than are people in cold climates, primarily due to our proximity to the coast. Conversely, children in colder climates are more likely to take up skiing and ice skating as part of their daily routine.

Children in regional areas of Australia have more opportunities for participation in sporting activities due to the ratio of people to facilities. They are also more likely to be involved in less-structured physical activities, such as playing with other children in the neighbourhood. City children tend be involved in more structured organised sport. This might account for the large numbers of Olympic and national sportspeople who have grown up in regional towns of Australia. Mark Taylor, an Australian cricketer who started his playing career in Wagga, and Matthew Hayden, who grew up in Kingaroy, are two such sportspeople.

SNAPSHOT

As Australia tries to maintain its international sporting dominance, coaches and selectors should be scouting for talent in country towns.

Research by the Australian Institute of Sport (AIS) has found country kids are more likely to excel at high level competition and be selected for national teams.

Researcher Dr Damien Farrow says they are more likely to play sport for social reasons and are often pitted against more senior players at a younger age.

Source: ABC News, 11 November 2005

Sociocultural experiences

The skill learning to which a child is exposed tends to be linked to sociocultural factors, such as family background, level of education, cultural traditions and economic status. Children of parents who participate in physical activity are themselves more likely to participate.

Whether it is measured by income, education, occupation or area of residence, lower socioeconomic status is generally associated with lower rates of participation in physical activity. These figures also indicate that children from lower socioeconomic groups have similar levels of physical activity to children from higher socioeconomic groups, but the type of physical activity tends to be in less organised sport.

Quality of instruction

There is absolutely no doubt that skill learning is more rapid if the learner receives professional coaching or teaching. This is because the information is presented in a more motivational and meaningful manner and is structured in a way to enhance learning. The presentation of information combined with accurate feedback and technical knowledge of the skills results in optimal learning.

Type of practice

The type of practice also seems to have a powerful influence on learning. This will be discussed in more detail in chapter 2, 'The motor learning process'. Providing opportunities to practice under a range of task conditions prepares athletes for coping with the changing nature of team sports. Practising skills in modified games seems to benefit learning more than practising skills in isolation.

Chapter review

Motor skills

Know

1. Skilled performance develops as a result of which four factors?
2. Which stage of learning places greatest emphasis on practice?
3. List the three stages of learning as proposed by Fitts and Posner. Link one characteristic of the learner with each stage.

Comprehend

4. What are performance curves used to measure?
5. Identify the three criteria for the classification of skills and give examples for each.

Apply

6. Discuss how coaching instructions may have to differ depending on the stage of the learner.
7. Reflect on your participation in sporting activities. What factors influence your ability to become an expert performer in your sport? What factors may limit your ability?
8. Identify the theories of motor learning adopted by elite players in order to change their technique.

Analyse
Evaluate
Synthesise

9. If you were a selector for a junior sporting team, what advantage would a knowledge of the relative-age effect have on your selection criteria?
10. Research by Dr K Anders Ericsson has demonstrated that it takes 10 000 hours of deliberate practice to become an expert performer. Debate whether *anyone* can become an expert performer in their chosen sport. Provide supporting evidence for your argument for or against. Include the factors that influence a performer's ability to learn a skill.

chapter 2

The motor learning process

The learning process

Learning is the process by which we acquire knowledge, information and skills. It is the result of establishing connections between neurons in your brain, so the first step in understanding learning is to understand how the connections in your brain are changed.

Neurons are nerve cells that send electrical impulses via neurotransmitters across the synapse (the gap between the neurons). Our five senses process information (external stimuli) and then select certain neural connections to become active.

The nature of motor learning is that every motor skill develops neural connections in a particular region of the brain. The more neural connections that are laid down, the easier it is for the brain to attach new connections to those that already exist. The left hemisphere controls the functioning of the right side of the body and is responsible for understanding written and spoken language, number skills and reasoning. The right hemisphere controls the functioning of the left side of the body and is responsible for artistic awareness, such as music and art.

Neurons are nerve cells that send electrical impulses via neurotransmitters.

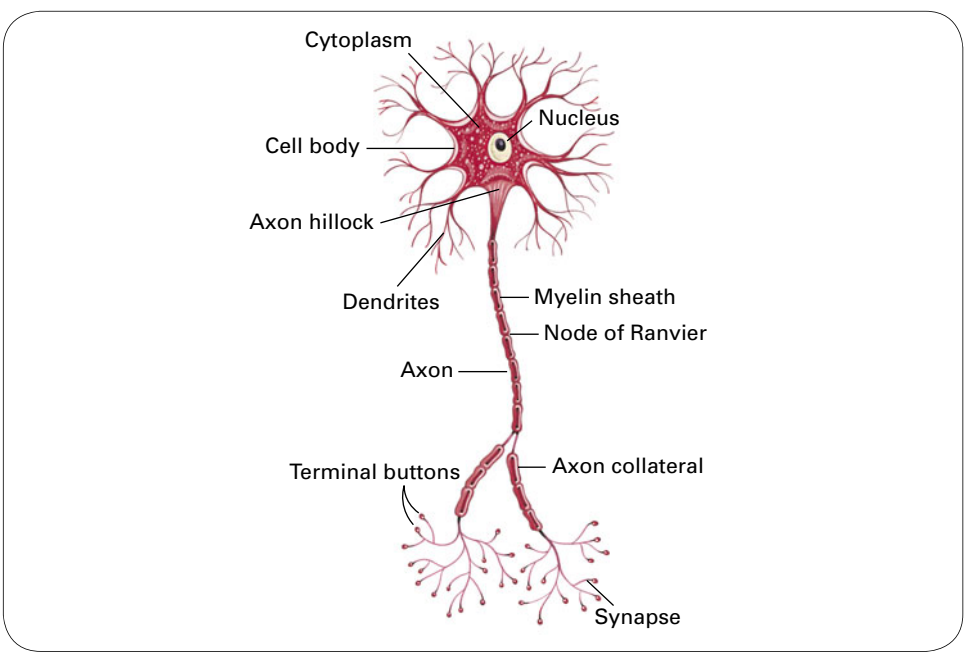

Figure 2.1 Linking neurons and synapses

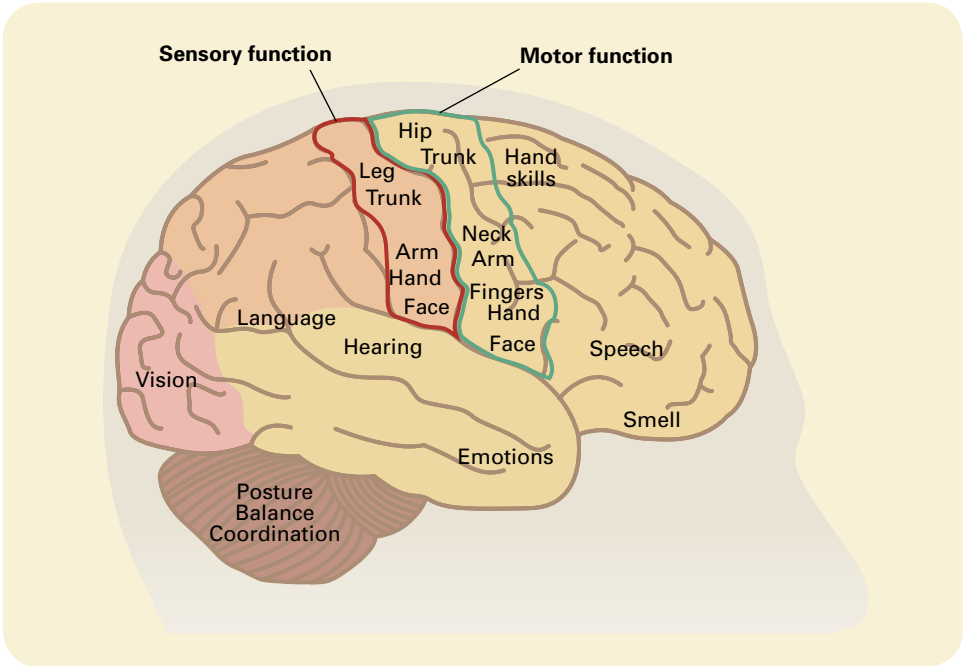

Figure 2.2
The brain is divided into regions that control various motor functions.

Learning and memory

To understand how you learn, it is important to understand the role that memory plays in developing motor skills. There are two types of memory systems: short-term memory and long-term memory. These two memory systems are different on two counts: the amount of information they can store and the length of time it lasts.

There are three regions in the brain for storing memory information:

- short-term sensory storage
- short-term memory
- long-term memory.

The short-term sensory storage is the first area stimulated by information. The receptors receiving this information can retain information for only a few seconds. Within this brief time, there is no limit to the amount of information the short-term memory can hold. Consider seeing flash cards held up by the teacher; you only retain the last one or two images until the next image displaces the previous one.

Short-term memory, also known as active or working memory, is characterised by a limited storage capacity in which information is lost or deteriorates quickly if it is not consciously rehearsed or encoded. For example, a friend tells you their phone number. Methods of remembering this number, or encoding it, are to verbally rehearse it (i.e. repeat the phone number over and over) or to use visual stimuli (i.e. 'see' the number in your head). This encoding is further strengthened if the information is recalled at a later time and further detail added, such as the linking of numbers with the name of the person to whom it belongs. This repetition transfers the information to a different part of the brain for retrieval at a later time.

Short-term memory is also called working memory. It is the temporary storage site in the brain for managing information.

Long-term memory is the site for large amounts of information that, when properly encoded and reinforced, can be recalled after considerable periods

Long-term memory is a system of permanently storing and managing information for later use.

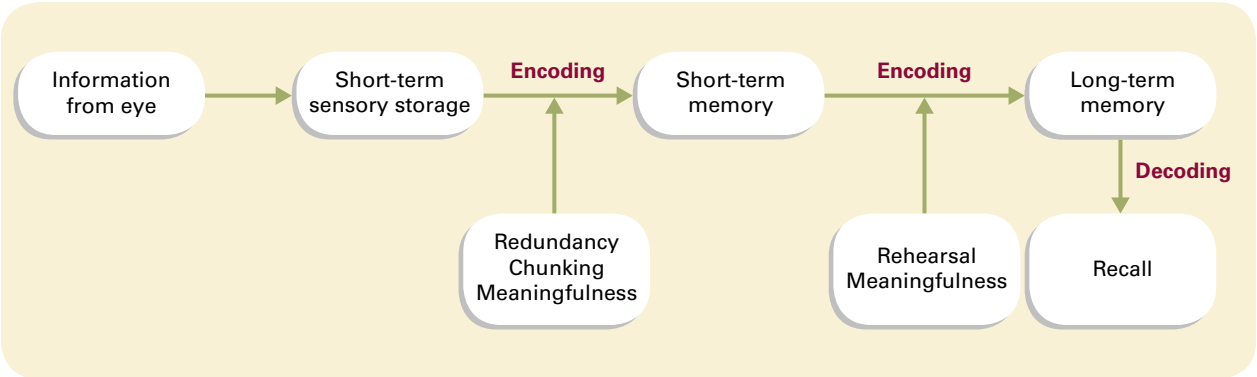

Figure 2.3 The different components of memory

of time. Consider recalling the name of your Year 1 teacher as proof of the storage capacity of your long-term memory.

The implication for coaches in skills training is to 'revisit' new skills at irregular intervals over a series of weeks. A training session might incorporate a new skill with a skill completed a month ago. These 'memories' of skills are further reinforced if players have the opportunity of talking through them with others, or of writing them down.

Learning experience

TESTING MEMORY

Aim

To illustrate the capability of the short-term and long-term memory.

Equipment

- 1 deep box
- 15 common objects, including 2 lesser known objects
- pen and paper.

Procedure

1 The teacher will hold up each object, one at a time for 3 seconds, before returning it to the box, and continue doing so until all 15 objects have been shown.
Do NOT write anything during this period.

2 When all 15 objects have been displayed, write down as many of the objects as you can recall. You have 2 minutes in which to do this.

Note: The teacher will keep a written list of the order in which the objects were displayed, as this is important for tracing the students' results.

Results and conclusions

- Your teacher will read the list of objects slowly back to the class, allowing time for you to check your list.
- Collate the class data by tallying results for each object (e.g. spoon: 14).

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- Observe trends in the results by identifying objects that were commonly recalled and those that had low levels of recall.
- Consider why some objects were more readily recalled than others.
- As a class, discuss the methods used for remembering the list of objects. Especially consider the student who recalled the most items. Create different techniques that can be trialled in order to improve the recall of another 15 different objects. You might consider putting the names into a sentence and trying to recall a sentence rather than individual words. Another option is to visually recall the objects in an 'artwork' in your mind.
- Compare the results and discuss in terms of the storage capacity of the short-term memory.
- Practise your working memory at <http://cognitivelabs.com/test6.htm>.

Meaningfulness of information

You may have experienced a time in which the information you were hearing or viewing made little or no sense because you could not attach meaning or understanding to it. Having a base level of knowledge on a topic provides a framework for attaching new connections of meaning and hence growing your understanding of the topic. Adding a new idea, image or understanding reinforces your understanding and makes learning more permanent. Revisiting a topic in homework creates further connections in the memory.

Feedback and memory

The effect of feedback on learning is explained in chapter 3 'Processing information, reaction time and feedback'.

Effective feedback should arrive as soon as possible after the completed skill performance. This simply reinforces the notion that if the external stimulus is not immediately attached to a pre-existing neural connection then it will be lost.

Overlearning

Once you have learnt a skill, you will need to keep practising to ensure you retain it. This continued practice is called '**overlearning**'.

Overlearning is learning a skill in which practice proceeds beyond the point at which a skill can be performed with a high degree of precision.

You might think that once you can serve 10 out of 10 serves over the net there is no more need for practice. Information in the long-term memory can be updated continually and reorganised to strengthen and refine existing motor programs. Also the nature of the brain is always changing and these changes affect the learning of motor skills.

Learning does not simply occur for everyone at the same rate. If a learner perceives a task to be meaningless, then there will be little or no motivation for learning. In general, the more practice you do, the more your performance will improve. To reach the pinnacle in sport requires endless hours of

practice. Learners learn in different ways and it is this concept that coaches need to keep at the forefront of planning. Knowledge of the impact that the following different styles of practice have on performance is important when designing training sessions.

SNAPSHOT

As a youngster, Sir Donald Bradman spent many hours on basic technique. He practised his stroke play and hand–eye coordination by hitting a golf ball with a single cricket stump against a corrugated iron water tank. This was the groundwork that developed his extraordinary footwork and stroke play that led to a test batting average of 99.94.

Types of practice

Repetitive practice of skills is considered to be a necessary condition for expert performance. However, it will only improve performance if the type of practice is suited to the level of the performer and the type of task being practised. It is important to consider the best way to schedule a practice session in order to maximise learning.

There are six goals of practice. These are to:

1 develop highly persistent movement skills
2 develop highly adaptable skills
3 practise specificity
4 increase confidence
5 increase ability to perform under pressure
6 increase decision-making ability.

Practice can be classified into different types:

- massed practice and distributed practice
- whole practice and part practice
- blocked practice and random practice
- varied and constant practice
- drill and problem solving.

Massed practice

Massed practice is a training routine in which a skill is practise continuously and consistently.

To practise a skill continuously and consistently is called **massed practice**. Examples of massed practice are performing 50 softball pitches, 25 overhead volleyball serves, 30 sprint starts, or kicking for 20 lengths of the pool.

Fatigue and motivation are the greatest impediments to using massed practice in a training session. Massed practice is undesirable for beginners.

Distributed practice

Distributed practice is a training routine that involves short, frequent practice sessions interspersed with rest intervals.

Distributed practice consists of short, frequent practice sessions interspersed with rest intervals. There is consensus that distributed practice is more effective for learning a skill than massed practice. The important element is the work to rest ratio—that is, how many trials and how long a rest period.

Examples of distributed practice routines include:

- 5 sets of 20 chest passes with a 2-minute rest
- 2 minutes practising forward rolls then 2 minutes on handstands and then repeat.

Comparing massed and distributed practice

Most of the evidence indicates that distributed practice is more effective in improving performance. But it has also been suggested that massed practice is preferable for highly skilled performers and that distributed practice is preferable when:

- the learner is in the cognitive stage of learning
- the energy demands are high
- motivation is low
- the task is boring.

Distributed practice allows recovery between trials and gives the performer time to think about the skill. Mental imagery of the skill in rest time has been shown to influence skill performance positively. However, if another skill is performed in the rest interval, this interferes with the retention of knowledge and so reduces the level of performance.

Whole practice and part practice

Whole practice is the learning of a skill in its entirety. **Part practice** is the learning of each of the separate components of a skill. For example, the lay-up shot in basketball can be taught all at once using whole practice, or broken down into its component parts of dribble, approach angle, take-off and release.

Whole practice is a type of practice routine that involves learning a skill in its entirety.

Part practice is a type of practice routine that involves learning a skill in its component parts.

Part practice is particularly effective when the skill being taught is complex and has clearly defined components (e.g. golf swing). Whole practice is effective for use in skills that are high in complexity and low in organisation, such as a jump shot or skating.

Some practitioners opt for combining the two styles in a progressive-part method. An example would be the learning of breaststroke. As there are two clearly defined components of the skill, the kick and the arm action, it is easier to learn each separate part before combining them into a whole skill. This allows the performer to practise the whole skill and then concentrate on the timing of individual components separately.

Blocked and random trials

In a physical education lesson you have a set time period in which to cover certain skills. For instance, in a tennis lesson, the class may learn the forehand and backhand and, if time allows, progress to a volley. A certain amount of time would be allocated to introducing each skill and the performers would have time on task to practise each of the skills individually in a repetitive fashion (e.g. 15 forehands followed by 15 backhands). This method of practice is called **blocked practice** and learners attempt the same skill repeatedly in order to refine and improve their performance. Blocked practice has been shown to be effective for performers in the cognitive stage of learning but ineffective for performers in the associative stage of

Blocked practice is the type of practice routine that involves the repetitious learning of one component of a multitask skill in order to refine and improve that component.

learning. Blocked practice is also useful for increasing player confidence, as performance tends to improve.

Another approach to learning multiple skills such as the forehand, backhand and volley is to use **random practice**, which mixes up the skills during practice (e.g. backhand, forehand, backhand, volley and forehand).

Random practice is the practice routine in which all components of a multitask skill are practised in random order within each practice session.

Random practice has been shown to develop longer-lasting learning of motor skills because of the development of neural pathways as a result of changing between skills. The random nature of the practice means that the performer must develop a memory of the skill before rapidly adjusting to a new skill. The creation of connections of new sensory pathways for the completion of the skill creates an action plan that is retrieved from memory when the skill is practised again. This process of creating and retrieving an action plan from long-term memory is called the retrieval process.

However, random and variable practice tends to increase errors and lead to a lowering of player confidence. Ensure that random practice is scheduled later in the season to allow time for learning to occur.

Constant and varied practice

Both constant and varied practice are associated with the practice of classes of skills such as throwing, kicking and hopping. **Constant practice** refers to the practice of only one class of skill without any variation (e.g. kicking a ball to a target 10 m away).

Constant practice is a practice routine in which only one class of skill is practised in the session.

Varied practice is a practice routine in which there are variations within the one class of skill.

Varied practice refers to practising a class of skills using variations within the one practice session (e.g. kicking to a target 10 m away, then 20 m away and 30 m away).

By developing a generalised movement pattern for the class of skill (e.g. kicking), the performer adapts certain parameters, such as force, speed of leg movement or range of movement to meet the requirements of the task. If the change to the parameters is ineffective, the kick, for example, will be too long or too short.

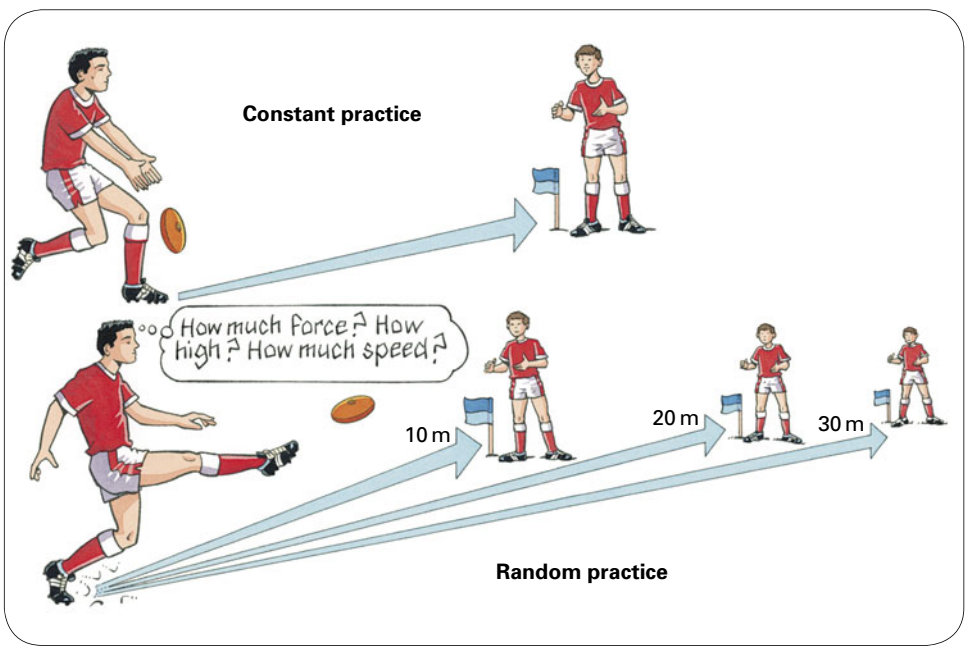

Figure 2.4
(a) Constant practice and (b) random practice

Speed and accuracy

There are conflicting views of the merits of emphasising speed over accuracy when learning a new skill. In skills in which speed is the predominant factor for successful performance, the best results are obtained by an early emphasis on speed. However, in skills where both speed and accuracy are important, emphasis on both from an early stage in learning is recommended.

SNAPSHOT

One study compared two groups of subjects in a simple hockey skill task. Group A was instructed to hit a ball 8.4 m to a target area, while group B was instructed to hit a ball 8.4 m as fast as possible but to no specified target.

The results showed that the two different groups developed distinctively different motor patterns to achieve their goal. The demands of accuracy tended to impede the development of efficient motor patterns, whereas the demands for speed tended to reduce the control and accuracy of the outcome. The implication for coaches is that in the early stages of practice accuracy should not be emphasised until the correct motor patterns of a skill are developed.

Figure 2.5
Accuracy should not be emphasised until correct motor patterns develop

Drills and problem solving

Drills have conventionally been the traditional method for developing sports skills through repetition in practice. However, by structuring practice that includes dynamic small-sided games, such as modified games or when using a teaching style called 'Teaching Games For Understanding' (TGFU), players have an opportunity to problem solve through exploration and guided discovery. This supports the notion of using productive approaches to coaching when planning training sessions, as discussed in chapter 6, 'Team cohesion, coaching styles and goal setting'.

This approach acknowledges that people learn best when they construct knowledge through engagement in practice. The merit of this approach is the development of 'intelligent performers'.

Learning experience

HOW TO DEVELOP THINKING PLAYERS THROUGH PROBLEM SOLVING

In order to develop thinking players, certain behaviours can be developed by changing the practice environment by imposing constraints. Examples of these constraints are shown below for a soccer practice session.

Pitch markings	Develop zone restrictions for shooting, tackling, etc.
Number of players	5 vs 3; 6 vs 4
Time in possession	Limit the time a team has to score.
Conditions or rules	Two-touch rule. Everyone on the team must have two touches before scoring.
Sensory constraints	Blindfold player while taking penalty shot in soccer.

Develop a list of constraints or restrictions, similar to the list above, for practice in a sport you play. Put these constraints into practice and discuss with the class the learning outcomes of these activities.

1. How did this change the way in which players communicated?
2. What were the advantages of this method of practice?
3. How did the role of the teacher/coach in these activities differ from that in traditional drills?
4. What other constraints can be changed?

Specificity and variability of practice

Specificity refers to practice being as close as possible to the context in which the skills need to be performed. For example, in a volleyball game the server will be involved in a rally prior to their service. However, in practice, the volleyball server only practises the service action in a repetitious routine. This practice is not specific to the task requirement of a server in a game. Practice has to include the essential components of performance. For example, a triathlete needs to practise coming out of the water and transitioning to the bike rather than simply getting on the bike.

Specificity refers to practice being as close as possible to the context in which the skills are performed.

Figure 2.6
Modern design of sporting equipment can provide variability of practice, such as this irregular rebounding surface.

Variability of practice refers to practice sessions that incorporate a variety of movement options and context changes. It has been shown to result in increased learning in comparison to blocked practice.

Here are some examples of variability of practice:

- netball: Practise shooting goals while standing on a wobble board or on one leg.
- swimming: Swim in the lane in the opposite direction.
  Have a fellow swimmer create a wash effect.
  Bump the swimmer on starting.
- hockey: Start training from a different part of the field.
- rugby: Change the weight of the ball or make it more slippery.
- rowing: Look for messy water.
- cricket: Use a slips cradle to create an irregular path of the ball.

Variability of practice refers to practice sessions that incorporate a variety of movement options and context changes.

Learning experience

SKILLED VS BLOCKED PRACTICE

Researchers Williams and Ford made this comment about skill acquisition:

> *After having conveyed information to the learner, coaches have to decide what practice activity their athletes should engage in and how best to structure that practice for effective learning. What skill should be practised? Should the skill be practised in a blocked (i.e. athlete practises only one skill for a period of the practice session before moving onto the next skill) or random (i.e. athlete practises several skills in a random order in a practice session) manner? How important is constant practice of the skill (i.e. athlete practises a skill without any variation across attempts) compared with the need for variability in practice attempts (i.e. athlete practises random variations of a skill, such as changes in distance, speed or height)? How should practice be scheduled to ensure transfer from practice to competition? Coaches must either consciously or subconsciously reflect on such issues when designing and implementing each and every practice session.*

Source: Williams, AM, and Ford, PR, *Journal of Sport Sciences*, vol. 27, issue 13, pp.131–192.

Use this article excerpt as a stimulus to compile a list of decisions that coaches need to make before planning a practice session. Design the list as a flow chart like the one in figure 2.7.

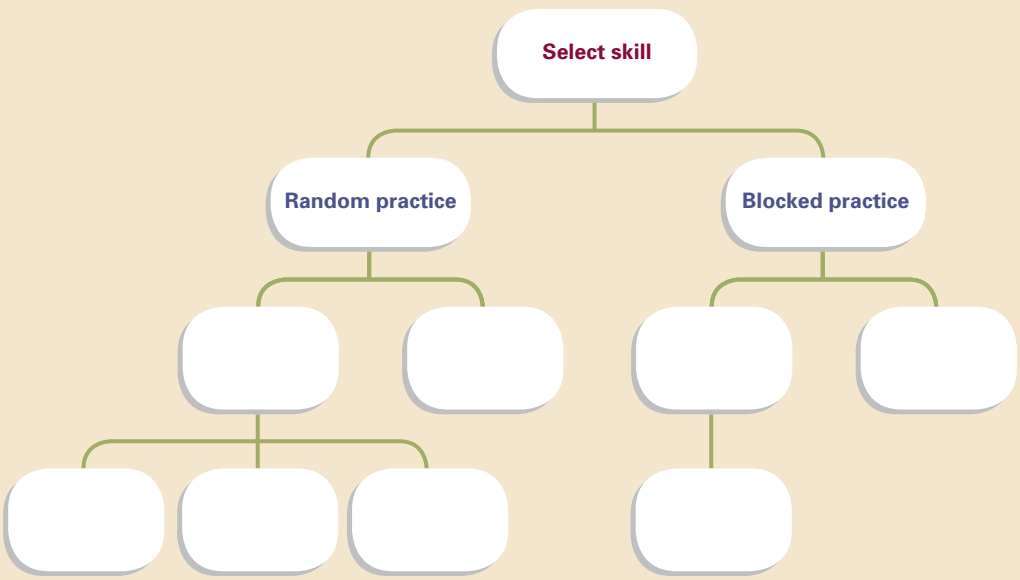

Figure 2.7 Random versus blocked practice

Learning styles

To this point we have discussed the many options that coaches must consider in order to develop effective practice sessions. One further consideration in this process is the preferred learning style of the performer. Identifying different learning styles and matching them with the appropriate teaching strategies can only enhance the learning process.

There are many different terms that categorise the unique learning style of an individual. Research at the Australian Institute of Sport applies four broad categories of learning styles.

Active/reflective

Active learners prefer learning through participation or performing the task. They also have a preference for working in groups. Reflective learners tend to think about a strategy before implementing it.

Sensing/intuitive

Sensing learners prefer following previously tested methods when learning something new. Intuitive learners, however, avoid repetition and adopt new strategies to situations. They become bored easily with the same routine.

Visual/verbal

Visual learners prefer to receive information via diagrams or, video feedback or to be able to create a visual image from instructions. Verbal learners prefer instructions to be spoken or written. This tends to be the least common type of learner, but it is the medium via which most coaches present information to athletes.

Sequential/global

Sequential learners understand information in logical steps and global learners are 'big picture' learners.

A useful technique to ensure that all types of learners are catered for in a team is to develop 'learning stations'. This provides different mediums for communication at the one station. For instance, a spiking drill in volleyball might have a video for visual learners, while verbal learners could receive instruction from the coach and active learners could start practising.

There are many learning style questionnaires that you can use to determine your preference for a certain learning style. Examples can be found at the following websites:

- <www.engr.ncsu.edu/learningstyles/ilsweb.html>
- <www.ldpride.net/learning-style-test.html>.

Learning preferences

A proponent of the use of learning preferences to enhance performance is Neil Fleming who devised the VARK questionnaire. **VARK** is an acronym for **V**isual, **A**ural, **R**ead/Write and **K**inaesthetic. It is a questionnaire that provides users with a profile of their individual learning preferences. It identifies preferred ways in which a learner takes in and gives out information. The VARK profile consist of four scores aligning with the following four modes of learning.

VARK is a questionnaire designed to identify a learner's predominant learning style: V = visual, A = aural, R = read/write, K = kinaesthetic.

V: Visual

Visual learners prefer information displayed in charts, graphs, flow charts, plays and moves that use symbols or arrows. Coaches who demonstrate plays

on a whiteboard are using a visual approach. Visual learning approaches do not include using videos and television or PowerPoint presentations, as these use a variety of modes.

A: Aural

Aural learners prefer information that is spoken or heard. The best methods of communication include speeches, discussions, telephone messages, texting and emails. Some learners learn by talking things through—even to themselves!

R: Read/write

The read/write learners' preference for learning is through written text such as books, the internet, handouts, lists and manuals. The predominant mode of learning is through a PowerPoint presentation.

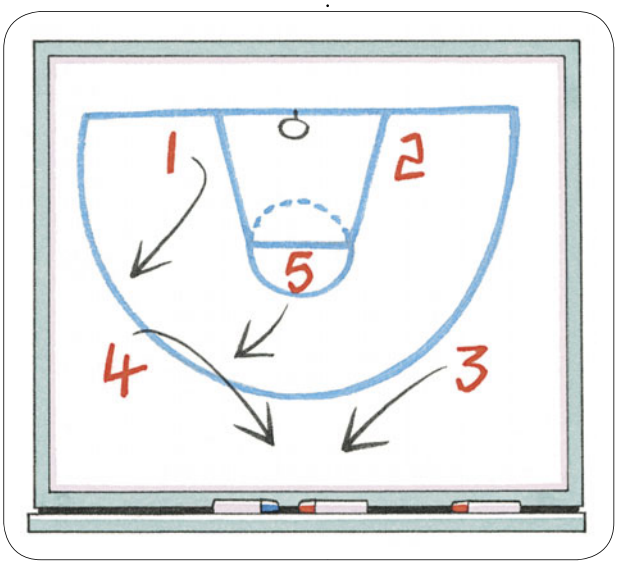

Figure 2.8
A whiteboard diagram may assist learners with a visual preference.

K: Kinaesthetic

This learner prefers learning through doing. This can be through experience, real-life examples, case studies, demonstrations, practice or performance. Most athletes and coaches fall into this category. This category is usually the most prominent preference.

Implications for coaches

Understanding that learners have different preferences for learning will better equip the coach to plan training sessions according to their players' or the class's learning preference. For example, if half of the class had a single preference for the kinaesthetic mode, then adding manuals and whiteboard drawings to training won't support their learning. In contrast, a learner with a visual preference might find the diagram in figure 2.8 a valuable learning tool.

Learning experience

VARK was first launched in 1987 through work completed by Neil Fleming at Lincoln University, New Zealand. The questionnaire provides users with a profile of their learning preferences (i.e. the ways in which they prefer to take in and give out information). The VARK website can be found at <www.vark-learn.com>.

1. Complete the online VARK questionnaire to determine your learning profile.
2. Identify your learning preference/s and suggest strategies that would assist in learning through this mode.
3. Determine the learning styles of all members of the class and discuss the fit with the current teaching strategies that are predominantly used.
4. Suggest teaching methods that would align with your preferred learning style.

Learning experience

LEARNING A NOVEL TASK

Purpose

To ascertain the preferred learning style used in the completion of a novel task.

Equipment

- 60 cm piece of rope (not string)

Task

In pairs, use the three resources below to complete the task of tying a bowline knot. One partner observes the other, to identify the main resource used in the completion of this task.

Resource 1

Figure 2.9
A bowline knot

Resource 2

Figure 2.10
How to tie a bowline knot

Resource 3

Simple instructions

1. Take the rope in your left hand at the half-way point and create a small loop.
2. Take the right-hand end of the rope and thread it through the loop from the back to the front.
3. You now have a small loop that will become the knot and a large loop.
4. Direct the end around the back of the left end and back through the small loop.
5. Pull the short end and the large loop in one direction and the long end in the opposite direction to tighten.
6. Place the large loop over your wrist and tighten gently.

>>

Discussion

1 Identify your partner's learning preference by observing which method of instruction they chose:
   - resource 1—the bowline diagram
   - resource 2—the sequence of diagrams
   - resource 3—the written instructions
   - a combination of all of the above
2 From your observation, what style of learner would you label your partner? Which style of learner does this task advantage?
3 Which learning style is not catered for?
4 How can the task be modified to accommodate all learning styles?

Chapter review

The motor learning process

Know	1	Sir Donald Bradman practised hitting a golf ball with a cricket stump against a corrugated iron tank. Identify the type of practice that he demonstrated. What is the advantage in using this type of practice over hitting a golf ball against a flat wall?
Comprehend	2	Explain why massed practice is not recommended for beginners learning a new skill.
	3	Explain the differences between the workings of the short-term and long-term memory.
	4	Provide examples of massed practice and distributed practice.
Apply	5	Explain what constraints could change a training drill from a blocked practice drill to a variable practice drill.
	6	Explain how you could structure a training session to cater for different learning styles if there are 20 athletes and numerous learning styles.
	7	Briefly explain the difference between performance and learning.
Analyse Evaluate Synthesise	8	Explain the importance to coaching of having knowledge of learning style.

Processing information, reaction time and feedback

Chapter 3

Information-processing model

The human body is capable of processing information at an astonishingly fast rate. The brain and the senses of the body can react to a tennis ball served at more than 200 km/h. However, when there is a large amount of information being sent to the brain from the senses, the brain slows down the rate of processing in order to interpret the information and react in a meaningful way.

Information from the external environment is received through the five senses: vision, hearing, smell, touch and taste. The senses stimulate the transmission of neurochemicals to neurons in the brain. The first stage in the information-processing model is called 'stimulus identification' (see figure 3.1). In this stage of the model, information is received and processed into 'patterns' of electrical signals. The signals move to the second stage of the model, 'response selection'. The primary purpose of this stage is how to respond to the stimulus. Does the batter in softball swing at the approaching ball or let it go through to the catcher?

Once the performer has decided on a response (e.g. to hit the ball), preparation is needed to plan for the movement. This third stage of the process model is called the 'response programming' stage. This involves retrieving an appropriate motor program from memory, coordinating the intended contraction of muscles to respond, and ensuring the sensory system is attending to appropriate cues. After the action has been primed, it is initiated via the **motor neurons** and the response is seen as movement output, the resulting movement action of the information-processing model.

A **motor neuron** is a nerve cell that conducts an impulse from the central nervous system to muscles or glands.

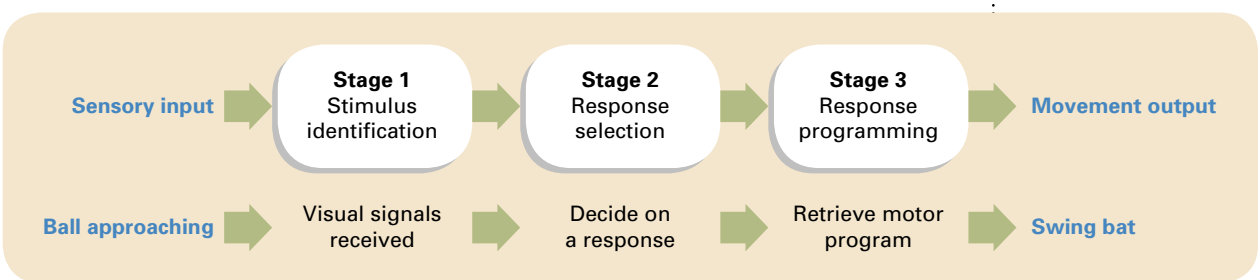

Figure 3.1 Information-processing model

Stages of the information-processing model

There are four stages in this model. The person:

1 detects the stimulus—e.g. sees the ball approaching
2 chooses the action—e.g. decides to hit the ball
3 organises the motor program—e.g. long hit to left field
4 initiates the response—e.g. swings bat.

The resulting outcome may or may not meet the demands of the task. Using these stages, we could describe the sequence for a volleyball setter.

In stage one, the setter detects a teammate in position 3 running for an attack through the centre (stimulus identification). In stage two, the setter decides to set a short ball for a quick attack (response selection), and in stage three, the setter retrieves the movement program and initiates the appropriate movement response (response programming).

Reaction time is the amount of time between a stimulus and the first movement initiated in response to it.

Although the processing of information occurs within a split second and cannot be seen, it can be measured by the speed of a person's **reaction time**. Reaction time is the amount of time between a stimulus and the first movement initiated in response to it. A person's reaction time is a reflection of their decision-making ability. It is the sum of the components as shown in figure 3.2 (response time = reaction time + movement time).

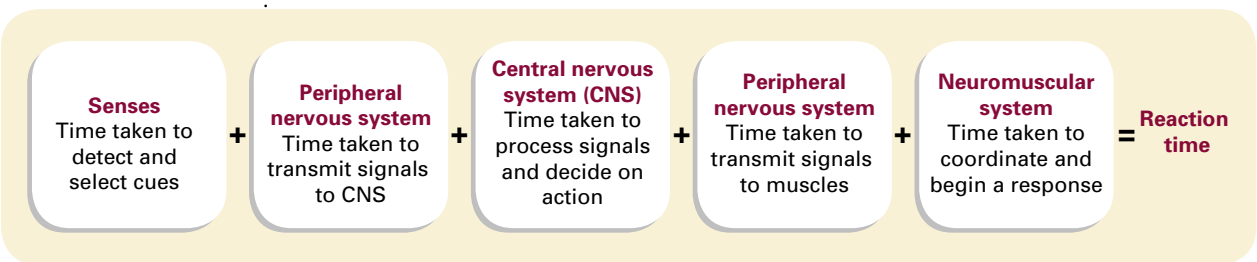

Figure 3.2 A model of the components of reaction time

Figure 3.3 represents the stages of information processing of a sprinter in a 100 m race. The sprinter takes 0.2 seconds to react to the sound of the gun before starting to move. If the movement task takes 11.5 seconds to complete, the response time will be 11.7 seconds.

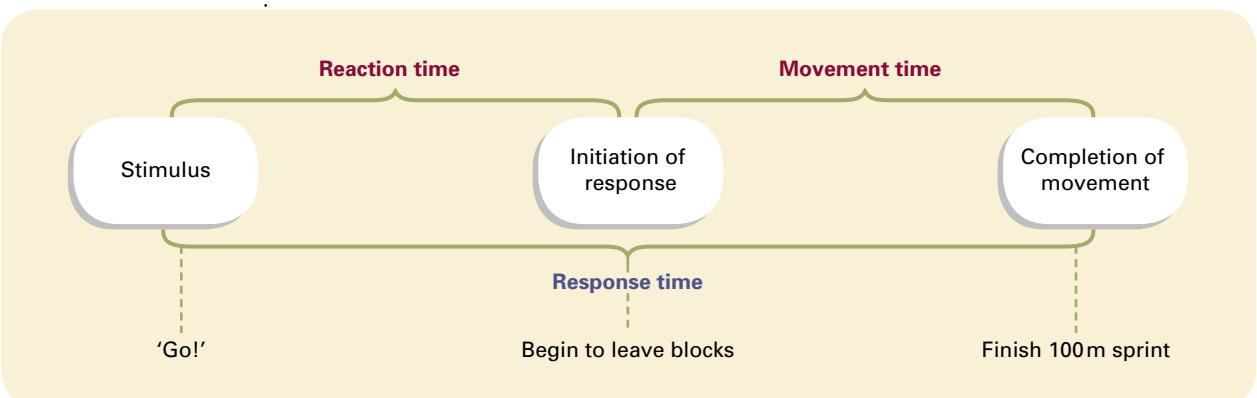

Figure 3.3 Reaction time is the total time from the perception of the stimulus to the completion of the task.

Reaction time is dependent on several factors: arrival of the stimulus at the sensory organ, conversion by the sensory organ to a neural signal, neural transmission and processing, muscular activation, soft-tissue preparation and the selection of an external movement response. Each of these factors has an associated processing time that contributes to the overall reaction time.

Types of reaction times

Reaction times can be divided into two broad types: simple reaction time and choice reaction time.

Simple reaction time

Simple reaction time is the time between the application of a specific stimulus and its required response. There is only one stimulus and one response. Examples include pushing a single button when a light comes on and starting to move when the starter's gun is fired.

Figure 3.4
An athlete's reaction to the sound of the starting gun may decide the difference between first or third place.

SNAPSHOT

The simple auditory reaction time is one of the fastest reaction times and is thought to be rarely less than 100 m/s. The average auditory reaction time is about 170 m/s and the average visual reaction time is about 260 m/s. The current false start criterion used by the International Association of Athletics Federations (IAAF) is set at 100 m/s. However, this was only lowered from 120 m/s in 1990, on the basis of scientific research. The 100 m/s limit has since led to some very contentious and widely publicised outcomes. The most famous of these being the disqualification of Linford Christie from the 1996 Olympic 100 m final for a false start.

Choice reaction time

Choice reaction time is the time between the presentation of more than one stimulus and the beginning of one of many responses. The more choices a performer has to choose from, the more information they must process, resulting in a slower reaction time. This relationship between

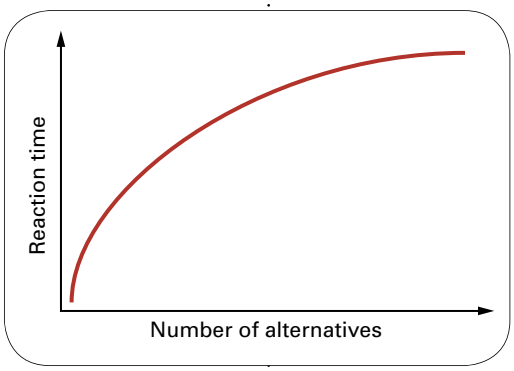

Figure 3.5
Hick's law: the relationship between reaction time and the number of possible responses

the number of stimulus-response alternatives and choice reaction time is called Hick's law (see figure 3.5). Put simply, the greater the number of choices, the slower the reaction time.

In the sporting context, delays in reaction time can severely inhibit performance. Take, for instance, the reaction times required to respond to a ball served as in figure 3.6. If the ball takes 565 m/s to travel from the server to the receiver, and the receiver takes 300 m/s to move to the ball, then they have only 265 m/s to react to the ball. This reduced reaction time may cause an error at best and a miss at worst. Thus, in ball-striking sports such as tennis, the receiver needs to initiate the required response *before* the ball passes the net. This relies heavily on two skills of the performer; namely, anticipation and selective attention.

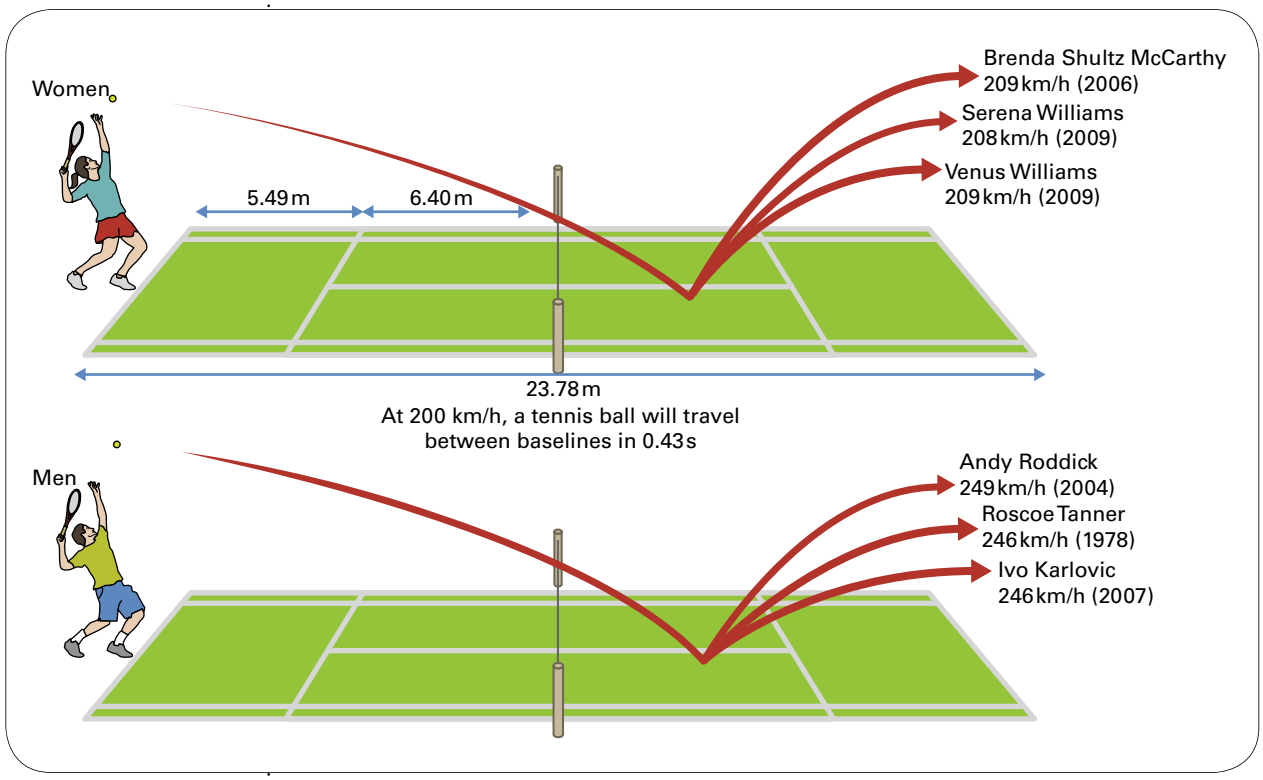

Figure 3.6
Velocities of tennis service

Anticipation

Anticipation is the process in which a subject prepares to initiate a particular response before the appearance of the signal. Anticipation is the ability to predict future events on the basis of early signals or past experiences. It relies on information from the senses. For example, if a tennis player sees their opponent start their stroke from underneath the ball, they might anticipate a topspin lob.

At the elite level of sport, researching your opponent's game play is integral to preparing for a match. For instance, a batter might anticipate a bouncer from the first ball of the over, as this has been the pattern of play observed of this bowler over a period of time. Kinaesthesis is also a means of

predicting what will happen. The 'feel' of a shot may indicate to a player that it was too long or too short. A player shooting in basketball may 'feel' that the released shot is too long and instinctively follow it in to retrieve the rebound.

How to reduce reaction time

Anticipation allows you to overcome some of the delay caused by reaction time. It has been shown that anticipation can be learnt. Performers can be taught to recognise traits in an opponent's responses that predict their next move. Experts are more able than novices to pick up anticipatory information from their opponent's movement patterns.

Video evidence is commonly studied to identify characteristics of an opponent's play that might help a player anticipate their opponent's next move. If you are trained to identify particular cues from an opponent, your response time will be much faster.

National teams usually have a statistician whose job it is to compile data on the frequency of particular moves or shots and their success rates. One of the aims of such analysis is to identify probable patterns of play.

As a player, you also need to think about how to stop the opposition from anticipating your next move. Cricketers and pitchers use this technique successfully when they change the speed of delivery of the ball and catch their opponent unaware. The ability to disguise critical cues, such as the bowler's action or the pitcher's grip, slows down the reaction time of opponents and provides a competitive advantage.

Learning experience

REACTION TIMES

Task

To calculate the reaction time.

Procedure

1. Draw a table in which to record your reaction times. Go to <www.humanbenchmark.com/tests/reactiontime/index.php> and take the test. Record your reaction times for 20 trials.
2. Graph the performance curve of your reaction time over 20 trials. Provide a description of the trend in the results. Suggest possible reasons for this trend and the factors that influence reaction time.

Factors influencing reaction time

Athletes with faster reaction times have an advantage over opponents. In ball sports, players with faster reaction times will have extra time in which to monitor the movements of other players or the flight of the ball before initiating an action. Several factors that influence reaction time are:

- age
- gender

- intensity of stimulus
- signal detection
- previous experience
- selective attention
- the psychological refractory period
- stimulus–response compatibility.

Age

Reaction time decreases with age. The reaction time of 5-year-olds is almost twice as long as that of 24-year-olds. The difference is attributed to learning and experience. However, reaction times start to increase again from the early twenties and keep increasing as people age.

Intensity of stimulus

The intensity of a stimulus refers to the ability of the senses to detect it. It is easier to detect a loud noise than a very soft noise. As the intensity of a stimulus increases, there is a corresponding decrease in the reaction time. For example, a performer takes a shorter time to react to bright colours than to less intense colours.

Signal detection is the ability to determine whether or not a signal (stimulus or cue) is present. For example, a batter must decide whether there is spin on the ball before deciding how to play the shot. The ability of the senses to receive a signal or stimulus depends on the intensity of the signal or stimulus and the effectiveness of the senses. For a performer to be able to sense a stimulus, it must first be within the range of one or more of the human senses. Humans are unable to sense many stimuli, e.g. some lights are too dim, some sounds too high or low, and some contact too light to be felt by skin receptors.

Some stimuli are more easily detected than others:

- A large object is seen more easily than a small one.
- An object that has a contrasting colour to its background is easier to see.
- Irregular displays are more easily seen than regular displays, e.g. a blinking light is seen more easily than a constant light.

Predictable signals, such as a server who always serves to the forehand, require little processing space and responses seem almost automatic. Conversely, highly unpredictable signals, such as spin of the ball off the pitch, demand a lot of processing capacity and attention. In most sports, visual cues take up the majority of the information-processing capacity. This includes tracking of the trajectory of the ball as well as the movement of players.

The trialling of fluorescent pink cricket balls by Cricket Australia in Sheffield Shield matches held at night is a step towards selecting a ball that players, spectators and television audiences can all see clearly. Discolouration of the white ball has been a perennial problem and using a ball of a different colour may offer a solution. Yellow and orange balls have been trialled unsuccessfully in the past, and the white balls used in one-day internationals are replaced after only 35 overs. The trials of different coloured balls will continue until a preferred colour is found. However, there may have to be a compromise between a ball that can be seen easily by the batsman and a ball that can be viewed easily on television.

The functioning of the sense organs cannot be improved with practice. However, practice can make you aware of your sensory capabilities. Peripheral vision can be improved with training. Beginners have very little peripheral vision in the early stages of learning a new skill.

To train peripheral vision hold a ruler in front of you at arm's length and at eye level (see figure 3.7.) On the top of the ruler write a letter, e.g. 'H'. Keeping your head still, close one eye and stare at the letter with the other eye. Move the ruler slowly from side to side and follow the letter without moving your head or eye.

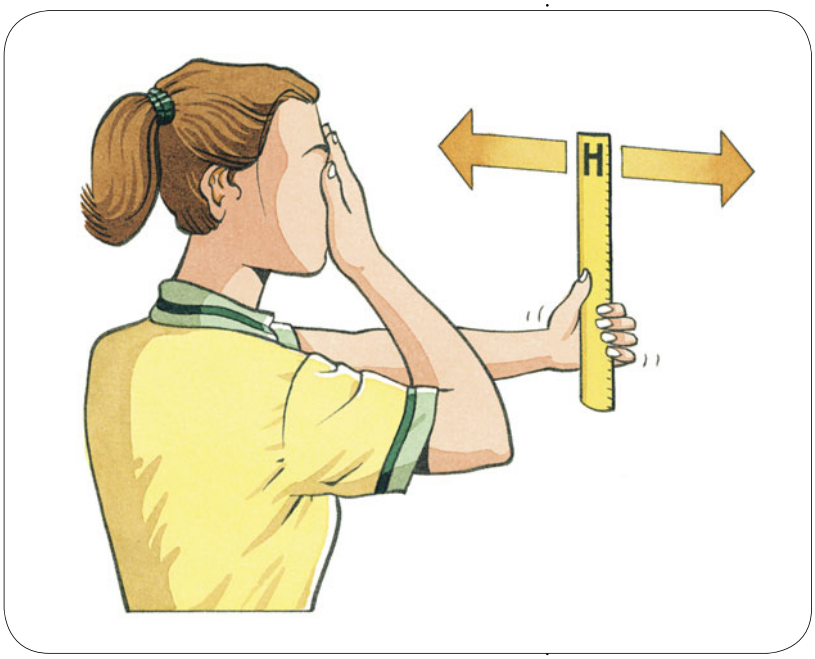

Figure 3.7
Testing peripheral vision

Eye dominance

Eye dominance is the visual equivalent of handedness. Just as people are right handed or left handed, individuals are also right-eye or left-eye dominant. Eye dominance controls many important visual motor functions, including the ability to aim, which, although it can be affected by both eyes, is predominantly controlled by the dominant eye. The dominant eye will direct the focus of attention towards external stimuli, such as the oncoming ball or the movement of the opponent. This suggests that the dominant eye should play a significant role in the development of sport skills, from aiming tasks, such as archery and golf-putting, to faster-paced sports, such as tennis and soccer.

The majority of individuals are pure **dextrals**—i.e. right-eye dominant and right handed.

Dextral pertains to the right hand side of the body.

The assessment of eye dominance is very simple. First, with the palms facing down on a table, place one hand on top of the other so that the fingers of one lie at a 90-degree angle to the fingers of the other, while the thumbs overlap. This will create a triangular space bounded by the thumbs at the bottom and the rest of the hands on the sides. Adjust the spacing so that the triangle has approximately 3 cm sides. Then, with outstretched arms and both eyes open, site a target approximately 7 metres away through the triangular space in your hands. The target must be small enough to fit into the space. Now close your right eye. If the target disappears, you are right-eye dominant. Conversely, if you close your left eye and the target disappears, you are left-eye dominant.

The application of knowledge of eye dominance to practice is important when learning physical skills. Activities that involve aiming, such as archery, require the dominant eye to be the main controller of the line of sight. Similarly, when putting in golf, it is important to know whether to look over the ball or between the ball and the feet in order to align the putting line with the line of sight of the dominant eye.

The technique in softball batting and tennis forehand skills too can be adapted to a more open stance, to ensure that the dominant eye is not obstructed.

Visual training may assist players to improve their ability to detect visual cues. To be able to scan the play for movement cues, try performing a training session

in total silence. This removes the auditory senses as a means of communication and focuses attention on the sense of vision. By overloading the visual senses the player has to scan the play more to receive cues from fellow players and position themselves so they can be seen. The dominant eye will fix the focus of attention on the external stimuli, such as the approaching ball or fellow players.

Visual occlusion training is a method of training an athlete's visual ability to detect cues. It involves blocking the pertinent visual stimuli in order to identify key performance cues.

Selective attention is the ability to filter out irrelevant background information.

Visual occlusion training involves the occluding or blocking of visual stimuli in order for the player to identify key performance cues from an opponent. Figure 3.8 demonstrates the key performance cues of a volleyball skill. From this information can you predict the type of serve that will follow?

Figure 3.8
Visual occlusion training allows for the detection of cues that enable anticipation of the movement outcome.

Figure 3.9
Brisbane Lions' player Brendan Fevola using selective attention to block out the roar of the crowd and the movements of the players around him

Selective attention

Our senses are continually bombarded with stimuli, but we do not pay attention to all of them. For example, while you are working or listening in class, birds might be twittering outside, cars might be passing by. Your sense of hearing may have detected them, but you were unaware of them. The ability to filter out irrelevant background information (e.g. background noise) and attend to only relevant stimuli is called **selective attention**. It effectively reduces the number of incoming stimuli that need to be processed and so reduces processing time. A higher level of arousal means that a performer is more responsive to stimuli and more alert.

A coach can improve a player's selective attention by:

- making the relevant stimuli stand out (e.g. using a white cricket ball instead of a red one)
- using language suited to the level of the learner
- including as few relevant cues as possible in initial practice
- directing a player's attention to performance cues (e.g. 'watch the bowler's hand')
- basing explanations on the past experience of players.

The psychological refractory period

Our information-processing system can only deal with one piece of information at a time, which can take up to 0.5 seconds. If a second stimulus is presented before the first has been processed, the second waits

in line. The reaction to the second stimulus is therefore delayed. This delay is called the **psychological refractory period**.

Focusing on multiple tasks at a time can have a marked decline in performance.

The results of studies have indicated that to be most effective, the second stimulus must be presented within 0.05 seconds after the first. When players baulk or fake a pass they are attempting to get their opponents to respond to this movement and so delay their ability to respond to the actual movement. Examples include a 'dummy pass' in football or a fake hit in volleyball.

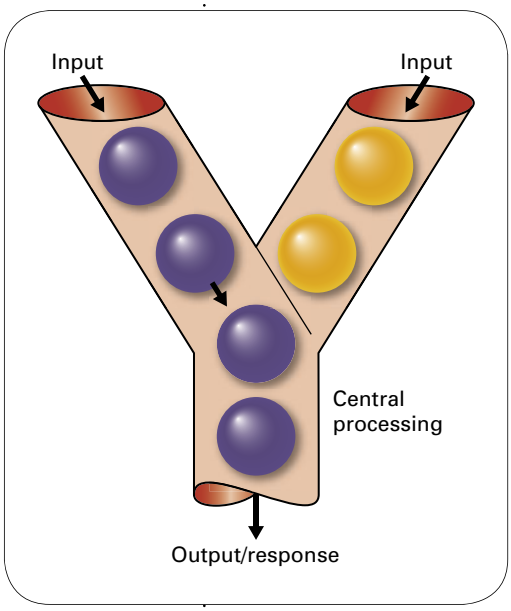

Figure 3.10 Incoming signals from a variety of sources line up for processing one at a time

The **psychological refractory period** is the delay in processing a signal while the preceding signal is processed.

Stimulus–response compatibility is the degree of correspondence between a stimulus and its correct response.

Stimulus–response compatibility

Stimulus–response compatibility is the degree of correspondence between a stimulus and its correct response. The greater the compatibility, the shorter the reaction time.

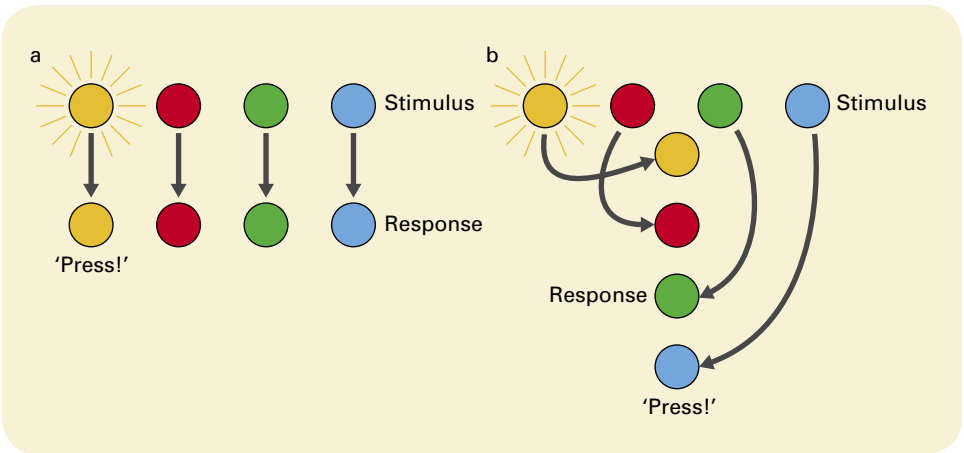

Figure 3.11 Stimulus–response compatibility: (a) a compatible situation and (b) a less compatible one

Learning experience

DROP CATCH

Hypothesis

That reaction time is increased when correspondence between stimulus and response is low.

Task

If the response is compatible with the action, then your reaction time will decrease. However, if the response is not compatible with the action, then reaction time will be increased. As an example, perform a drill called 'Drop Catch'. The coach throws the ball to players standing in a line in quick succession saying either 'drop' or 'catch' on each throw. 'Drop' means the players have to catch the ball, and 'catch' means the players have to let the ball drop to the ground. Try it and see how your response times are affected by stimulus–response incompatibility!

Learning experience

RESEARCH REPORT: SIMPLE REACTION TIME

Hypotheses

1 That simple reaction time improves with practice.
2 That simple reaction time of males and females differs for the same task.

Materials

- metre rulers

Subjects

Do this experiment in pairs.

Procedure

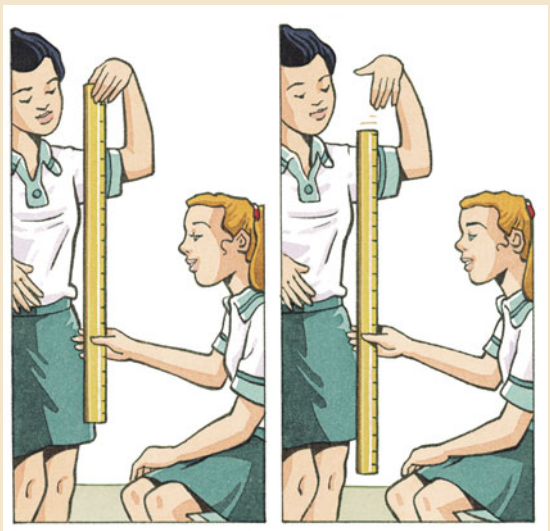

Figure 3.12
Measuring simple reaction time

1 Your partner sits with their dominant arm resting on a desk. The person's arm should extend beyond the desk from a point halfway between the wrist and the elbow (see figure 3.12).
2 Hold the metre rule at the upper end (the 100 cm end) with one hand. (The test will work best if you have a steady hand.) Let the ruler dangle between your partner's slightly separated thumb and index finger, as shown in figure 3.12. Your partner should not be touching the ruler at this time.
3 Line up the 20 cm mark on the ruler to correspond with the top of your partner's thumb.
4 Instruct your partner to concentrate on the 30 cm mark on the ruler. You are going to drop the rule, and your partner must try to catch it between the thumb and forefinger on the 30 cm mark. After catching the ruler, they must hold on until you have recorded the result.
5 Release the ruler without warning. Count the exact number of centimetres above the 20 cm mark up to the upper edge of your partner's thumb.
6 Repeat this five times and then calculate the average score for the five trials.
7 Use figure 3.13 to calculate your partner's approximate visual reaction time.

Conclusions

Pool your results with those of the rest of the class and then discuss them with respect to the two hypotheses.

>>

Distance of fall (cm)	Time of fall (s)	Distance of fall (cm)	Time of fall (s)
1	0.045	31	0.252
2	0.064	32	0.256
3	0.078	33	0.259
4	0.090	34	0.263
5	0.101	35	0.267
6	0.110	36	0.271
7	0.120	37	0.275
8	0.128	38	0.279
9	0.136	39	0.282
10	0.143	40	0.286
11	0.150	41	0.289
12	0.157	42	0.293
13	0.163	43	0.296
14	0.169	44	0.300
15	0.175	45	0.303
16	0.181	46	0.306
17	0.186	47	0.310
18	0.192	48	0.313
19	0.197	49	0.316
20	0.202	50	0.319
21	0.207	51	0.322
22	0.212	52	0.326
23	0.217	53	0.329
24	0.221	54	0.332
25	0.226	55	0.335
26	0.230	56	0.338
27	0.235	57	0.341
28	0.239	58	0.344
29	0.243	59	0.346
30	0.247	60	0.349

Figure 3.13
The time an object takes to fall a certain distance

Learning experience

ASSIGNMENT: TYPES OF CUES

Select one sporting example for each of the categories of activity in the table below. Choose a skill for each activity and list the cues (internal or external) that you would concentrate on to improve your performance. An example has been provided for category 2. You should add your own example here as well.

Category of activity	Example	Specific skill	Cues
1 Direct interceptive			
2 Indirect interceptive	Tennis	Receiving serve	Quick feet
3 Performance			
4 Aesthetic			

Learning experience

RESEARCH REPORT: IDENTIFYING CUES

Hypothesis

The earlier the relevant signals are detected, the better the athletic performance.

Equipment

- volleyballs
- volleyball net
- sheet to cover net

Subjects

This activity is done in teams of three.

Procedure

1. Set up the volleyball court as normal. Hang a cover over the entire width of the net, preferably extending right down to the ground and to the sidelines, so that the players receiving serve cannot see the other side of the court or the players serving to them.
2. Three players take up receiving positions on one side of the court. Another three position themselves in preparation for service behind the baseline at the opposite end of court.
3. The servers take turns to serve a total of 12 balls. The receivers use a dig pass to a fellow team member who catches the ball.
4. Record the number of successful returns of the serve, i.e. the number of times a team member successfully catches the ball.
5. The two teams swap positions.
6. Take the cover off the net and repeat the procedure.

Results

Compare the numbers of successful returns of serves when the net was covered and when it was uncovered.

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Conclusions

1 Was the success rate greater when the net was covered or uncovered?
2 Which cues assisted in the reception of service when the net was covered?
3 Which cues assisted in the reception of service when the net was uncovered?
4 What effect does early detection of the ball have on performance?

Variation

1 Place a cover over only half of the net (on the left side or right side of court).
2 Have six players in a normal rotation on one side of court.
3 Have the setter set balls to hitters waiting behind the screened side of court.
4 The receivers report on the cues that they felt were important in detecting to where the ball would be hit.

Learning experience

PHYSICAL TASK: SIGNAL DETECTION AND BACKGROUND

Hypothesis

That background colour influences detection of a visual signal.

Materials

- tennis racquets
- tennis balls whose colour blends with that of the court (e.g. green on a grass court)
- tennis balls whose colour contrasts with that of the court (e.g. white or yellow on a grass court)

Procedure

Play two games of tennis, one using the balls of a colour that blends with that of the court, and one using the balls of a contrasting colour.

Results

In which game did the players perform better?

Conclusions

1 How did the colour of the balls affect performance?
2 What implications do your findings have in relation to the design of sports equipment?

Learning experience

PHYSICAL TASK: INFORMATION PROCESSING AND PAST EXPERIENCE

1 In volleyball in the late 1960s and early 1970s, the Japanese introduced a unique method of attack in the front court. Instead of simply spiking high balls from positions 2 or 4, they varied the height and position of the set. From an information-processing point of view, how did this change in play limit an opponent's ability to anticipate a particular form of attack?
2 Devise your own attacking play in volleyball that:
   a presents your opponents with two or more cues in quick succession
   b is what the opponent least expects and so slows down their reaction time.

>>

3 Videotape a volleyball game played by other members of the class.
4 Play back the tape and identify cues that indicate a player's intentions so that you can better predict their next move.
5 Return to the court and play a second set of volleyball, paying particular attention to the cues identified earlier on video.
6 Report on the effectiveness of using video footage in learning how to anticipate an opponent's game play.

Learning experience

RESEARCH REPORT: THE EFFECT OF THE INTENSITY OF A SIGNAL ON ITS DETECTION

Hypothesis
That the colour and size of a ball influences visual acuity.

Materials
- balls of different sizes and colours

Subjects
This activity is done in pairs.

Procedure
1 Partner A is positioned on the baseline of the volleyball court, lying face down with their feet nearest to the net.
2 Partner B is standing on the attack line on the opposite side of the net with an assortment of balls.
3 Partner B selects a ball to throw once partner A is lying face down.
4 Partner B throws the ball high over the net, calling out partner A's name. The throw must be high enough to give A time to hear their name, get up, and run and catch the ball.
5 Repeat the task twice, giving partner A less and less time to receive the ball.

Conclusions
1 Which type of ball did the receiver have most difficulty in perceiving?
2 Was the size of the ball or the colour more important in distinguishing it from its background?
3 List some specific sports skills that would benefit from using this type of exercise as a visual training program. Give reasons for your answers.

Feedback and learning

Feedback is all the information that an athlete receives about the performance of a skill, either during the performance or at its completion. There are two major categories of feedback, intrinsic and extrinsic (see figure 3.14). Many research studies have been conducted to determine how feedback influences the learning of motor skills. All confirm that feedback is integral to the learning process.

Intrinsic feedback is information that comes from the senses both during and after a movement pattern.

Intrinsic feedback is the sensory information that results from a movement pattern. The information primarily comes from the senses within

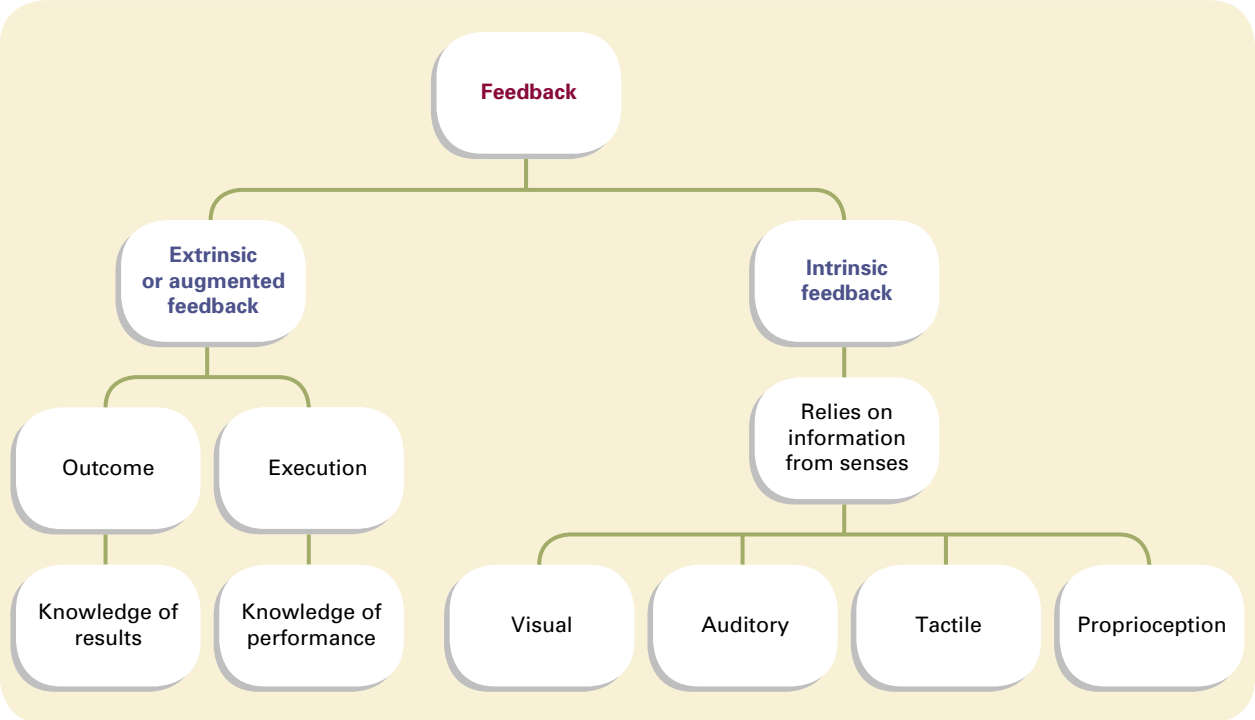

Figure 3.14 Types of feedback

the muscles, joints and from the movement itself. This information sent from within the body is called proprioception. When you pick up an object that you think is a lot heavier than it actually is, the resulting movement is over-exaggerated. The proprioception of the movement immediately indicates the error.

Extrinsic (augmented) feedback is the feedback that results at the completion of the movement. It is also called augmented feedback. It is feedback that is received from an external source and is divided into two main categories: **knowledge of results** and **knowledge of performance**.

Extrinsic (augmented) feedback is feedback that is received at the completion of a movement. It is divided into knowledge of results and knowledge of performance.

Knowledge of results is a form of extrinsic feedback that indicates the outcome of the performance (e.g. 5.6 m in long jump) rather than the movements that brought about the performance.

Knowledge of performance is a form of extrinsic feedback (usually verbal) that indicates the technical correctness or quality of the movement. It may include identification of the parts of the skill that were performed correctly or incorrectly.

Figure 3.15 The difference between knowledge of results and knowledge of performance

Skill	Knowledge of results	Knowledge of performance
Long jump	The distance covered was 4 m.	There was not enough drive from the take-off foot.
Tennis	The ball landed out.	The racquet face was too open.

Knowledge of results is the feedback received from an external source (e.g. a teacher, coach, a video). It usually comes in the form of verbal feedback indicating information about the degree of success of the movement and could, for example, be a score out of 10 for a gymnastics routine.

Knowledge of performance is feedback that indicates the quality or technical correctness of a movement. Coaches use this form of feedback more frequently, and examples include 'ball contact was too late' or 'take-off stride was too long'.

Figure 3.16
An athlete receiving immediate knowledge of her performance by viewing delayed video footage of it.

Feedback and performance

The type of feedback a performer receives can have a significant impact on their motivation. Feedback that is positive, contains instructional information and is timed to closely follow the performance is reported to develop intrinsic motivation. Motivating feedback includes information that alerts a performer to their progress towards short- and long-term goals.

Reinforcement can be both positive and negative. **Positive reinforcement** is one of the major aims of feedback. Positive reinforcement immediately after an athlete has performed will encourage the athlete to repeat the performance. It results in consistent and beneficial changes in behaviour.

Negative reinforcement is behaviour that increases as a result of a negative reinforcer being removed. An example of negative reinforcement is studying for an exam so that you don't fail. The low grade is the negative reinforcer for studying harder. Another example is performing a tighter tuck in diving in order to ensure that the landing is vertical so as to avoid the pain of a poor entry.

Punishment is the opposite of reinforcement—i.e. it aims to reduce the likelihood of a response occurring again. For example, having to do

Positive reinforcement is an increase in the future frequency of a behaviour due to the *addition* of a stimulus immediately following a response.

Negative reinforcement is an increase in the future frequency of a behaviour when the consequence is the *removal* of an aversive stimulus.

Punishment is a term used in behavioural psychology to describe the process of adding a negative consequence to a behaviour in order to extinguish that behaviour.

20 push-ups if you are late for training tries to eliminate the behaviour of being late. Punishment informs the performer of what *isn't* required but doesn't provide a way of achieving a desirable outcome. Therefore, punishment and negative reinforcement are not effective as means of feedback in achieving performance improvements.

Learning experience

FEEDBACK AND PERFORMANCE

Timing of feedback is an important consideration. Feedback that is provided in a timely manner after completion of the performance has been found to be more beneficial than delayed feedback.

Task
To draw a straight line 7 cm long.

Trials
10 trials in total

Procedure

1 Work in two groups. One group will be the subjects and attempt to draw lines 7 cm long without using a ruler. The other group will be divided into four groups, each doing one of the following:
   - Provide no knowledge of results—Provide only positive reinforcement.
   - Provide detailed knowledge of results—Tell the subject the exact length of each line.
   - Provide limited knowledge of results—Tell subject 'right' or 'wrong' after each trial ('right'= within +/–1 cm).
   - Provide irrelevant knowledge of results—Provide the same feedback on every trial regardless of the line length that is drawn.
2 Pair each subject with a student taking on one of the four roles. The results of each trial must be recorded without showing the subject. A total of 10 trials are to be recorded.
3 Provide the statistics in a spreadsheet and then plot a graph that records the length of each of the 10 trials as an error in mm. Compare the results of all subjects using the four different knowledge of results as different keys. Draw conclusions as to the trends identified and the impact that different knowledge of results had on performance.

Feedback needs to be timely and specific

The more precise the knowledge of results or knowledge of performance, the more accurate the performance will become. There is a fine line between providing too much feedback, especially to novices, and providing too little feedback. Read the article 'Building the feedback sandwich' for further details on the aims of feedback.

Verbal feedback such as 'Well done' contributes to intrinsic motivation but could be more effective by being specific: 'Well done—you drove your arms hard out of the blocks'.

Building the feedback sandwich

What is feedback?

Feedback is one of the coach's most powerful coaching tools, yet only about 2–3 per cent of class time is spent giving feedback to athletes. Feedback is the information an athlete receives from his or her own body and from other people about his or her performance. The value of intrinsic feedback (the athlete's own 'feel' of the performance) is often underestimated. A good coach will encourage his or her athletes to reflect on their own performance before providing extrinsic feedback.

The feedback the coach provides can take two forms. General feedback, such as 'Well done Sally!', helps to motivate the athlete but does not provide any information on how he or she performed.

Specific feedback, on the other hand, provides athletes with information that will help them understand what they have done and how they can improve. For example, 'Sally, your elbows are still lower than your hands when you're doing freestyle. You need to lift your elbows higher, so they are pointing to the roof.'

The feedback sandwich

To be effective, coaches should combine both general and specific feedback into a 'feedback sandwich'.

Start with some general feedback to get the athlete's attention, then add some 'meat' to the sandwich by giving him or her some information on how to improve performance.

Finally, top the sandwich off with some more general feedback, which will encourage the athlete to try again. For example:

- 'That's much better, Monica!' (general feedback)
- 'You only just missed it then. Your right hand needs to support the ball on the side first, then as you're shooting, it can help guide the ball to the target.' (specific feedback)
- 'Let's see if you can get it in this time.' (general feedback)

Why give feedback?

Giving an athlete feedback on performance is very important. Feedback can be given:

- as reinforcement: it can cause athletes to repeat (or diminish) a behaviour or movement pattern.
  Example: 'Simone, that was much better! You held your wrist firm right through the stroke and the ball went exactly where you wanted. Well done!'
- to provide information: so that the athlete is more independent of your support and is better able to do the task next time.
  Example: 'John, I think you'd find it easier if you left your run into the centre till a little bit later. That way the others will have cleared the area and you will have more room to move. OK?'
- to motivate: framing feedback in a positive way can encourage your athletes to try harder next time.
  Example: 'Lennie, you threw your arms up high and got two more centimetres on that jump—that's great! Let's see if you can improve another two on this one.'

Tips on giving feedback

- Be specific: give athletes the information they need to improve their performance.
  Example: 'Alex, your foot is pointing too far to the left. Move your toes a couple of centimetres this way so they point in the direction you want the ball to go … That's it!'
- Be positive: try to comment on something the athlete has done well first. Then, if you need to correct something, clearly explain how it should be done without harping on what was done wrong.
  Example: 'Bill, the ball toss was great—it was in just the right spot. Now let's see you reaching up to hit the ball with your whole body fully stretched.'
- Don't overload the athlete with information: try to keep your comments clear, concise and simple. Focus on one correction at a time, or the athlete won't be able to remember everything you've said.
- Give feedback promptly after performance but don't forget to give the athlete the time and the opportunity to reflect on how it felt first.
  Example: 'How did that feel Nici? Was it easier to throw the ball? Don't forget, you need to follow through all the way with your arm.'

Try to give both individual and group feedback: in that way you won't be 'picking' on one athlete all the time. Try bringing the whole group together; share the feedback with everyone occasionally.
Example: 'Okay, gather round. That was looking much better, team. The chest passes were much stronger and you were starting to look for each other. Remember to flick the wrist down hard towards the floor when you're bounce passing—that will make the passes a lot snappier. Let's do another 10 good passes each—off you go!'

Remember: feedback should be:

- S: Specific
- P: Positive
- I: Informative
- C: Concise
- C: Clear.

Source: Rebecca Layton, *Aussie Sports Action*

Types of feedback

Verbal feedback is probably the most commonly used form of feedback by coaches. Feedback can also be nonverbal, such as hand signals, body posture, pats on the back, a smile or signals. Video feedback has quickly become a mainstream form of feedback in sport. Video replays of a performer's skill provides visual feedback rather than verbal feedback. The provision of feedback contributes to the growing neural connections that are established and improves the ability of a performer to process information.

Figure 3.17 Verbal feedback by coaches is often accompanied by nonverbal feedback such as hand signals.

The provision of video feedback should be incorporated regularly into training sessions and not just at the start. The extent of time a performer is exposed to visual feedback allows for changes in performance to be enacted and recognised. Guidance must accompany the use of video feedback. Knowing what to look for is just as important as simply seeing the movement again. The coach or teacher needs to identify critical aspects of the skill and break it down into component parts. The performer must also have a clear image in their mind of what an exemplary performance looks like against which they can compare their own performance. Figure 3.18 offers a sample of a breakdown of the subroutines in long jump.

Illustration	Teaching cues/points	☹	☺	😐
		No, not really	Yes, pretty much	Not sure
	• **Tall running** • **Speed**	_____ _____	_____ _____	_____ _____
	• **Drive knee powerfully** • **Drive arm** • **Body upright** • **Plant take-off foot**	_____ _____ _____ _____	_____ _____ _____ _____	_____ _____ _____ _____
	• **Body upright** • **Head up** • **Knee high** • **Arms above head**	_____ _____ _____ _____	_____ _____ _____ _____	_____ _____ _____ _____
	• **Lever action off board** • **Arms pull through** • **Head remains up** • **Legs out in front** • **Heel strikes ground before body comes over**	_____ _____ _____ _____ _____	_____ _____ _____ _____ _____	_____ _____ _____ _____ _____

Figure 3.18
Key subroutines in skills can be used to assist in the analysis of the movement

Chapter review

Processing information, reaction time and feedback

Know

1. Which sensory reaction time to a stimulus is faster, visual or auditory?
2. Explain the difference between simple reaction time and complex reaction time.
3. Differentiate between knowledge of performance and knowledge of results.
4. What are two types of external feedback?
5. Explain the difference between internal and external feedback.

Comprehend

6. During a basketball match you have received the ball and dribbled to the three-point line. You need to decide whether to shoot, continue dribbling or pass. Identify relevant cues from fellow players and opponents that will assist you in making your decision. In what ways would an experienced player have an advantage over a beginner in selecting a course of action?
7. It is a given that the provision of feedback leads to learning. Can you provide instances when feedback could be detrimental to performance?
8. Movement time is a subcomponent of reaction time. Explain.

Apply

9. Use figure 3.17 as a template for completing the subroutines for a skill you are learning.
10. What component of skill acquisition are you developing when a player varies the setting position for attack in volleyball?
11. Having identified your eye dominance, explain the impact this knowledge has on performance in ball sports and sports that require the skill of aiming.
12. Visual training relies on a player's ability to recognise their opponent's visual cues. Outline specific methods for enhancing visual training in a given sport.

Analyse
Evaluate
Synthesise

13. The discovery that the brain is not 'hardwired' from birth, but holds an ability to change, is the area of research called 'neuroplasticity'. 'Neuro' is for 'neuron', the nerve cells, and 'plastic' is for 'changeable, malleable, modifiable'. It is a relatively recent research area that identifies the brain's ability to change with learning, memory and experience. An expert in the field of neuroplasticity is Dr Norman Doige whose book *The Brain that Changes Itself* provides an insight into this new frontier in science. Research the connection between learning about neuroplasticity and learning to improve skills in sport.

Psychology

HOW CAN AN UNDERSTANDING OF PSYCHOLOGY THEORY INFLUENCE PARTICIPATION IN, LEARNING OF AND PERFORMANCE IN PHYSICAL ACTIVITIES?

chapter 4

Performance-enhancing psychological skills

Sport psychology

As early as 1913 a **sport psychology** congress in Switzerland discussed the personal accounts of athletes and how **psychology** influenced performance in sport. In 1928, Pierre de Courbetin, who was responsible for the modern Olympic Games, influenced the sports medicine organisation to include the study of psychological aspects of sport. Over the decades, coaches have implemented different strategies in an effort to enhance an athlete's performance. In 1957, Australian swim coach Forbes Carlisle introduced his swimmers to hypnosis, and American baseball teams underwent relaxation training. Today, mental skills training is commonplace in all Australian representative teams, with the AIS employing five full-time sport psychologists to administer psychological skills training across 26 sports.

Performers at all skill levels can benefit from a basic understanding of sport psychology. According to sport psychologist Dr James E Loehr, 'At least 50% of the process of playing well is a result of mental and psychological factors'. Knowledge of sport psychology can help with:

- performance enhancement through mental skills training (e.g. goal setting, imagery and confidence)
- anxiety management and relaxation
- concentration and mental preparation
- arousal management
- team building and leadership
- post-performance debriefing
- injury rehabilitation.

There is a range of psychological skills that can help athletes improve performance. Like physical skills, psychological skills must be practised through regular inclusion in training and competition. This and subsequent chapters identify a range of mental skills and how they can be applied to your performance schedule. The following mental skills are at the core of sport psychology:

- imagery
- concentration
- motivation
- self-talk and flow
- performance routines

Sport psychology is the study of the psychological and mental factors that influence and are influenced by participation and performance in sport, exercise and physical activity.

Psychology is the study of the human mind and mental states.

- simulation training
- arousal and relaxation training
- goal setting
- team dynamics
- feedback mechanisms
- self-determination theory
- psychology of injury.

Imagery

Imagery is one of the most important psychological skills. Sport psychologist John Silva defines imagery as 'using all the senses to re-create or create an experience in the mind'. Imagery is sometimes also referred to as 'visualisation', 'mental practice' or 'mental rehearsal'.

Imagery is a psychological term that uses all the senses to re-create or create an experience in the mind.

Imagery is based on the idea that:

1 an image can be created in the mind without an external stimulus
2 the image may involve one or more of the senses
3 an image is created from information stored in the memory.

In imagery, you imagine the skill being performed without moving a muscle. This imagery creates a muscle memory within the muscular and nervous systems of how to do the skill.

There are two main ways of viewing the image: internally or externally. The internal view sees the performance from the perspective of the athlete's eyes, i.e. actually being in the race. The external perspective sees the athlete as though viewing a video of themself in performance. Either imagery view is acceptable, and some athletes have a preference for alternating between the two perspectives. As well as using the visual senses, it is important to combine the use of all senses—tactile, olfactory, auditory and kinaesthetic. This could include the smell of the stadium, the noise of the crowd, or the feel of the blocks under your feet.

Figure 4.1
An athlete practises imagery before performing.

Learning experience

IMAGERY SKILL

1 Have a clear image of the skill in your mind and ensure the image is technically correct. You might need to view a video of an elite proponent of the skill to do this.
The more skilful and experienced the athlete, the more they will be able to gain from this form of mental practice.
2 It is important to have an image of the entire skill. For instance, it would be more of a hindrance than a help to recall the take-off phase of the volleyball spike without including the spike itself.
3 You need to be in a relaxed state when putting this mental skill into practice. For maximum benefit, find a quiet environment away from outside distractions.
4 The image created in your mind must depict the desired outcome of performing the skill, e.g. scoring two points from the free-throw line or finishing in a personal best time.

SNAPSHOT

How can simply thinking about skiing downhill actually assist athletes to achieve this skill?

When you vividly imagine performing a skill, you use the same neural pathways you use when actually performing the movement. This is called the **psychoneuromuscular theory**. A research study of downhill skiers monitored the electrical activity of skiers' leg muscles while they imagined skiing a particular downhill course. The findings showed that the electrical impulses were strongest in the roughest section of the course, which, it could be hypothesised, would be the most demanding.

Psychoneuromuscular theory proposes that by imagining performing a skill an athlete stimulates the same neural pathways as when actually performing the movement.

Figure 4.2
A downhill skier

Concentration

Concentration is the ability to maintain attentional focus to relevant environmental cues.

How often have you heard coaches say, 'Concentrate on what you are doing'? This is only useful to athletes if they know what they should be concentrating on. **Concentration** is a broad term that means the ability to maintain attentional focus to relevant environmental cues. You commonly hear athletes

recall how 'focused' they were in competition. Some sports such as hockey, tennis and football require lengthy periods of concentration, whereas other sports such as sprints, archery and golf require brief periods of intense concentration.

Concentration is also the ability to rapidly change attentional focus to meet the environmental demands. Most team sports would require athletes to be able to change their attentional focus during competition.

Robert Nideffer's background in diving led to his interest in research in predicting and controlling behaviour. In turn, this research led to the development of a model of attention.

This model (see figure 4.3) identified two dimensions of concentration: width (broad or narrow) and direction (external or internal). The width of an athlete's attention can extend along a continuum from a single cue to numerous cues. The direction of attention can also extend between internal (thoughts, feelings) and external (opponent, ball). The combination of width and direction leads to four different categories.

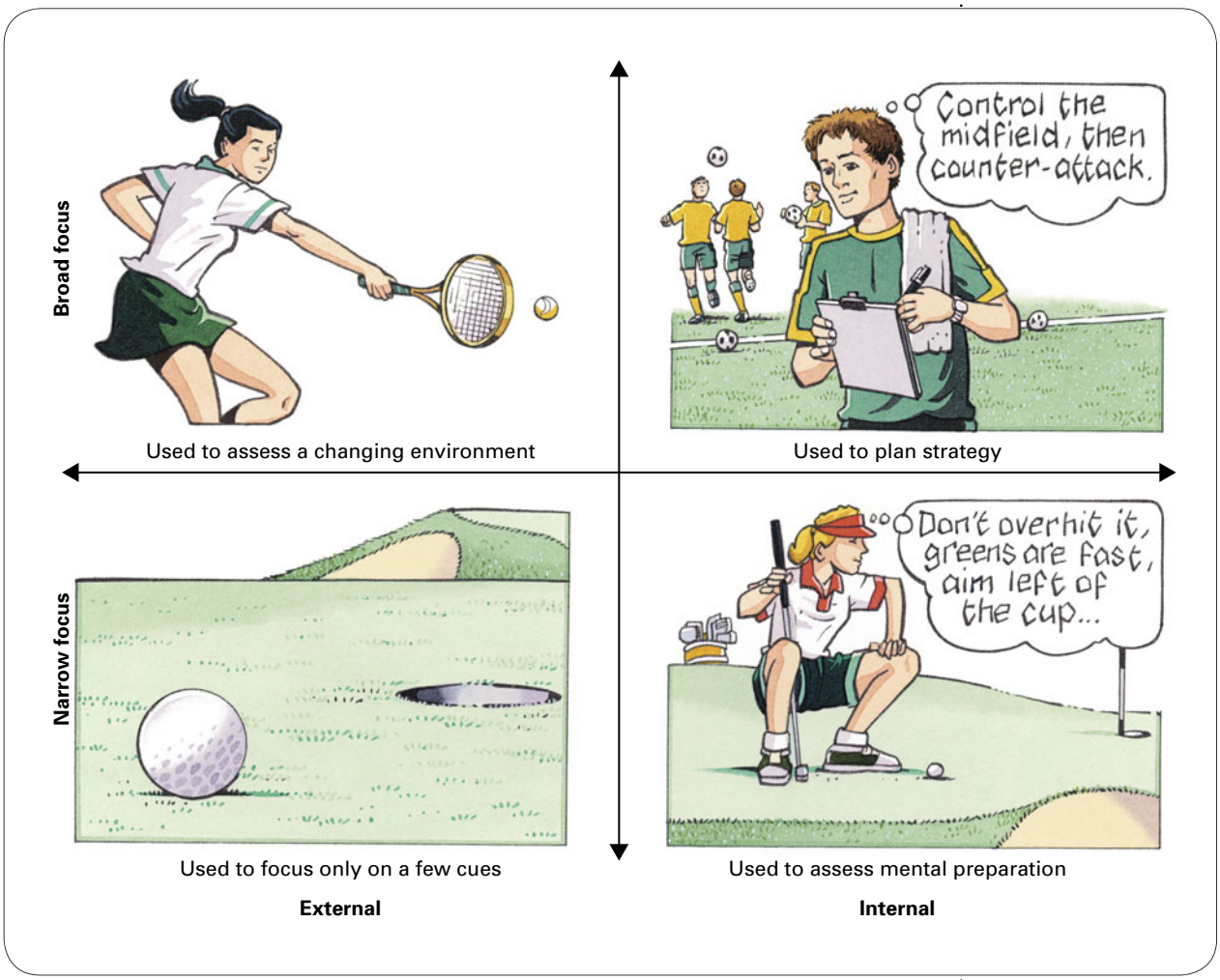

Figure 4.3
Nideffer's model of attentional focus

A person with a broad attentional focus can attend to several cues at once. This is important in sports in which the environment changes rapidly, such as soccer or netball. A striker in soccer or the centre position in netball are two players who would benefit from a broad attentional focus. A person with

a narrow attentional focus can respond to one or two cues, e.g. a golfer teeing off or a basketballer taking a free throw.

An external attentional focus draws attention outwardly to the environment or an object, such as where opponents are positioned on the field or the flight of the pitch in softball. An internal attentional focus is directed inwardly to feelings and thoughts, such as those of a marathon runner during the latter stages of a race. Read the following article, 'Internal or external? For Jonny, Doris holds the key', to gain a better understanding of attentional focus.

Internal or external? For Jonny, Doris holds the key

DAMIAN FARROW AND JUSTIN KEMP

Weighing up the best method for completing a skill is a matter of focus, say Damian Farrow and Justin Kemp. What goes through the minds of players as they prepare to execute a skill that has been practised many times before?

When standing with the ball in hands, 40 metres out directly in front of goal, what do Matthew Lloyd and Jade Rawlings think about? Is it how they should guide the ball on to their boot? Or the kick's outcome? Lloyd's goalkicking success rate of 73 per cent, relative to Rawlings' 51 per cent, would suggest there are certainly differences.

Can goalkicking success rates be related to what players focus their attention on as they execute the kick? A flurry of sports science research over the past decade has tried to address this issue by examining what is the optimal strategy for focusing the attention of athletes as they practise and perform the skills of their sport.

Essentially, two types of attentional focus have been examined. An internal focus of attention is said to occur if the player's attention is directed to his or her body movements, such as focusing on guiding the ball on to the boot when kicking. Attention directed to the effect of the movement, such as the flight of the football, is termed an external focus.

The typical finding to emerge from these attentional focus comparisons is that the learning and subsequent performance of a skill is superior if the player has adopted an external focus of attention.

For example, one such experiment that examined the learning of a golf chip found that players who focused on the movement of the club head during the swing performed more skilfully than those who focused on their arms during the swing.

The logic behind the use of an external focus of attention approach relates to the old coaching chestnut 'paralysis by analysis'. Because of the amount of practice elite athletes have devoted to their skills, they generally can perform the skill automatically without conscious effort.

To introduce an internal focus of attention strategy that forces the player to focus directly on the movement disrupts their normal unconscious skill processing. A similar explanation has been forwarded as a reason for players choking under pressure—conscious thought about a movement turns the muscle memory of an elite performer into that of a novice.

Interestingly, when a player is kicking poorly—or in the case of West Coast, the whole team—coaches generally try to improve performance through technical instruction that is usually internal in focus, despite research evidence indicating otherwise.

To convince athletes and their coaches to change to an external focus of attention requires testimony from other successful athletes, and the strongest support for such an approach comes from Jonny Wilkinson—England's rugby goalkicking machine.

In 1998, when Wilkinson was having problems with his kicking, it was decided to forget about technique (internal focus) and focus on 'Doris'. Basically, every time he prepares to kick, he externally focuses his attention on an imaginary woman called Doris sitting in the stands behind the goalposts.

Initially, his focus was to hit her, and then as his skill level increased, he narrowed his attentional target to kicking a newspaper out of her hands and, now, he aims at a soft drink can.

The results of this technique speak for themselves and might convince other less consistent performers to switch their focus to the external.

Source: *The Age,* 31 July 2004, p. 9

Athletes change their attentional focus between the four categories of attentional focus depending on the situation, but must avoid distractors (such as emotions, irrelevant thoughts or events) that take concentration away from the task at hand. Have you ever found yourself thinking about your homework or about an assignment that is due next week when you are in the middle of a match? These distractions can be divided into two categories: internal distractors and external distractors.

Internal distractors

An **internal distractor** in a tennis match could be the pre-occupation with the previous poor shot selection. Focusing on past events takes concentration away from focusing on the present cues required for good performance. Negative thoughts are common distractors. Athletes who can turn negative self-talk into positive self-talk are far better at managing their ability to concentrate. On the other hand, athletes who are pre-occupied with the time left on the clock or with making a mistake can also perform poorly through lack of concentration.

Performing badly at a critical time in a match with a high degree of perceived importance is commonly called **choking**. Choking is a process, not a single incident. There are two views of the causes of choking. First, the perceived importance of the performance pre-empts athletes to consciously monitor movements that normally are executed without conscious control. This monitoring disrupts natural skill execution that otherwise would be automatic. Second, as arousal increases, athletes become immersed in internal distractions, such as worry, resulting in failure to attend to important cues. Worry uses working memory that otherwise would be used to focus on the task. An athlete's attention becomes internally narrowed on distractors, such as the fear of losing, the performance expectations of the audience or the fear of making a bad decision. It is the culmination of perceived **pressure** that leads to muscle tightness, increased heart rate and breathing, sweaty hands and a dry mouth. The increased pressure creates more anxiety and limits an athlete's ability to change their attention to a broad external focus. As a consequence, they experience increased muscle tension, which results in poor timing and coordination.

Recent research indicates that appropriate training under increased pressure and anxiety may prevent choking in high-stake situations. This not only has implications for sporting performance but also for workplace performance in occupations where pressure is an integral component, such as police work or fire fighting.

Keys to performing well under pressure

1 Identify the skills that suffer most when you are under pressure. Ensure that you put extra time into practising these skills so that you are confident in your ability to perform them.

Internal distractor is a thought that distracts attention from the present attentional cues.

Choking is a process of increasing anxiety due to the perceived importance of an event.

Pressure is a feeling that is created by an athlete in response to performing in a sporting situation.

Figure 4.4
Poor concentration follows fatigue.

2 Practise skills under pressure in training so that this becomes the 'norm' rather than the exception.
3 Slow down. Athletes under pressure have a tendency to rush things, especially when time is limited. Don't get caught by rushing and making an error.
4 Realise that pressure is simply how we perceive a particular situation; an Olympic final and training match use the same rules, the same strategies and the same ball, so the athlete needs to understand that pressure is something that they perceive and can control.
5 Identify relaxation techniques that work for you, if you know that you are prone to 'cracking under pressure'.
6 Take the focus away from how you feel or the performance outcomes and focus on the skills. Cue words are useful in redirecting focus.

Fatigue is also a distractor from good performance, as anyone who has played high-intensity sport will attest. Poor concentration follows hand in hand with tiredness. This is why a high level of fitness plays such an important role in maintaining good sporting performance.

Figure 4.5
Auditory distractors, such as crowd noise, are common in golf.

External distractors

Visual distractors are by far the most common form of external distractor. There are many opportunities in the playing environment to be distracted by visual movement in the form of spectators, your opponents, the scoreboard, cameras on centre court, etc.

Auditory distractors include crowd noise, mobile phones, loud spectators, train or aircraft noise and the noise of an opponent during a match (e.g. outbursts or grunts from tennis players). Success can hinge on an athlete's ability to block out these distractors and maintain concentration on the relevant cues of the match. Tiger Woods has an innate ability to remain focused. Read the article 'What makes Tiger Tiger?', on next page.

What makes Tiger Tiger?

MARTIN BLAKE

Mental toughness

Young Australian Marc Leishman recently played in the same group with Woods in America, and three times he saw Woods in trouble, and threatened. Each time, he played unbelievable shots. 'It's his ability to do it when it matters,' said Leishman.

Woods ought to stand as the template for sports psychologists. He might not lead all the statistical categories, but he leads the ones that count (for example, the money list—he has won $10.5 million this year; and scoring—his average 68 shots a round being the best on the US tour). There is nobody out there who is physically or mentally harder (and his win in last year's US Open with a broken leg and a left knee that required a reconstruction, is the best evidence of that).

His late father Earl probably can take credit here. It is part of the folklore that Earl Woods did 'all kinds of things to mess him up' when Tiger was learning to swing the club, aiming to distract him, or more to the point, preparing him for the distractions that would come.

In an early Nike advertisement, Earl Woods recalled dropping a whole bag of clubs during his backswing; his boy pausing, striking the ball, then turning. 'He never said a word, but that look said, "Take that!"'

Golf is a game that people tend to lose rather than win. It is about reducing errors. Consider Greg Norman, a great player who won tournaments around the world including two majors, but who was robbed or suffered self-inflicted wounds at so many others.

Tiger Woods is the only golfer in the world who is above this. In the 58 tournaments in which he has led or been equal leader going into the final round, he has won 51. When the South Korean Yong-eun Yang came from behind to beat him at the PGA Championships this year, Yang had to play not only the round of his life, but the shot of his life—a hybrid club to the shadow of the flag at the last. Yang won it; Tiger did not lose it.

Earl Woods' words from that advertisement ring true: 'I said: "Tiger, I promise you that you'll never meet another person as mentally tough as you in your entire life". He hasn't, and never will.'

Source: *The Sunday Age*, 8 November 2009, p. 9

Strategies to improve concentration

Being able to concentrate has been shown to be critical for effective performance, hence it is important to be able to develop techniques that improve concentration. Other techniques that improve concentration, such as mental imagery, controlling arousal levels and goal setting, will be discussed in subsequent chapters.

Self-talk

Self-talk is based on the theory that what people say to themselves has an effect on the way they behave. Self-talk can be in the form of thoughts in your head or words actually spoken. The central idea is that focusing on the desired thought leads to the desired behaviour. It is a psychological skill that has been used since the early 1900s. Self-talk is widely promoted as an integral psychological skill for improving sport performance.

There are four main forms of self-talk:

1 positive—'Great shot!'
2 negative—'I'll never make the team.'
3 technical or instructional—'Drive with the arms.'
4 neutral—'I must take the dog for a walk when I get home.'

Self-talk is a technique used to improve concentration. Self-talk is based on the theory that what people say to themselves has an affect on the way they behave.

Positive and motivating self-talk is particularly effective in physical skills that require strength and endurance. For example, 'Let's go!' has a positive effect on self-confidence, concentration and motivation.

Negative self-talk is detrimental to performance and includes critical thoughts and counterproductive emotions: 'You can't even beat this guy'. Negative self-talk paves the way for over-analysis of one's ability and detracts from the task at hand. An athlete can be their worst critic if they let themself. Generally, negative self-talk is associated with poor performance and is usually the most common form of self-talk of athletes.

Technical or instructional self-talk is particularly effective in fine motor skills requiring precision and accuracy, such as archery and golf. Metaphors such as 'wrist snap' assist the athlete develop a narrow focus of attention.

Neutral self-talk is sometimes useful for athletes in endurance events. For example, marathon runners try to put aside the feelings of pain or discomfort and think about 'anything else' but running.

Refocusing plans

Some athletes plan specific thoughts for moments they know could occur in a match which may distract them. For example, when tennis players double fault their serve, they may use pre-planned technical self-talk to refocus (e.g. 'Keep your eyes on the ball—hit at its peak.') rather than simply looking at the negative outcome. Athletes need to train themselves to remove negative self-talk from their performance and replace it with positive, technical self-talk cues.

Thought-stopping

Consider the thoughts of two different athletes as each steps to the line to take a free throw. One thinks, 'This is an easy two points. I've made this shot 100 times before', whereas the other thinks, 'I missed the last two shots. If I miss this it'll be three in a row'. These two athletes may have very similar skill levels and experience, but they differ greatly in their level of confidence. The key is to identify when you use negative self-talk and turn these thoughts into positive ones. One technique to achieve this is called 'thought-stopping'. Whenever you recognise a negative thought, say a cue word out loud (e.g. 'stop!') and then refocus on the task. Once you get better at this you can say it quietly to yourself. The key is to recognise the negative thought and to stop its impact on performance. A professional golfer used to put paperclips in her left pocket at the start of a round and with every negative thought she would transfer a paperclip to her right pocket. It was her way of stopping the thought and acting on it. After each round she could count the number of paperclips in her right pocket to determine her progress.

Learning experience

CHANGING NEGATIVE SELF-TALK TO POSITIVE SELF-TALK

Self-talk has been shown to increase self-confidence and decrease distracting thoughts, as well as being useful in reducing anxiety. The table below contains common negative self-talk phrases. Rewrite the negative self-talk phrases as positive ones.

Figure 4.6 Changing negative self-talk to positive self-talk

Negative self-talk	Positive self-talk
■ You idiot, how could you miss such an easy shot?	■ Everyone makes mistakes—just concentrate on the next point.
■ I never play well in the rain.	■ No-one enjoys playing in the rain. It will take extra concentration, but I can play as well as anyone.
■ This referee stinks. We'll never win.	
■ The coach must think I'm hopeless. He never helps me.	
■ Why did I get fouled in the last minute of play? Now I'm going to miss the last chance at points.	
■ There's no sense in practising. I have no natural talent anyway.	
■ I'll take it easy this practice session and come out hard next session.	
■ We'll win this meet if I can score better than 9.0 on this routine.	

Simulation training

Anyone who has played competitive sport will understand that the practice environment is not always the same as the playing environment.

Running on to the court in front of a large crowd for the first time or playing in weather conditions that are unfamiliar can be potential distractors that impair performance. To avoid such distractions, you can prepare by training with similar environmental distractors through **simulation training**. If your opponents use particular tactics, ensure that you are familiar with these tactics at training prior to competition. When performing skills in training, ensure that they mimic the competition rules, e.g. only one chance at a gymnastics routine or one shot at a penalty goal. The preparation of the Australian Olympic team for the Beijing Olympics involved acclimatising

Simulation training is training that mimics the competition environment as close as possible.

to the heat and humidity by training in similar conditions in the northern hemisphere months prior to the commencement of the games.

Performance routines

Performance routines are routines established by the athlete in order to maintain focus.

Routines in sport have been shown to be effective in allowing performers to mentally prepare for competition. A **performance routine** involves the practice of a set routine in a game, and its aim is to ensure that a player focuses attention on the actions that they can control and that are relevant to successful completion of the skill. For instance, a basketballer might use the same routine when shooting free throws such as bouncing the ball a certain number of times before shooting, and a sprinter may develop a race plan that involves deliberately focusing on task-specific cues at certain stages of the race.

Another strategy for developing concentration is the use of associative concentration techniques in which the athlete focuses on internal body signals such as heart rate, respiratory rate and muscle tension. Again the aim of this technique is to focus attention and avoid distractors.

When an athlete is completely focused on the task at hand and their skills match the challenge of the competition, they will often report that 'they are in the zone'. This state of mind is called 'flow', a term proposed by Mihály Csíkszentmihályi (pronounced cheek-sent-me-high-ee) a Hungarian professor who defined flow as 'the state of concentration so focused that it amounts to total absorption in an activity'. Colloquially, it can be said that you are on 'automatic pilot'. His research identified nine essential elements of the flow state:

- equal balance between challenge and skills
- transformation of time—('It was over before I knew it')
- clear goals
- merging of action and awareness
- total concentration on the activity
- loss of self-consciousness
- a sense of complete control
- effortless movement
- no need for extrinsic rewards.

Psychology of injury

Sports injuries cost Australia $1.83 billion in 2003 (Medibank 2004), accounting for 45 452 people being hospitalised in the 2002–2003 financial year due to sport and recreation-related injuries. It is little wonder that there is a rich body of research into possible interventions that may influence the reduction of sports injuries. Several research studies report that psychological factors, especially stress and anxiety, are related to sports injuries. It would be reasonable to hypothesise that programs aimed at training athletes to relax would reduce injuries.

An **intervention** is a certain program or practice administered to a population. The resulting outcomes are observed. Positive feedback, for example, could be an intervention to see its result on team performance.

So, is it possible to reduce the risk of injury using psychological skills? Numerous studies have used imagery, team-building strategies, relaxation techniques and attentional control **interventions** in order to reduce risk of sport injury with surprisingly positive results. One particular study used imagery training with college swimmers and reported an impressive 52% reduction in swimming injuries. Athletes should also be aware of the psychological strategies that can facilitate recovery.

Causes of injuries

Although physical factors such as collisions and muscle tears are the main contributors to sports injuries, psychological factors have also been shown to play a role. The Stress–Injury Model, created in 1988 by Jean Williams and Mark Andersen and reviewed in 1998, identifies the relationship between stress and injury. These sport psychologists found that athletes with a high-risk profile are two to five times more likely to be injured. A risk profile takes into consideration factors such as personality characteristics, coping skills and life stress levels. Athletes with certain personality traits who have a lot of stress in their lives and poor coping skills are at the top of the list for risk of injury (i.e. athletes with higher levels of stress are more prone to injuries). The physiological responses to stress include increased heart rate, inability to attend to cues or missing them altogether and increased muscle tension. If you suffer from stress when put under pressure, there are interventions you can use to help you cope better. Athletes who were trained in skills such as relaxation, imagery and techniques for staying focused under pressure had fewer injuries than athletes who did not have the same intervention.

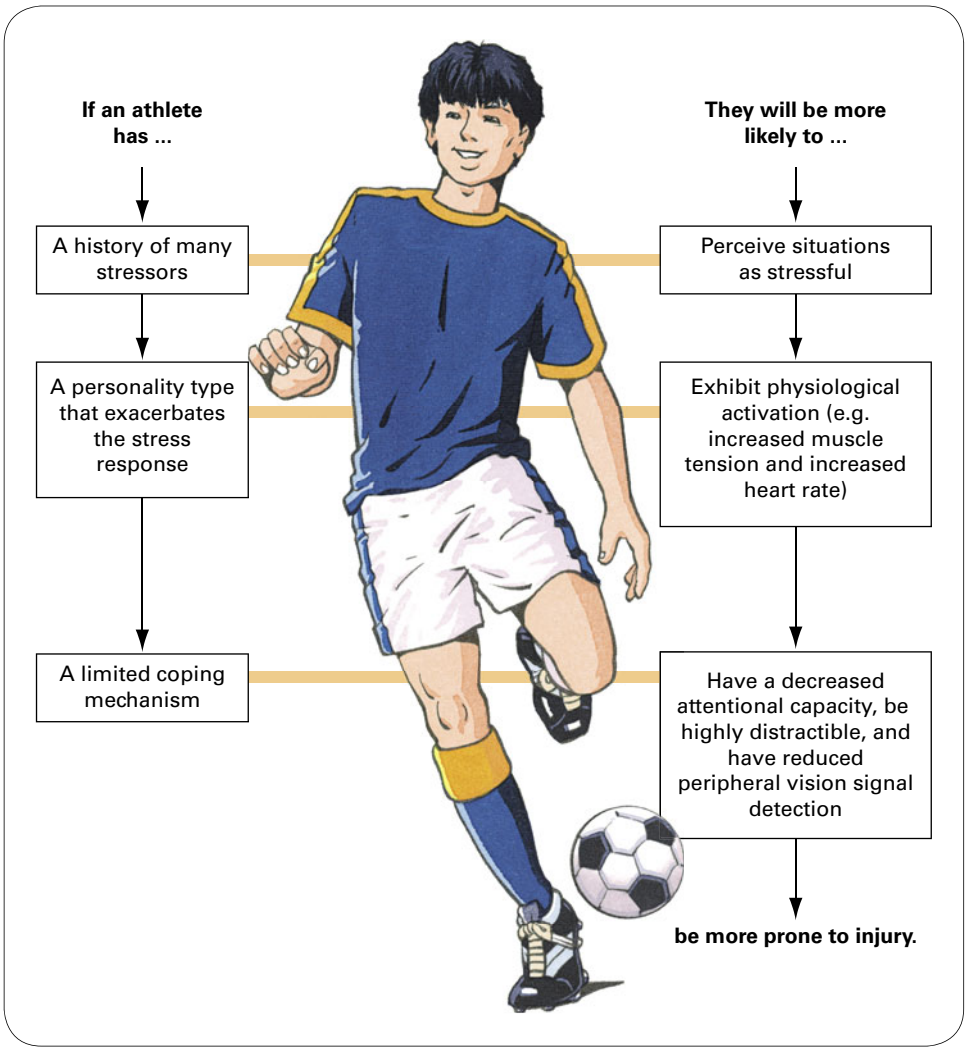

Figure 4.7
The Stress–Injury Model identifies the relationship between an individual's stress response and likelihood of injury.

Rehabilitation plan for injured athletes

- Relaxation training can assist with identifying stressors and change the perception of potentially stressful situations.
- Knowing about the injury-healing process will make you aware of the mechanisms for repair.
- Maintain a network of social support.
- Attend training sessions to keep in contact with fellow athletes and coaches.
- Implement imagery skills in the rehabilitation of the joint to develop muscle memory.
- View videos of your performance pre-injury to ensure a clear mental image.
- Discuss the rehabilitation process with other previously injured athletes.
- Focus on developing tactical skills during this period in which physical skill training may not be possible.

Learning experience

INJURY AND RECOVERY

Interview a fellow classmate who has been injured. Record the interview and transcribe the responses. Follow this athlete over a period of time through the three phases of the injury process outlined below:

- injury phase—dealing with the emotions that accompany an injury
- recovery phase—dealing with the emotions of rehabilitation and maintaining motivation
- return to play phase—dealing with the emotions of returning to full play.

Injury phase

1 What was the nature of the injury?
2 Explain how it occurred.
3 How did you feel when the injury happened?
4 How did you feel when you found out the severity of the injury?

Recovery phase

5 How did you feel 2 weeks after the injury?
6 Do you understand the process of healing that your body is experiencing?
7 What was the rehabilitation process like?
8 What factors assisted your recovery?
9 What factors inhibited your recovery?

Return-to-play phase

10 Who decided you could return to play?
11 Were you keen to return to play?
12 Did you commence play before you were fully recovered?
13 What emotions did you experience when returning for the first game?
14 Did you compensate for your injury during play?
15 Will the injury have long-term effects on your ability to perform?
16 What has this experience of injury taught you about yourself?

Chapter review

Performance-enhancing psychological skills

Know

1. Outline the four types of attentional focus outlined in Nideffer's model.
2. Create a list of positive self-talk statements you can use during performance.
3. Provide examples of internal and external distractors that hinder performance.
4. Identify three techniques that aim to improve concentration.

Comprehend

5. Identify a sport or playing position that would benefit from a broad external attentional focus.
6. Use the thought-stopping technique during performance and monitor its effect.
7. Explain why concentration skills are so important in maintaining good performance.
8. The Stress–Injury Model (Andersen & Williams 1998) shows a connection between stress and injury. Can you explain the cause and effect relationship between these two variables?
9. Survey your team and identify situations that tend to make them feel negative. Discuss strategies that the team could employ to minimise these feelings.

Apply

10. Keep a training journal that records your self-reflective thoughts about your performance. Write down your thoughts as soon as training is complete. Identify patterns of self-talk in training and subsequent performance effects. You may wish to complete this task for other self-monitoring strategies.
11. Develop routines within training that deliberately incorporate mistakes or errors. Identify the feelings of the team following these errors and incorporate a strategy to deal with fellow team members making a mistake.
12. Performance cues are an important component in maintaining focus. Explain the importance of developing cues by reference to psychology theory.

Analyse
Evaluate
Synthesise

13. The opponent's cheer squad is causing players in your team to become distracted and lose their temper. Identify strategies for dealing with this during the match, as well as strategies to be implemented in subsequent training sessions.
14. Debate the statement that 'Athlete X has a psychological edge over their competitors' by identifying what makes an athlete mentally stronger than a rival. Research the term 'mental toughness' to support your argument.
15. Implement a psychological intervention strategy that aims to improve performance in your sport. Identify the strategy, then over a period of weeks outline the aim of the intervention and hypothesise on the expected results. Perform pre- and post-tests and support your findings using this data. Draw conclusions and recommendations from your results.

chapter 5

Motivation, arousal and anxiety

Understanding the reasons for participation in and withdrawal from sport and physical activity is crucial for coaches and teachers when planning for effective learning environments. Methods for enhancing motivation and knowledge of factors that affect it are important skills that can be applied to sport, work or school.

Motivation

Motivation is defined as the 'direction and intensity of one's efforts' (Sage 1977). 'Direction' refers to an individual's attraction to certain situations, e.g. an athlete's desire to beat their personal best. 'Intensity' refers to how much effort an individual will put into the situation.

Given that there have been more than 30 theories that try to explain motivation, it is no wonder that it is not a topic that is easily understood.

Motivation is primarily concerned with encouraging others to achieve a goal. It can influence how people feel, act and think, and so strengthen or weaken their desire to work towards a goal. Enduring motivation comes from within and cannot be 'given' to someone. This internal motivation is the key to the development of talent in sport. Take, for example, the feats of Kurt Fearnley as reported by Liam Fox.

Motivation is the direction and intensity of effort.

Learning experience

Read the transcript of the report by Liam Fox about the feat of Kurt Fearnley in completing the Kokoda Track. Outline your understanding of what motivates individuals to perform feats such as this. Research other athletes or individuals who overcame adversity to achieve great things. What social, emotional and environmental factors influence a person's drive to achieve?

LIAM FOX: You get to see plenty of interesting things in this job. The downside can be that it becomes harder to be moved by the events you witness, but Kurt Fearnley did it to me twice in less than two weeks.

The first time was the day before he set out to tackle the Kokoda Track during a visit to a home for the disabled in Port Moresby.

He told the residents how, after being born without a large part of his spine, doctors only gave him a week to live.

But his parents bundled him up and took him back to Carcoar, west of the Blue Mountains, where he grew up crawling around the bush near his family home.

As a child he was told that one day he might be able to push buttons in a lift or answer telephones, but his life changed when he was introduced to wheelchair sports.

His local community raised the money to buy his first racing wheelchair and six years later he competed in his first Paralympics. Now he's a champion and races all around the world.

In fact he'd just won his fourth consecutive New York marathon less than a week before his trip to PNG.

He told the crowd at the disabled home he was proof anything was possible. I left thinking wow, what an incredible outlook after being dealt a rough hand in life.

The next day I flew up to Kokoda to report on the start of Fearnley's trek. The enormity of the challenge had set in as he flew over the Owen Stanley Ranges but he was still confident he'd complete the track.

He'd taught himself how to crawl again after becoming used to moving around in his wheelchair.

He put on his custom-made gloves, strapped on a thick layer of foam and gave us a demonstration. Imagine sitting on your hands and knees and pulling yourself along with your arms.

To say it's extremely hard work is an understatement. The strain on your arms, shoulders and abdominal muscles is immense.

It was hot and humid at Kokoda and I was exhausted just filming Fearnley manoeuvre his wheelchair from the runway to the nearby village. I flew back to Port Moresby wondering if he'd make it to the other side.

Eleven days later he was due to arrive at Owers Corner at the southern end of the 96-kilometre mountain track.

The last hill rises sharply up from a deep valley. Faces bobbed above the long grass and then Fearnley came into view pushing himself up the steep red-clay path on his hands and knees.

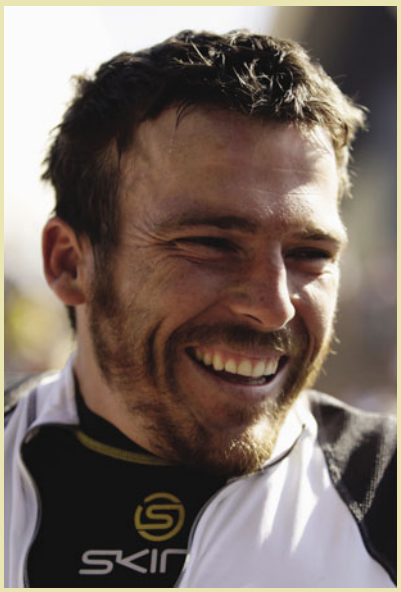

Figure 5.1
Kurt Fearnley

Local villagers cheered and the porters sang a Gospel tune as he passed under the arch that marks the end of the Kokoda Track. His hands shook visibly as the gloves were pulled off.

Fearnley said it was the toughest thing he's ever done; every day he was more exhausted than he'd ever been before.

Jason Fearnley said there were times when he thought his brother wouldn't be able to go on. The trek leader Wayne Weatherall used words like superhero and superhuman to describe the feat.

Champagne corks popped and there was more singing before Fearnley's parents Glenn and Jacqueline emerged from a hiding place to congratulate their son.

Despite the pain and exhaustion Fearnley said he'd fallen in love with PNG and its people. He plans to return soon, possibly to help improve services for the disabled.

But for now he says his next challenge will be to see how quickly he can get back to his local beach in Newcastle.

Driving back to Port Moresby I thought 'I've just seen something truly incredible: a man complete one of the world's most gruelling treks without the use of his legs'.

Source: 'Correspondents Report', ABC Radio National, 22 November 2009
<www.abc.net.au/correspondents/content/2009/s2749548.htm>

Self-determination theory

One popular understanding of motivation is self-determination, the theory developed by Edward Deci and Richard Ryan. This research grew from the influence of rewards on intrinsic motivation. The basic premise of this theory is that individuals seek to master their environment and in doing so satisfy three psychological needs: autonomy (self determination), which is associated with the perception of choice; competence, which is associated with the individual's need to overcome challenges that match their abilities; and relatedness (sense of belonging), which is associated with an individual's need to be part of a support network.

The self-determination theory proposes several forms of motivation:

- *Intrinsic motivation* is the inherent pleasure that comes with trying, learning, engaging and experiencing an activity, such as learning a backflip or enjoying a round of golf.
- *Extrinsic motivation* is involved when the activity is personally important for the rewards or outcomes that result from participation rather than solely for the interest in the activity, e.g. 'I did it for the money'.
- *Amotivation* is a lack of motivation to act. Individuals do not want to participate because it does not fulfil the three psychological needs.

Perception of competence is the most critical factor that influences participation and persistence in physical activity. Children's main motivation for involvement in physical activity is having fun and being with friends. Children, in particular, who attribute failure to lack of ability, are more likely to drop out. In addition, those individuals with low achievement needs tend to attribute success to luck or a task being too easy. It is important, especially for those children participating in sport who perceive themselves as lacking ability, to create an environment that:

- avoids comparison with others
- focuses on a player's strengths
- encourages participation following failure
- promotes understanding of individual differences.

Learning experience

Discuss the following:
Children participate in sport for fun and the most common reason for dropping out is 'because it's not fun'. This fun element underlies the concept of intrinsic motivation. What can organisers of children's sport do to maintain intrinsic motivation? Does the issuing of trophies and rewards undermine intrinsic motivation?

Anxiety and arousal

Although the terms 'anxiety' and 'arousal' may at first glance be seen to have opposite meanings, on closer scrutiny the two terms are very similar.

Anxiety is predominantly related to negative emotions. A person who is anxious about an upcoming competition may not be able to sleep well and,

consequently, may not perform at their best. **Anxiety** is a subjective feeling of apprehension that is accompanied by a heightened state of arousal. There are two dimensions of anxiety: the physiological (called somatic anxiety) and the psychological (or cognitive anxiety). An example of cognitive anxiety is having negative thoughts about an upcoming performance. For example, an athlete may fear being beaten, as they perceive their skills to be inferior to those of their opponent. This leads to increased levels of arousal. An example of somatic anxiety would be the feeling of 'butterflies' in your stomach, sweaty palms or an increased heart rate. Whether or not the athlete performs to their optimum will depend on whether they perceive these physiological signs as positive or negative.

Anxiety is a subjective feeling of apprehension that is accompanied by a heightened state of arousal.

The wobblies: This test of nerves is enough to make you sick

GREG GROWDEN

What's in a game-day ritual? Greg Growden gets inside the head of Wallabies winger Lachie Turner, a self-confessed nervous nellie.

Lachie Turner goes through a roller-coaster of emotions on game day … and most of the conflicting ones happen just before kick-off.

The Wallabies winger admits that in the dressing rooms the tension, the over-riding fear he may let people down, and his pursuit of excellence can make him 'violently ill'.

Then when he runs onto the field there is an outpouring of exuberance. His ritual is to head to the goalposts, make an almighty leap and tap the crossbar. Why?

'About two years ago I was struggling mentally and wasn't playing great football,' Turner said yesterday. 'I had been watching tapes of Timana Tahu playing league, and how he slam-dunked the crossbar.

'I did it at training, and decided before one game I would go out there and do it as a reminder to not take everything so seriously, and it stuck.

'I had a lot more fun that game and came off the field smiling. So I do it each game now as a reminder to have some fun and keep a smile on your face.'

It also reinforces the importance of being decisive.

'These moments come and go so quickly, and if you're not positive, not willing to back yourself, and don't have a go, you're going to miss them. So I want to make the most of everything.'

Figure 5.2
Lachie Turner uses rituals to calm his nerves.

Source: *Sydney Morning Herald*, 30 July 2009

Arousal, on the other hand, is a blend of physiological and psychological activation and is not always associated with a negative emotion. Arousal ranges on a continuum from being in a deep sleep to extensive excitement, and is a prerequisite for optimal sporting performance.

How a player thinks about a situation is usually the catalyst for a series of reactions that lead to increased levels of arousal. It is in the player's best interest to be able to identify the levels of arousal that are requisite for optimal sporting performance. Each player's optimal level of arousal will be different as it depends on personal factors, such as personality traits (e.g. tendency to be a perfectionist), level of confidence, expectations and cognitive anxiety,

Arousal is a term used in psychology to describe the heightened sense of physical and mental alertness or activation.

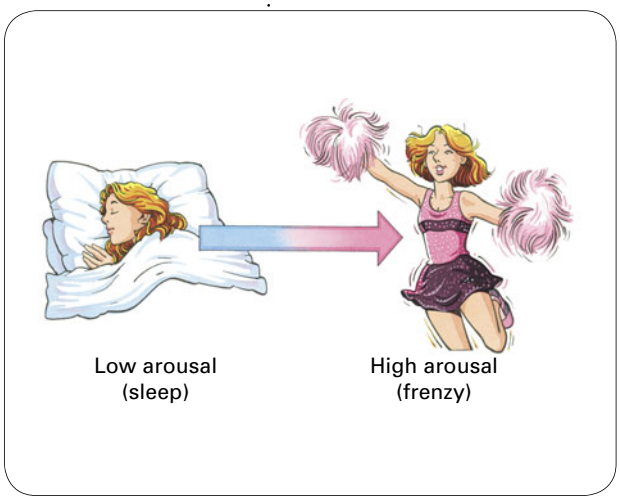

Figure 5.3 Arousal continuum

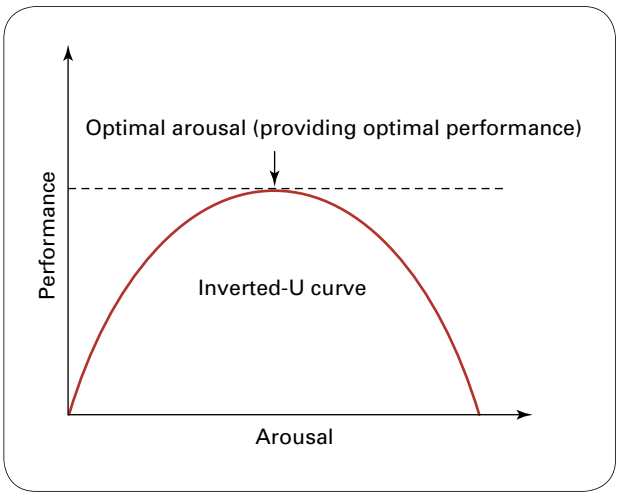

Figure 5.4 Inverted-U hypothesis

as well as situational factors, such as coaching style, rewards, audience and the difficulty of the task. All factors influence the effect of arousal on performance.

Several theories have attempted to qualify the relationship between arousal and performance. One of the earliest theories is the inverted-U hypothesis (sometimes called the Yerkes–Dodson law, after its researchers).

Inverted-U theory, also known as the Yerkes–Dodson law, describes the relationship between performance and arousal.

The **optimal level of arousal** is the level at which an athlete performs at their best. Different sports have different optimal levels of arousal.

The **inverted-U hypothesis** equates low levels of arousal with poor performance. As arousal increases, performance improves until an **optimal level of arousal** is reached. Beyond this peak an athlete is over-aroused and performance deteriorates. The relationship between arousal and performance differs greatly between sports. For instance, a golfer requires far less arousal for optimal performance than a hockey goalie.

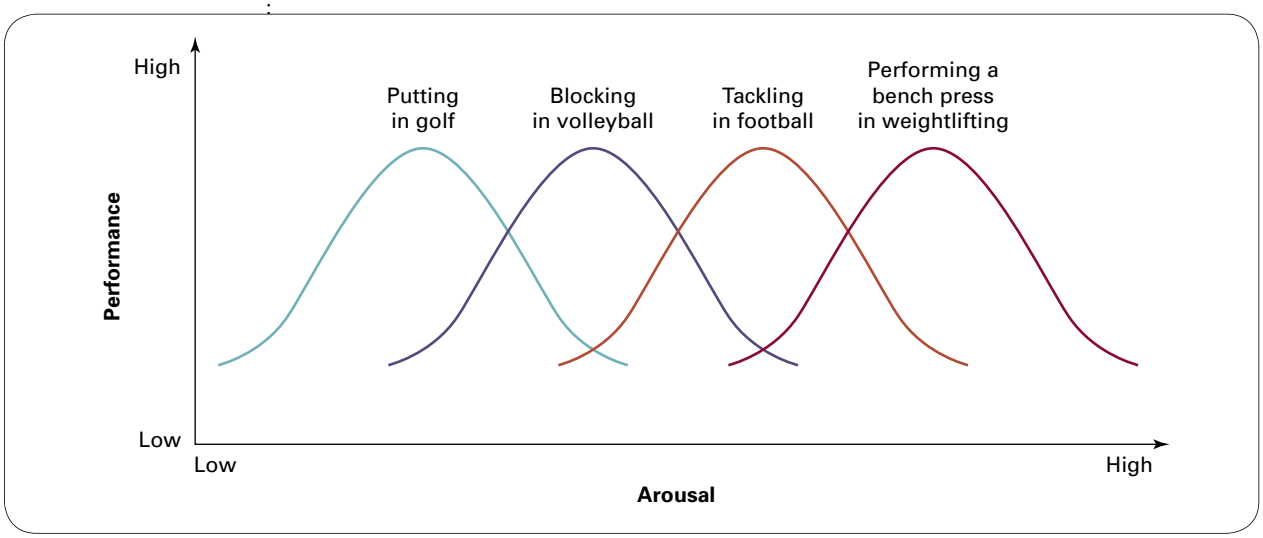

Figure 5.5 The relationship between levels of arousal and levels of performance for various skills. Fine motor activities are towards the 'low' end of the arousal continuum, and gross motor activities are towards the 'high' end.

The optimum level of arousal for a beginner is considerably lower than that for a skilled performer carrying out the same task. This partly explains why skilled performers are at their best in competitive situations whereas novices underachieve in similar situations. Another theory called **social facilitation theory** was devised by Zajonc after he sought to explain the random change in players' performances in front of an audience. He noted that when people perform a simple skill in the presence of an audience, it has a positive effect on performance; however, when they performs a task that is more complex, their performance declines. His theory supports the inverted-U hypothesis in that the audience creates the increased arousal that impedes performance of difficult or newly learned skills and improves performance on skills that are well rehearsed. This theory holds true even if only one other player is present. For a player in the early stages of learning a new skill, the implication for practice is to avoid an audience, as the audience would have the effect of increasing arousal levels and diminishing performance. It is recommended that an audience is introduced to practice only at the stage when the performer has consistent motor patterns.

Social facilitation theory seeks to explain the change in a player's performance when in front of an audience.

Measuring anxiety

It is important for every athlete to be aware of how their body responds to perceived threats. In order to control arousal levels, an athlete must first be aware of them during practice and competition. To achieve a better understanding of anxiety levels, athletes must make self-monitoring a part of their usual routines. **Self-monitoring** is a means of linking emotions with performance. Complete the following checklist of performance states for your best and worst performance. Compare your responses. Most athletes find a distinct difference between feelings associated with playing well and playing poorly. This is the start of the self-monitoring process.

Self-monitoring is a means by which athletes match emotions with performance.

Checklist of performance states

Played extremely well	1 2 3 4 5 6	Played extremely poorly
Felt extremely relaxed	1 2 3 4 5 6	Felt extremely anxious
Felt extremely confident	1 2 3 4 5 6	Felt extremely unconfident
Felt in complete control	1 2 3 4 5 6	Felt had no control at all
Muscles were relaxed	1 2 3 4 5 6	Muscles were tense
Felt extremely energetic	1 2 3 4 5 6	Felt extremely fatigued
Self-talk was positive	1 2 3 4 5 6	Self-talk was negative
Felt extremely focused	1 2 3 4 5 6	Felt extremely unfocused
Felt effortless	1 2 3 4 5 6	Felt extremely difficult
Had high energy	1 2 3 4 5 6	Had low energy

Source: Weinberg, RS & Gould, D, 2007, *Foundations of Sport and Exercise Psychology*, p. 275, Human Kinetics.

Plan to complete the above checklist after every training session and competition. The goal is to begin to understand the relationship between how

you feel and what you think and your performance outcomes. Being able to label your feelings is an important step in understanding and changing behaviour.

Feelings are important to success. Your emotional state influences your thinking, your behaviour, your posture and your health. Feelings are choices, so it is important to understand and use emotional states to your advantage. Listed below are some feelings identified in peak performers. You can choose to experience any one of them at any time:

Joy—a feeling of intense happiness
Enthusiasm—a feeling of being energised
Purpose—a feeling of certainty and direction
Determination—a feeling of being fully committed to a task or goal
Courage—a feeling of strength in the face of adversity
Focus—a feeling of pinpoint concentration
Belonging—a feeling of connection to others
Timing—a feeling of being in perfect sync.

Source: adapted from Jeffrey Hodges, 'Champion thoughts, champion feelings', *Active Education*, 21 February 2010, pp. 61–62

Measures of arousal

Arousal produces physiological changes in the body and can be measured using a number of physiological indicators, including muscle tension, brain wave activity, respiration rate, biochemical indicators, blood pressure and sweating.

Learning experience

AROUSAL TESTING

Aim

To test the influence of arousal on task performance.

Hypothesis

That as the level of arousal increases task performance improves.

Procedure

This test consists of two trials.

Trial 1: Students draw two circles of 7 cm diameter side by side and 4 cm apart as shown below.

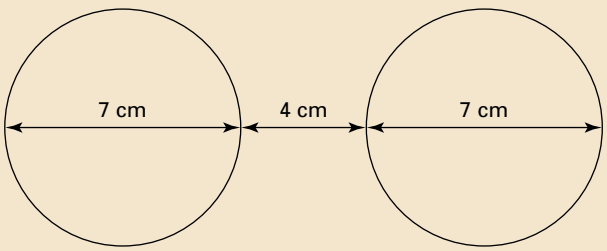

Figure 5.6
Arousal test diagram

Work in pairs. One student in the pair marks each circle alternately with a dot, to mark as many dots as possible in 10 seconds. Their partner observes and counts the number of dots as the student completes the task. Swap roles and repeat the trial. Tally the results and pair up students of similar scores for trial 2.

>>

Trial 2: Students again draw two circles of 7 cm diameter and 4 cm apart on paper. The teacher informs the class that the winner in each pair of trial 2 will determine who leaves early for lunch (or a similar reward). Students repeat trial 1.

Note: The reward is intended as a means of heightening students' arousal levels and it is not required to be followed through.

Discussion

Discuss the results of the two trials in terms of the impact of heightened levels of arousal on performance.

1. What impact did the reward have on performance?
2. What expectations did students have for Trial 2 scores pre-test?
3. Identify any signs of anxiety before the commencement of each trial. What measures were identified to indicate increased levels of arousal?
4. In which trial were students' anxiety levels higher? Explain.
5. Determine your ideal arousal level for optimum performance in this activity.
6. This task was a simple motor skill with no decision making. Explain why increasing the difficulty of a task and creating pressure for the performer would have a detrimental effect on task performance.

An **electroencephalogram (EEG)** measures brain wave activity. Three different brain waves (alpha waves, beta waves and theta waves) are associated with differing levels of arousal.

Electroencephalogram (EEG) is an instrument that measures brain wave activity.

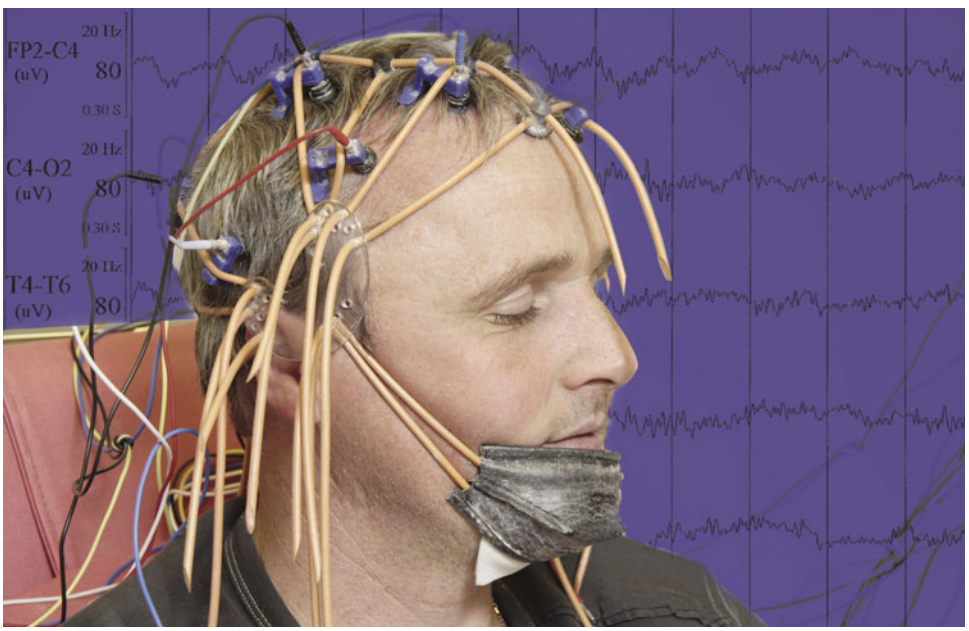

Figure 5.7 An electroencephalogram measures brain wave activity.

An **electrocardiograph (ECG)** measures the electrical activity of the heart; but high heart rate fluctuations alone are not a good indicator of levels of arousal, as they can result from other causes.

Catecholamines are one kind of biochemical indicator of arousal. They are a group of **neurotransmitters** in the brain and include **epinephrine**, which is

An **electrocardiograph (ECG)** measures the electrical activity of the heart.

A **neurotransmitter** is a chemical that carries messages between nerve cells.

Epinephrine is a synthetic form of adrenaline. It relaxes the airways and constricts blood vessels.

commonly known as adrenaline, and **norepinephrine**. The arousal response by the body releases catecholamines into the blood and this measure is a reliable indicator of arousal.

Norepinephrine, also called noradrenaline, is a neurotransmitter. It increases blood pressure, rate of breathing and blood sugar levels.

An **electromyograph** measures electrical activity in muscle. Muscle tension level is an approximate indicator of the level of arousal.

A **spirometer** measures a person's respiration rate, tidal volume and vital capacity, all reasonable indicators of levels of arousal. The higher the measure, the higher the level of arousal.

The **spirometer** is an instrument for measuring the capacity of the lungs.

Increased arousal levels cause muscle tension and fatigue and subsequently reduce coordination, resulting in inferior performance. Muscles that are tense for long periods also require more energy so, in endurance events such as marathons or events that have long wait times between performances (e.g. athletics and gymnastics), it is advantageous for the athlete to remain as relaxed as possible both before and during the event, in order to conserve energy. To perform at an optimal level, an athlete needs to be aware of their level of arousal on a scale of 1–10 at any point in time. If they are under-aroused they need to energise; if they are over-aroused they need to relax.

Psychological recovery

Just as an athlete performs a cool-down routine to assist in the removal of lactic acid from the muscles, so too should they incorporate a **psychological recovery** routine into their training program. Psychological skills are aimed at controlling emotions and the link between the mental and physical state should never be underestimated. A training journal in which you record your feelings about your performance can be a valuable insight into the methods of relaxation that most benefit your sporting performance. Relaxation and debriefing are two methods known to aid psychological recovery.

Psychological recovery is the process whereby an athlete incorporates psychological skills into their recovery plan.

Relaxation techniques

Relaxation is the state in which one is physically and psychologically free from uncontrolled tension, anxiety and negative thoughts. It is commonly characterised by feelings of ease, looseness and readiness. The aim of relaxation training is to physiologically calm the body, shift attention away from anxiety-creating thoughts and ultimately achieve optimal levels of arousal. Relaxation training is important in maintaining optimal arousal in both training and competition performance. It is also a useful mechanism for assisting in good sleep patterns. All of the following techniques can be practised without the need for any equipment or facility.

Relaxation is the state in which an individual is psychologically and physically free from uncontrolled tension, anxiety and negative thoughts.

Progressive muscle relaxation

Edmund Jacobson's 1938 **progressive muscle relaxation** technique involves the tensing of a muscle group and then letting go of this tension after about 4 or 5 seconds. The technique heightens an athlete's awareness of the difference between tension and relaxation in muscles. The regimen works best by starting at the head and working towards the feet. This technique requires

Progressive muscle relaxation technique uses the alternate tightening and relaxing of muscles in order to heighten an athlete's awareness of tension within the body.

practice before it is implemented as part of a competition routine, but, once mastered, it can be used successfully at the end of a training session or before going to bed.

Abdominal breathing

Proper breathing exercises are common practice in martial arts and are key to controlling anxiety and muscle tension. **Abdominal breathing** is also known as diaphragmatic breathing. Slow, rhythmic deep breathing is a sign of a calm, controlled person. The breathing of a person under pressure tends to be shallow and irregular; sometimes they might even hold their breath. Breath holding has been shown to increase muscle tension, but taking deep, slow, complete breaths triggers a relaxation response.

Abdominal breathing is a relaxation technique aimed at controlling anxiety and reducing muscle tension. It is also known as diaphragmatic breathing.

Learning experience

ARE YOU A CHEST BREATHER OR AN ABDOMINAL BREATHER?

Place your left hand on your chest and your right hand on your abdomen. As you breathe see which hand rises more. If your left hand is rising more, you are a chest breather. Chest breathing is shallow and does not allow air to get to the lower lobes of the lungs, which have some of the richest supplies of blood vessels. The following exercise develops abdominal breathing and aims to fill every pocket of the lungs with air.

Diaphragmatic breathing exercise

1. Sit or lie comfortably.
2. Place one hand on your chest and one on your abdomen.
3. Focus on inhaling so as to fill the lower level of the lungs first by forcing the abdomen out. Feel your abdomen rise. Your chest should rise only slightly.
4. Hold this breath for several seconds and then exhale slowly through the mouth by pulling the abdomen in and pushing the shoulders down.
5. To aid the relaxation process, try to perform the above routine at a rate of 4 seconds for inhalation and 8 seconds for exhalation. This heightens the focus on the exhalation phase of the technique. Complete 5 times trying to deepen the relaxation experience on each trial.
6. Remember that deeper breathing is created when we exhale fully and not by inhaling more.

Use the relaxation breathing technique before competition to focus your mind on the breathing process and avoid distractors. It also physically allows for the body to relax and the mind to be refocused and centred on the task.

Figure 5.8
Slow, rhythmic deep breathing is a sign of a calm, controlled person.

Music

Music forms part of the pre-competition environment for many athletes by evoking a relaxation response. An athlete can have a selection of music for relaxation on a portable device to assist in creating an optimal arousal mood. As well as relaxing the mood of the athlete, the music limits environmental distractors that may cause increased anxiety levels.

SNAPSHOT

Layne Beachley, seven-time world surfing champion, wore headphones connected to a music device before every surfing competition, but never turned it on. Her competitors saw the headphones and assumed that she was listening to music and so didn't disturb her. Layne preferred a silent pre-event routine and didn't want the distraction of other competitors talking to her. She solved the problem by pretending to listen to music and was not distracted.

Figure 5.9
Layne Beachley

Debriefing process

You have come off the court with a 50 point loss to a team that you should have beaten by twice that margin. You feel angry, hurt, fed up and dissatisfied with the effort of your teammates, and lack motivation. You pack up the equipment with fellow dejected teammates and make the trip home. You go through the match over and over in your head and 'stew' on the outcome and consider where things went wrong—blaming everyone and anyone. This is a common scenario for players who do not have the opportunity to experience a **post-performance debriefing**. The debriefing process is an opportunity for the exchange of meaningful feedback on the process of the performance as well as the outcome in a supportive environment. It provides an opportunity for players and coach to share experiences and personal evaluations of the performance. It allows for performers to reflect on their own practice, learn from experience and set in motion a plan of action for improvement in subsequent performances. A debriefing also resolves all emotional frustrations that can be detrimental to future performances.

A **post-performance debriefing** is the process of providing feedback on performance in a supportive environment.

Post-performance debriefings should consider all aspects of the performance: perceptual motor (or tactical), physical, technical and mental. The main purpose of a debriefing is to self-analyse the existing performance and consider what might be improved in order to achieve future performance satisfaction. The debriefing process is an integral part of the goal-setting process. To maintain a constructive environment for the exchange of ideas, it is important to establish performance indicators that are meaningful to the team or performer. **Performance indicators** should relate to tangible outcomes that can be monitored, such as fouls for/against, focus in pre-match, points from service, forehand errors and emotional control.

Performance indicators are measurable indicators that demonstrate whether a goal has been achieved. Standards are used as a benchmark for future performance goals, e.g. time in possession, race times and rate of improvement.

Aims of debriefing

Debriefings should provide knowledge of results and performance. They should also:

- analyse existing performance levels
- resolve emotional frustrations
- identify potential and limitations
- set clear guidelines for future performance.

Steps in debriefing

The following steps provide a systematic strategy for assisting communication and reflection post performance.

Step 1 Select the best time, place and location for the debriefing.

Step 2 Recall the performance (video evidence assists) and engage in self-reflection. Refer to four areas: perceptual motor, physical, mental and technical. Refer to the post-performance self-evaluation questionnaire (figure 5.10) to assist in this process.

Step 3 Coach shares perceptions of performance with players, using quantified data. Coach and players emphasise what needs to be changed.

Step 4 Identify strengths and weaknesses, and clearly address strategies that aim to improve performance.

Step 5 Refocus on amended goals with renewed strategies.

Step 6 Monitor performance for improvements.

POST-PERFORMANCE SELF-EVALUATION—*TRACK AND FIELD COMPETITION*

This evaluation is following: *Performance time/ height/distance:*

Name: _____ Preliminary heats ○ _____

Event: _____ Semi finals ○ _____

Date: _____ ***Best time:*** _____ Finals ○ _____

Answer the following to the best of your ability, with an emphasis on your strongest competitive event.
Use the scale: 0 = Not at all, 6 = Very much, and blacken out ● the response that reflects how you feel now.

1 Overall, are you satisfied with your performance with this event? Yes ○ No ○

2 Do you feel you achieved your major goals for this event? Yes ○ No ○

3 Following warmup and immediately before my event I felt:

		Not at all 0	1	2	3	4	5	*Very much* 6
a	physically prepared	○	○	○	○	○	○	○
b	mentally prepared	○	○	○	○	○	○	○
c	eager to race/compete	○	○	○	○	○	○	○
d	confident	○	○	○	○	○	○	○
e	worried about performance	○	○	○	○	○	○	○
f	healthy	○	○	○	○	○	○	○
g	butterflies in stomach	○	○	○	○	○	○	○
h	in control	○	○	○	○	○	○	○
I	focused	○	○	○	○	○	○	○
j	technically in tune	○	○	○	○	○	○	○

		Not at all 0	1	2	3	4	5	*Very much* 6
4	I was mentally ready for my competitive event?	○	○	○	○	○	○	○

		0	1	2	3	4	5	6
5	I was able to use my feelings/emotions to my advantage?							
a	Before competing	○	○	○	○	○	○	○
b	During competition	○	○	○	○	○	○	○

6 Did you have a race or event plan? Yes ○ No ○

7 If yes, were you able to follow it? Yes ○ No ○ Partially ○

8 If yes, did it work for you? Yes ○ No ○ Partially ○

		0	1	2	3	4	5	6
9	I was able to cope with my emotions following my event.	○	○	○	○	○	○	○

		Very poor 0	1	2	3	4	5	*Excellent* 6
10	Technically my event was	○	○	○	○	○	○	○
11	Strategically my event was	○	○	○	○	○	○	○

Other comments:_____

_____

_____

Instructions for scoring

Yes = 5
No = 0
Partially = 3
Intensity scores are from 1 to 6
Readiness scoring—maximum out of 77
Q3 a–j: Add your scores. Note: Q e and g score the reverse. Total readiness /77 = %
Assessment scoring—maximum out of 44 Total assessment /44 = %
Add up the total of Q 1, 2, 5b, 7, 8, 9, 10, 11.

If Readiness % is greater than the Assessment % (difference is a negative score) then it is possible that you were not totally prepared, physically or mentally or both, for your performance or that you are too hard on evaluating yourself.

If Assessment % is greater than the Readiness % (difference is a positive score) then you may be performing beyond your expectations or you are too easy on evaluating yourself.

Example: Readiness score 71/77 = 92%
Assessment score 30/44 = 68%
Difference is = –24

If you evaluate yourself regularly over time you will recognise your pre-performance states of readiness more accurately, and better assess your efforts with a view to improving your performances.

Source: Printed by permission of the author J M Hogg (1998). 'The post performance debriefing process: Getting your capable track and field athletes to the next level of performance', *New Studies in Athletics*, 3, 49–56

Figure 5.10
Post-performance self-evaluation questionnaire

Chapter review

Motivation, arousal and anxiety

Know

1 The inverted-U hypothesis describes the relationship between which two variables?

2 List three psychology techniques that can be used to evoke relaxation.

Comprehend

3 Each sport requires its own kind of attentional focus. Select a sport and identify the differing attentional styles required of key positions. Remember that the attentional style may change in given situations.

4 Many athletes and swimmers can be seen in the marshalling area prior to an event with headphones on, listening to music. What is the psychological technique that they are using and what is the benefit of this technique?

Apply

5 The article titled 'The wobblies' provides an insight into the pre-game nerves of an Australian Rugby Union player. Design a pre-game routine for your own sporting performance. Monitor its impact on performance by using a journal. Implement other anxiety-reducing strategies and monitor their impact on performance.

6 Gamesmanship is used in sporting contexts and can be strategically planned to disrupt the concentration of an opponent. Identify examples of gamesmanship in sport. What psychological strategies can players implement in response to these tactics by opponents?

7 Survey athletes to identify external stressors that cause increased anxiety during a competition season. Implement one strategy that reduces the effects of anxiety on performance.

Analyse
Evaluate
Synthesise

8 Implement a post-performance debriefing as part of your sport. Use the questionnaire in figure 5.10 over a period of 4–6 weeks to initiate discussion and set objective goals for subsequent performances. Using graphs, track the mental state of readiness over this period to evaluate performance.

Team cohesion, coaching styles and goal setting

Chapter 6

Much of our discussion so far has focused on the skill learning of the individual performer. However, the nature of sport means that, more often than not, individuals must perform together in a team. The saying 'a team of champions doesn't always beat a champion team' highlights the fact that there are more elements involved in making a winning team than individual brilliance. Your future work will ultimately involve being a team member, no matter what vocation you select. A pilot, an engineer, an artist or a computer programmer all require effective team-member skills. This chapter uses a sporting context to look at the nature of teams, some factors that influence interactions within them and, consequently, the degree of success they achieve.

What is a team?

A team can be defined as the following:

A collection of two or more individuals who:

- *possess a common identity*
- *have common goals and objectives*
- *share a common fate*
- *exhibit structured patterns of interaction*
- *demonstrate group processes such as communication and cooperation*
- *consider themselves to be a group.*

Source: adapted from A Carron & H Hausenblas, 1998, *Group Dynamics in Sport*, 2nd edn, Fitness Information Technology

The identity of a team is exemplified by having a team name, wearing team uniforms and attending team training, all of which set one team apart from another. The common goal, often, is that of winning. From day one a team develops its own structure, which is based on the expectations and perceptions of the group members. But not every team will be successful. To better understand these differences it is important to understand the factors that impact on the level of success. First, for a team to be effective there are three structural characteristics that must develop:

1 Group roles
2 Group norms
3 Social support.

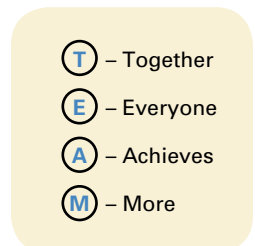

Figure 6.1
A team combines individual strengths.

Group roles—informal and formal roles

A role is a set of expected behaviours of the person occupying a specific position. In most teams you will have formal roles, such as a captain, and playing positions with specific responsibilities. In addition, there are the more informal roles such as organisers or emotional stabilisers who adopt these roles because of their skills, personality and qualities. Every team has a practical joker!

Role clarity

It is important for coaches or team leaders to identify qualities of each player in the team and link these qualities with a specific role. How the role contributes to the team should also be discussed openly. It is also very important to clarify any ambiguity that these roles may bring. Role conflict has been cited as one of the more powerful factors in player dissatisfaction. Group discussion of expected role behaviour lessens the likelihood of role conflict between team members.

Role acceptance

The ability to develop an effective team stems from an ability to identify roles and for players to accept these roles. Players who accept their roles are more likely to be satisfied with their responsibilities.

Role conflict

Despite having allocated roles within the team and for players to have accepted these roles, conflict arises when a certain player doesn't have sufficient skill, time, motivation or understanding to carry out the responsibilities of their role. This impacts on team cohesion.

Group norms

Norms are structured rules that govern the way a group is organised and maintained.

All groups have **norms**. A norm is defined as the 'structured rules that govern the way a group is organised and maintained'. Typically norms are established to maintain routines and to set standards of behaviour that help to increase team cohesion. Arriving at training on time, helping prepare equipment for practice, following acceptable dress codes and setting high standards are all examples of positive norms. Norms have a significant influence on individuals, and it is good practice to encourage team leaders to include team members in the decision-making process about norms.

Social support

The differences in team members' backgrounds, personalities, attitudes, expectations and abilities all contribute to the diverse make-up of a team. The one commonality between all team members is to be satisfied with their place in the team. Social support has been linked to increases in feelings of team cohesion. Also relevant in building effective teams is the ability for team members to spend time together in close proximity. This is seen in teams such as the State of Origin teams, which have pre-match 'camps' to bond with other team members. Road trips and fundraising events are other examples that contribute to the development of a team's identity and strengthen team cohesion.

Teamwork divides the task and multiplies the success.

Building successful teams should follow the MAPS model:

- **M**ission—Develop a clear mission statement that links with team goals. What is the team trying to achieve? Skill improvement, winning, enjoyment?

- **A**ssessment—Identify the strengths and weaknesses of the team so that resources can be developed to address this and improve the team's potential for success.
- **P**lan—Develop individual and team action plans. These should include specific behaviours with clear timelines.
- **S**ystematic evaluation—Implement a periodic overview of the entire plan; look at whether goals were achieved and areas for improvement.

SNAPSHOT

Are you a goose?

When you see geese heading south for the winter, flying in a 'V' formation, think about what science has learnt about why they fly that way. As each bird flaps its wings, it creates uplift for the bird immediately following it. By flying in a 'V' formation, the whole flock can fly at least 71% farther than if each bird flew on its own.

Perhaps people who share a common direction can get where they are going quicker and easier if they cooperate.

Whenever a goose falls out of formation it feels the resistance of trying to go it alone and quickly gets back into formation to take advantage of flying with the flock. If we have as much sense as a goose we will work with others who are going the same way as we are. When the lead goose gets tired he rotates back in the wing and another goose flies on the point. It pays to take turns doing hard jobs for our group. Perhaps the geese honking from behind are even the 'cheering squad' to encourage those up front to keep up their speed.

Source: P Mears and F Voehl, 1994, *Teambuilding: A Structured Learning Approach*, St Lucie Press

Team cohesion

Team cohesion is a result of a group's desire to remain together. It is the blend of two key dimensions: task cohesion and social cohesion. Task cohesion refers to a team's ability to work together to achieve its goals.

Social cohesion is the degree to which members of the team like each other and enjoy one another's company. Teams that have members who fight or form cliques would be said to have low social cohesion. Have you been part of a team that had high task cohesion but low social cohesion? The factors that contribute to making a cohesive team also contribute to its success.

Characteristics of a cohesive team

Team cohesion is not a stable trait. It is the result of the interaction between personal and situational factors as well as effective leadership. The same team in its second year of competition may not have the same 'spark' it had in its inaugural season, even though it consists of exactly the same players as in the previous year:

- A situational factor that assists in developing team cohesion is the opportunity to spend time together as a team. This instills a sense of pride and develops unity.

Figure 6.2
Team identity is important.

- Personal factors that influence team cohesion include the blending of personalities that make up the team. Team members may come from very different backgrounds and experiences, but if everyone has a common team goal cohesion is likely to result.
- Effective leadership is the third factor that contributes to team cohesion. This will be discussed further in this chapter.

Cohesive teams:

- share common goals and beliefs
- have a collective identity
- resist disruptive influences
- work hard
- demonstrate unselfish play
- sacrifice for the good of the team.

Figure 6.3
Team cohesion comes through working together.

How to develop team cohesion

1 Acquaint each player with the responsibilities of all players—not just their own position. During a training session it may be beneficial to change player roles to see the difficulties encountered by fellow team members. For example, the centre position player in netball can become the goal shooter. This provides a better understanding of each other's playing responsibilities.
2 Ensure that an environment for open communication is established. The ability to communicate effectively and express feelings will go a long way to developing group cohesion.
3 Ensure that the team's success is not attributed to specific roles so that the role of every team member is seen as important.
4 Set team goals. Team goals maintain focus on what needs to be achieved. As individual goals are achieved, new performance-based goals can be developed. Take pride in achieving set goals.
5 Learn something new about players in the team. At team meetings players can share observations of characteristics that they admire in other players.
6 Avoid the formation of cliques within a team as this only benefits a small number of players and alienates the rest of the team.
7 Encourage group identity by making team members realise an identity. Develop team routines or provide special privileges, such as team breakfasts.
8 Avoid excessive player turnover.
9 Make newcomers feel welcome to the team.
10 Do not expect complete social cohesion. There is always potential for conflict within teams. The absence of any conflict may indicate a lack of interest.

Learning experience

DEVELOPING TEAM COHESION

1 Form groups of 4–5.
2. Draw on your experience as a member of a team to discuss and identify the behaviour that a good team member would display in each of the following situations:
  a Coming on to the court from the bench in a tight game
  b Reacting to errors made by teammates during a match
  c Experiencing consistently poor refereeing decisions during a match
  d Participating in a training session
  e Taking a training session in the absence of the coach.
3 Decide on the top three behaviours for each situation and present your conclusions to the class.

Goal setting

Team **goal setting** can enhance team cohesion and team effectiveness.

Goals give a team direction and mental focus, and enable athletes to focus attention on the process of achieving success. Goals can be set by an individual and by a team. It is the matching of individual goals with team

Goal setting is a means by which individuals and teams direct their focus.

goals that can sometimes be complicated. Goals are necessary for improving performance and maintaining motivation. The researcher RS Weinberg put it this way:

> *The coach must have goals. The team must have goals—real, vivid, living goals … Goals keep everyone on target. Goals commit me to the work, time, pain and whatever else is part of the price of achieving success.*

Source: RS Weinberg, quoted by RH Cox, 1985, in *Sport Psychology*, William C Brown

Types of goals

Three main types of goals have been identified by researchers in sport: outcome goals, performance goals and process goals.

Outcome goals

Outcome goals are goals that focus on the result of a particular event, e.g. finishing fifth.

Outcome goals focus on the result of a particular event, e.g. coming in the top three in the 1500 m for your age group. When focusing on this type of goal, performers usually compare themselves to other performers.

Performance goals

Performance goals are goals based solely on comparing the individual's performance with their previous performance.

Performance goals concentrate solely on comparing the individual's performance with their previous performance (e.g. running 400 m in less than 55 seconds).

Process goals

Process goals focus on the technique rather than the performance result.

Process goals focus on the technique of performance rather than the overall result. An example would be completing the hurdles by using the correct number of strides between each hurdle and not changing lead legs. Process goals focus on the procedures that an athlete needs to perform in order to have a good performance.

What type of goals to set?

A study of swimmers found that nearly half set themselves a combination of all three goals and none set only outcome goals. Athletes in sports that rely on precision skills, such as golf and archery, benefit greatly from setting process goals. As a general rule, performers should not solely set outcome goals, as this emphasises the achievement of particular results and may cause stress and anxiety.

Effective goal setting

Short-term goals are particularly important, as working towards them provides immediate feedback and incentives that motivate the athlete to continue. The ability to accomplish preset goals gives the performer greater confidence and self esteem.

A second important characteristic of effective goal setting is the ability to set difficult but achievable goals and to re-assess them at regular intervals. A basic rule for setting achievable goals is to aim just above your current performance level. Athletes and teams that set more difficult goals exert greater effort and persistence in reaching these goals. However, setting the level of goal difficulty beyond the capability of an athlete or the team is not advised, as players tend to 'give up' before reaching them.

Reassessment provides an opportunity to reset goals if the initial standards were set too high or too low or if you become over-committed and are trying to do too many activities.

Always write down your goals and keep them in a prominent place, e.g. on your bedroom wall or on the refrigerator door.

Always reward yourself when you reach a performance goal on the way to a long-term goal. Also, when you achieve a goal, remember not to take it for granted: reflect on how you achieved it and analyse the process you went through. An effective way of doing this is to keep a journal.

All too often athletes concentrate on outcome goals, goals that focus on the result of an event or game and usually involve an athlete comparing their performance with that of another athlete. However, when athletes who set outcome goals do not succeed, they often blame themselves for their failure and attribute it to lack of ability. This, in turn, may lead them to avoid the activity because they feel that cannot achieve success.

If, however, athletes set performance or process goals, they identify other determinants of success, such as improved technique, a reduction in performance time, or their ability to out-manoeuvre their opponents. All coaches should teach athletes that personal success means achieving performance goals rather than achieving outcome goals.

Goals such as 'Give it your best' or 'Have fun' are not measurable and are unproductive in that they do not identify specific actions to be taken and so should be avoided. Figure 6.4 provides examples of effective and ineffective goals.

Figure 6.4 Writing effective goals

Poorly written goal	Improved writing of goal
Improve forehand in tennis	Prepare racquet head earlier
Improve first serve in tennis	Make ball toss more consistent in height and direction

Figure 6.5
Coaches work with teams to set achievable goals.

Learning experience

A sample goal-setting sheet for a skill in volleyball is shown below. Use the questions in this template as a guide for developing your own goal-setting task for a skill specific to your sport.

Sample goal-setting sheet for volleyball

Goal: To improve my hitting out of the front court, position 4
Type: Technical **Date set:** _____

To achieve this goal (answer all six questions):

1 What do I have to do?
- Be more assertive/decisive in swinging at the ball.
- Develop a more appropriate spatial relationship with the ball.
- Develop a more dynamic approach/take-off.

2 How am I going to do this?
- Practise hitting from the back court more often myself (as opposed to drills with others).
- Develop a drill to improve 'spatial relationship' specifically.
- Develop a drill to automate a dynamic approach.

3 How can I measure improvement?
- Objectively—6 out of 10 (60%) → 8 out of 10 (80%)
- Subjectively—feedback from coaches/teammates and video of self

4 Who can help me achieve this goal?
- Coaches, and teammates whose ability in this area I admire/respect

5 How will I know I have achieved it?
- See 3 (when I am achieving 60–80% consistently and without conscious thought)

6 How will I prevent myself from achieving this goal? What excuses will I use?
- 'Too difficult', 'I can't' and 'she'll be right'

Source: FS Pyke (ed.) 2001, *Better Coaching: Advanced Coach's Manual*, 2nd edn, Australian Sports Commission

Guidelines for goal setting

Goal setting is a very effective psychological skill that can be learnt, like imagery or relaxation techniques. It can have positive results in both sport and life. Goals are not to be confused with dreams or wishes. Goals need to be realistic and achievable at the performer's skill level.

The nature of the goals being set is very important. The goals must spell out exactly what you want to achieve. To set a long-term goal, the athlete must first establish a problem-solving approach to the development of short-term goals. How am I going to get there? For example, if an athlete has the goal of representing their state in 100 m at the national athletics championships in December, this can only be reached by meeting various short-term goals. The relationship between the short-term goals and the ultimate long-term goal can be represented as a staircase, as seen in figure 6.6.

Setting goals can help you to:

- achieve more steadily
- improve the quality of your training
- improve your motivation to achieve
- increase satisfaction with your performance
- ultimately improve performance.

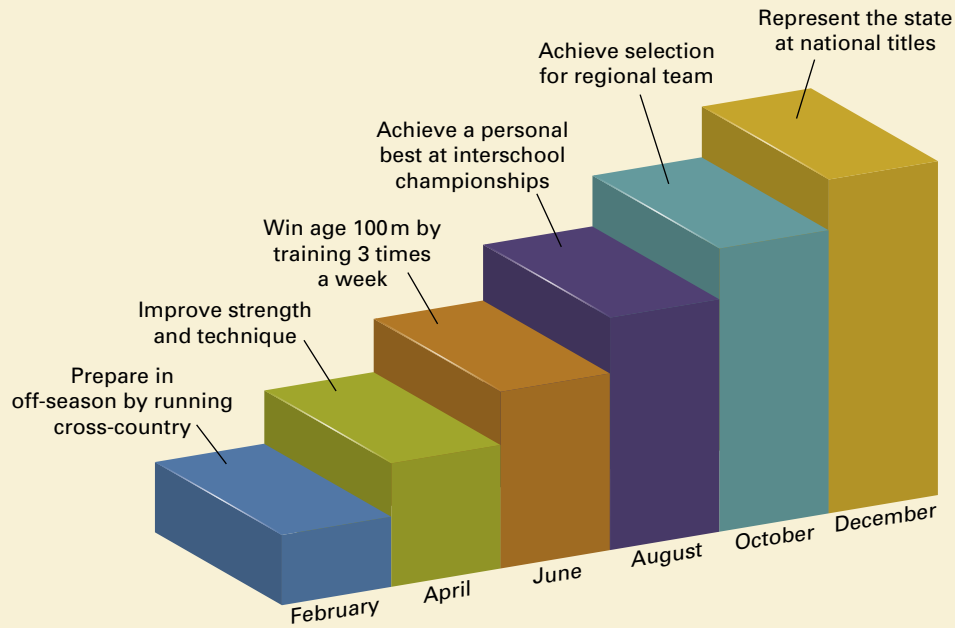

Figure 6.6 The staircase model of short- and long-term goals

Effective goals should be SMARTER

Specific: Exactly what do you want to achieve?

Measurable: How will you know when you have reached your goal?

Achievable: Do you have the desire and ability to achieve this goal?

Realistic: Are you prepared to spend time and effort to make your goal a reality?

Time-framed: When do you aim to achieve the goal?

Evaluate: Goals needs to be constantly evaluated and adjusted to reflect your progress.

Recorded: Prioritise your goals by writing them down and sharing with your coach and team members.

Source: Adapted from *Wisemove Leaders Handbook*, Womensport & Recreation South Australia

Figure 6.7
Jessica Watson, solo long distance sailor

SNAPSHOT

Olympic athletes' perceptions of goal setting

Robert Weinberg is a professor in physical education, health and sport studies at Miami University in Oxford, Ohio. He has over 30 years experience in applied aspects of sport psychology and has been voted by his peers as one of the top 10 sport psychologists in North America. A study* he conducted explored the perception of Olympic athletes concerning the frequency and effectiveness of goal-setting strategies, as well as goal preferences and barriers to achieving these goals.

Olympic athletes (185 male and 143 female) from a variety of sports completed a questionnaire detailing their perceptions, use and effectiveness of a number of different goal-setting strategies. Descriptive results revealed that all of the Olympic athletes practised some type of goal setting to help enhance performance, and they found their goals to be highly effective. Athletes also reported that improving overall performance, winning and having fun were the three most important goals. In addition, setting difficult goals that were somewhat above the level at which they perform was the most preferred level of goal difficulty.

* RS Weinberg, D Burton, D Yukelson and D Weigand, 2000, 'Perceived goal setting practices of Olympic athletes: an exploratory investigation', *The Sport Psychologist*, 14(3)

Coaching styles

Coaching style refers to the distinctive behaviours that characterise coaching practice. All coaches bring a different coaching style to their profession. This is partly a reflection of their different personalities as well as their experience and knowledge of their sport. This section looks at skills common to effective coaches and some of the different coaching styles.

The Australian Coaching Council's Level 1 coaching manual suggests there are five coaching styles: authoritarian coach, business-like coach, nice guy coach, intense coach and easy-going coach. You may be able to identify the style of a particular coach you know. These five styles are primarily descriptors of the individual coach's leadership style and personality rather than the skills they exhibit. To get a better idea of what actually constitutes an effective coach, a study by Amorose and Horn (2000) observed that coaches who exhibit a leadership style characterised by low levels of autocratic behaviour and who provided high frequencies of positive, encouraging and informational feedback and had low frequencies of ignoring players' successes and failures may create an environment that facilitates the development of intrinsic motivation in their athletes.

Another way to consider coaching styles is to look at the instructional methods used by the coach. Coaches may have a preference for a particular style but with practice can develop a repertoire of different instructional approaches. The many different approaches to teaching were identified by a well-known researcher of teaching called Muska Mosston. His research, which spans 30 years, developed a spectrum of teaching styles that move from instructor centred to learner centred. There is no approach that is considered better than the other, they are simply alternatives that would better suit a particular learning outcome.

The 11 styles rest along a continuum with command style at one end and self-teaching style at the other.

The command style originated from the introduction of military fitness drills led by Commonwealth defence forces in Australian government schools in 1871. The hallmark of this style is the instructor leading the activity, followed exactly by the participants. This style of instruction is still used today. At the other end of the spectrum is the self-teaching style, in which the learner decides whether or not to involve the teacher in the teaching process and decides what they will learn.

Figure 6.8 Different physical education teaching styles

Teaching style	Description
Command style	The teacher breaks down the skills into parts and demonstrates the right way to perform the skill. Students try to move exactly when and how the teacher tells them. The teacher provides feedback and the students try to replicate the teacher's model.
Practice style	The teacher makes several stations in the gym where students work on different parts of a skill or different skills. Students rotate around the stations and do the tasks at their own pace. The teacher moves around and helps students when needed.
Reciprocal style	Two students work together on a task that the teacher has designed. One student practises while the other gives feedback to the partner. The students might use checklists to help provide accurate feedback.
Self-check style	Students work alone on a task and check their own work. The teacher might give them a checklist so that the students can provide feedback to themselves while they learn the task.
Inclusion style	The teacher designs a learning task and there are several levels of difficulty. Students choose the level at which they want to work. Students can decide to make the task easier or harder by changing levels of the task to suit their ability.
Guided discovery style	The teacher asks students to discover a solution to a movement problem. The teacher asks students a series of specific questions, and the students investigate possible answers by experimentation.
Convergent discovery style	Students try to learn a skill or concept by using logical reasoning. The teacher asks a question, and students try to reason and think about different solutions. By critically thinking about the question and trying solutions, students can discover the single, right answer.
Divergent discovery style	The teacher asks students to solve a movement question. The students try to discover different solutions to this question. There are multiple answers to the one question.

(continued)

Teaching style	Description
Learner-designed individual program style	The teacher selects the general subject matter, but the student makes most of the decisions about the learning experience. The student decides what will be learned within the teacher's guidelines and then designs a personal learning program in consultation with the teacher.
Learner-initiated style	The student decides what will be learned as well as how it will be learned. The teacher and student set some basic criteria, but the student is responsible for the decisions about how and what to learn. The teacher can help with information if the student needs it; however, the student still experiences increased independence.
Self-teaching style	The student decides everything about learning something new. They even decide if they want to involve the teacher or not. The teacher accepts the student's decisions about learning.

Source: compiled from M Mosston & S Ashworth, 2002, *Teaching Physical Education*, 5th edn, Pearson Education, publishing as Benjamin Cummings, San Francisco
http://www.spectrumofteachingstyles.org/

This continuum can further be divided into two distinct groups, namely reproductive and productive approaches, based on the degree of decision making of the performer. Reproductive approaches to coaching include styles A–E (see figure 6.9) and use a coach-centred approach. The performer reproduces the desired motor skill and the coach makes all of the decisions. Repetition and quality of practice are central to using this style. Examples of this style is pre-season training in which athletes are taken through fitness drills by a trainer, or repetitious serving practice in tennis.

In contrast, the productive approaches to coaching (styles F–K, figure 6.9) shift the focus to the performer, with the coach using a more democratic style. The coach involves the performer in the decision-making process and consequently aims to enhance their motivation through involvement in the learning process. An example of productive approaches includes Teaching

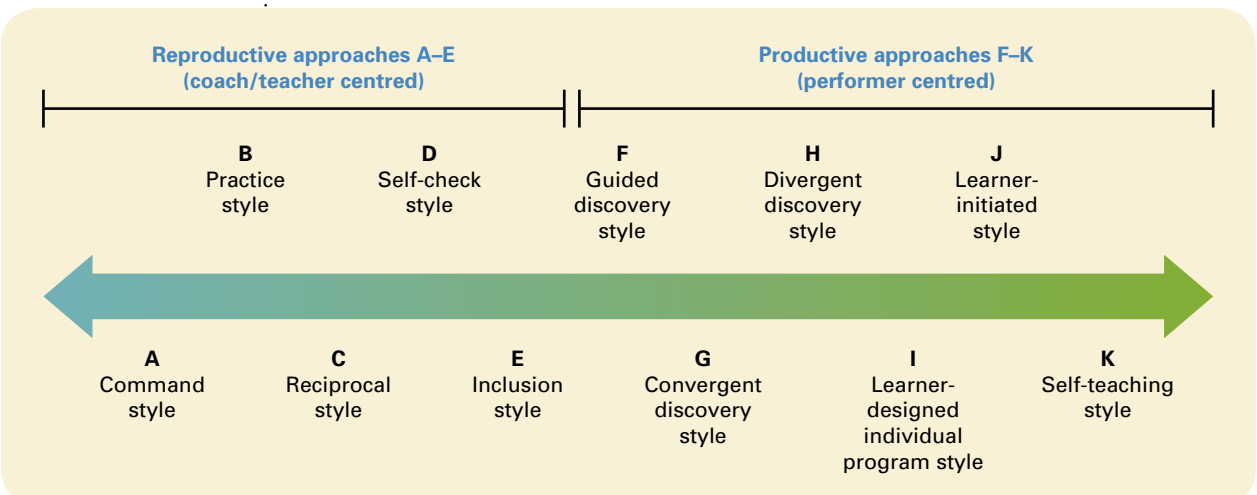

Figure 6.9 Continuum of teaching styles

Games for Understanding in which the performer needs to analyse, strategise and evaluate in order to determine the best possible way to outplay an opponent. Productive coaching aims to develop a thinking performer.

The teaching style that the coach selects depends on a number of factors: the pre-planned learning outcomes, the teaching content, the environmental conditions and the developmental stage of the learner. The following examples may better illustrate how these factors impact on a coach's decision for a particular teaching style over another.

Learning experience

You are the teacher/coach in the following scenarios. Apply your knowledge of the differing delivery styles of teaching to indicate whether a productive or reproductive approach would be more beneficial. Select which of Mosston's 11 teaching styles (i.e. command, inclusion, etc.) would suit the situation. Explain.

- Cricket trials for a large number of Year 5 students on an oval with limited space
- Athletics throwing events for Year 8 students
- Experienced senior players learning tactical skills in a team game
- Swimming lessons for beginners
- Teaching the cha-cha steps to a class of beginners
- Groups of three combine to create an attacking play in a team sport to draw the defence away from the scoring shot/goal

Characteristics of effective coaches

Growth in coach education courses and research on coaching highlights the importance of a quality coach as central to the learning process. Like teaching, coaching requires certain characteristics to be effective.

Effective coaches:

- provide positive feedback frequently
- provide a high level of technical corrections
- use higher order questioning (develop a thinking player)
- are predominantly engaged in instruction
- are organised in their management of the environment
- are good communicators
- are good leaders
- are also good teachers
- are reflective on their practices.

You may wish to contribute characteristics that you consider important.

Chapter review

Team cohesion, goal setting and coaching styles

Know	1	Identify three different types of goals.
	2	Why should outcomes goals not be the only kind of goals set by a player?
Comprehend	3	Explain Mosston's teaching style spectrum in terms of involvement of the performer in the decision-making process.
	4	Observe a physical education lesson or coaching session. Identify the teaching style/s used in this session. Outline alternatives to this lesson that would incorporate a productive coaching approach.
	5	As part of the process of developing team cohesion, it is recommended that team members 'get to know' each other. Develop some ice-breaking and team-building activities that can be implemented at training sessions that would develop team cohesion.
Apply	6	Develop and implement a goal-setting program for a training season with a team in which you are involved. Before beginning this activity establish some basic principles for goal setting using the SMARTER acronym as a guide.
Analyse Evaluate Synthesise	7	At the start of the season you are appointed as the coach of a team that has lost all of its matches in the previous season. Members of the team are not really looking forward to another season. From observation at the first training session it is evident that they don't really put in much effort to their training, but their skills aren't too bad. Develop a focus for the season by implementing effective goal-setting techniques. This could include strategies that focus on developing team cohesion. Report on how these strategies would be implemented over the course of the season and list the measurable indicators of performance.

Biomechanics

HOW DO BIOMECHANICAL UNDERSTANDINGS INFLUENCE THE LEARNING OF AND PERFORMANCE IN PHYSICAL ACTIVITIES?

chapter 7

Force

Newton's laws of motion

Sir Isaac Newton (1642–1727) discovered many of the fundamental relationships in mechanics that form a foundation for the analysis of human movement and physical activity. These understandings are encompassed in Newton's First Law of Inertia, the Second Law of Acceleration and the Third Law of Action and Reaction, each of which will be dealt with in the following chapters. These laws help us to understand how the application of force to a body determines the movement of the body and how we can make such movement more efficient. On the basis of this understanding, we can develop new skills, detect errors in performance, improve safety, assist in preventing injury, and develop new equipment designs. Importantly, such an understanding also gives athletes a reference point from which to begin asking questions about their skills, enabling coaches to ask relevant questions with regard to successful skill performance in their sport.

Linear forces

No movement can be started without the application of a force. When a runner wants to leave the blocks, they must exert a force against the blocks. When a footballer wants to push an opponent out of the way, they must exert a force against the opponent, and when an archer wants to shoot an arrow, they exert a force to pull back the bowstring. **Force** can therefore be defined as a pushing/pulling or hitting/throwing action that is applied to an object to start movement, stop movement or cause changes in movement. Typical forces include gravity, friction, buoyancy, air resistance and lift.

A **force** is that which causes a change in a body's motion or shape; force gives a mass a given acceleration.

Newton's Second Law of Acceleration ($F = ma$) states that the acceleration of an object is proportional to the applied force and in the same direction.

Newton's Second Law of Acceleration states that:

Any change in motion is directly proportional to the applied force and is made in the line of the force.

This law is expressed by the following formula:

$$F = ma$$

where F = force
m = mass
a = acceleration

When a batter in cricket applies a hitting force to a cricket ball, the ball will immediately move off the bat (see figure 7.1). The amount of force created

by the bat is equal to the force taken up by the ball. Because the ball is now in motion, its force can be described in terms of its mass and **acceleration** away from the bat. Force is measured in units called the **newton (N)**. For example, an individual weighing 70 kg and subject to the acceleration of gravity at 9.8 m/s^2 would have a weight force of 686 N.

Acceleration is the rate at which velocity is increased. If velocity is increased by 2 m/s, the acceleration is said to be 2 m/s/s. The first 'per second' refers to the velocity, and the second 'per second' gives the unit of time in which the additional amount of velocity is added on.

Newton (N) is the unit of force. 1 N is the force required to give an acceleration of 1 m/s^2 to a mass of 1 kg.

Figure 7.1
Cricketer Michael Clarke driving the ball

The mass of a hockey ball stays the same during a game of field hockey. Therefore, if a hockey player doubles the force of a hit by doubling the swing speed, the acceleration of the ball off the stick will also double (see figure 7.2). If a shotputter applies the same force to the shot at each attempt, but experiments with shots of varying mass, the picture will change. Let's say the shotputter first selects a 6 kg shot and then one of 3 kg. As the mass of the second shot is half that of the first, and given that the same force is applied, the acceleration of the second shot would be double that of the first. This is known as the inverse relationship in Newton's Second Law.

Tennis racquets made of graphite and/or titanium are extremely light (but very strong). When they are swung with a given force, their acceleration is greater than the acceleration of a heavier racquet swung with the same force.

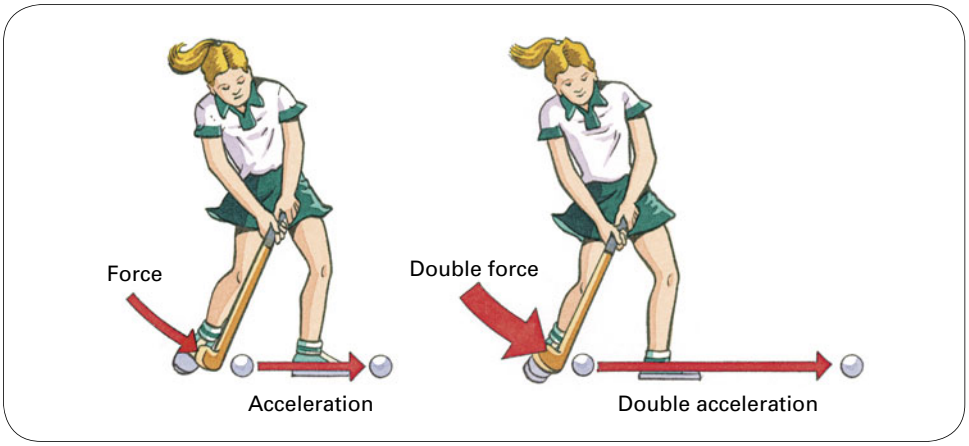

Figure 7.2
The effect of doubling the force of a hit in field hockey

Figure 7.3
BMW Oracle USA 17 in the first race of the 33rd America's Cup

In the America's Cup yacht race, the 2010 final between *USA 17* and *Alinghi 5* from Switzerland featured two multihulled yachts. The major problem facing the design teams of such yachts is the need to make the boat strong and stiff yet keep the mass as light as possible to enhance its acceleration and ultimately its speed. This balance between strength and mass is particularly crucial given the punishing winds and waters the yachts can experience.

The winner, *USA 17*, was designed by aeronautical engineers using exotic high-tech materials. The hull, bulkheads and skins of the trimaran were made from hundreds of layers of composite carbon structure with a honeycomb core. The 60 m frame is made from carbon fibre and kevlar. It weighs about 3500 kg and is an engineering marvel. Even the trampoline net between the hulls, which is used by the crew to move from one side to the other and to stow sails on, was cut down to a very small longitudinal strip right along the main hull, in an effort to cut weight and windage. The 'rigid' wing sail, unlike the normal 'soft' sail is about twice the span of a Boeing 747 wing.

The tolerance levels of these racing craft are so fine that such lightweight yachts are liable to crack open and sink as did *Australia 1* in 1995, *Young America* in 1999 and *Stars and Stripes* in 2003.

Formula 1 racing cars are also made of high-tech materials. The Renault F1 R29, driven by Mark Webber, which has a mass of 605 kg with driver, water and oil, has a carbon fibre chassis and aluminium honeycomb composite structure (see figure 7.4). Each car is made of 9000 different components, and many have a carbon fibre steering wheel. To save weight, the gearbox is also made of carbon–titanium casing, with increased use of aluminium and magnesium. Even the engine has low-mass components made from ceramics that are very strong, yet light, with less force required to accelerate them.

Figure 7.4 Renault F1 R29 racing car

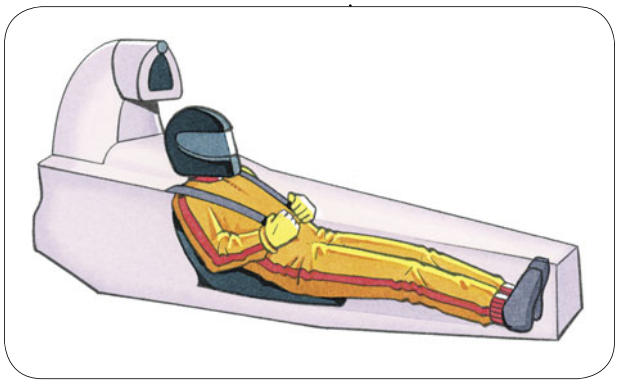

Figure 7.5 These drivers are cocooned in an immensely strong 'survival cell' of space-age materials such as kevlar (which is very strong and resistant to high temperatures) and carbon fibre.

SNAPSHOT

Melissa Wu, an Australian diver, is only 135 cm tall and here she has just dived off the 10 m diving platform. Her anthropometric qualities (i.e. size and proportions) give her many potential advantages in competition. A light frame gives her a high power to weight ratio, increasing acceleration off the board and, as a result, greater height and time in the air. A shorter stature and shorter limbs, enables faster rotations and a greater number of rotations in the air, with reduced shoulder cross-section on entering the water, enabling a cleaner entry.

Figure 7.6 Australian diver Melissa Wu

Learning experience

WRITTEN RESPONSE: LINEAR FORCE

1. A soccer player kicks a soccer ball weighing 0.5 kg with an acceleration of 60 m/s^2. What is the force of the kick?
2. A high jumper applies a force of 1000 N to the ground, which produces an acceleration of 15 m/s^2. What is the mass of the high jumper?
3. A golfer applies a force of 1000 N to a golf ball of mass 0.05 kg. What is the acceleration of the ball off the clubhead?
4. A baseball pitcher increases the force of a pitch from 800 N to 1000 N. Given that the baseball weighs 0.14 kg, what is the acceleration of the ball for each pitch?
5. To execute certain dives it is important for the diver to obtain maximum height off the diving board. Describe how each of the following variables of force, mass and acceleration ($F = ma$) could be manipulated to achieve maximum height?

Turning forces

The **centre of gravity** is the point on a body at which the Earth's gravitational pull is concentrated.

A **concentric force** is a force applied through the centre of gravity of an object causing it to translate.

When a force is applied to an object through its **centre of gravity** (almost synonymous terms are 'centre of weight' or 'centre of mass'), the object will move in a straight line. Another way of saying this is that the object will *translate*. This type of force is known as a **concentric force**. The term indicates that all parts of the object to which the force is applied will move in the same direction, without rotation. For example, a rugby player tackled through the centre of gravity will be pushed backwards in a straight line, without the body rotating (see figure 7.7).

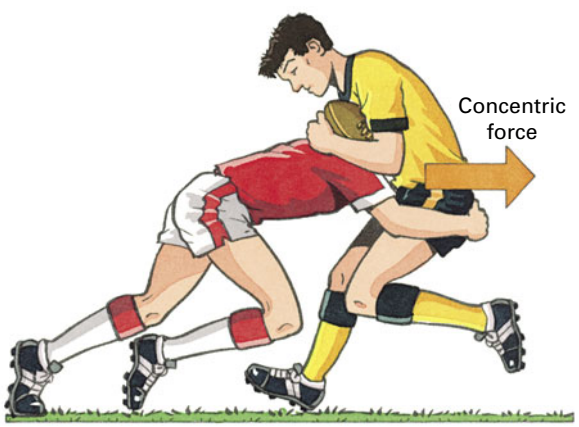

Figure 7.7
A rugby player is being tackled through the centre of gravity, resulting in the body moving straight backwards without rotation.

An **eccentric force** is a force applied to one side of the centre of gravity causing the object to rotate. If the axis is not fixed, the object may both rotate and translate.

To rotate an object, a force needs to be applied to the object away from, or to one side of the centre of gravity or pivot point. This is known as an **eccentric force**. For example, when a rugby player tackles an opponent around the ankles, the motion at the ankles is arrested and they become the pivot point for rotation (see figure 7.8). The opponent's body will then rotate and fall forwards

around this pivot point. The closer the tackle to the feet, the greater will be the rotation and the faster the player will fall. However, the tackler needs to be careful that the opponent's feet don't slip from their grasp!

Figure 7.8
Mirco Bergamasco, an Italian rugby union player, being tackled. The low tackle is made around the thigh, the hands then progressively sliding down the leg to the ankles. This ensures that the player will rotate forward, and is 'brought to ground', before reaching the try line.

Moment of force

To calculate the turning force that causes rotation, we need to calculate the **moment of force** (T). To do this you must identify:

1 the force and its magnitude
2 the force line
3 the axis of rotation
4 the moment arm and its length.

$$T = Fd$$

where T = moment of force
F = force
d = moment arm

Moment of force ($T = Fd$) is equal to the force applied to an object multiplied by the length of the moment or turning arm.

If a diver lets their body simply rotate off the diving board (without any leg drive), then for as long as they are in contact with the board their feet act as the fixed pivot point (see figure 7.9). Gravity is the only force that can be used to produce rotation, and the force line or direction of the gravity force acts through the centre of gravity of the body. The moment of force of the diver is the gravity force multiplied by the shortest distance from the **gravity line** to the pivot point, the feet. This distance is known as the moment arm. As the force of gravity is constant, the longer the moment arm, the greater the rotation of the diver. Given that the gravity force for the diver in figure 7.9 is

The **gravity line** indicates the direction of the gravity force passing through the centre of gravity of a body.

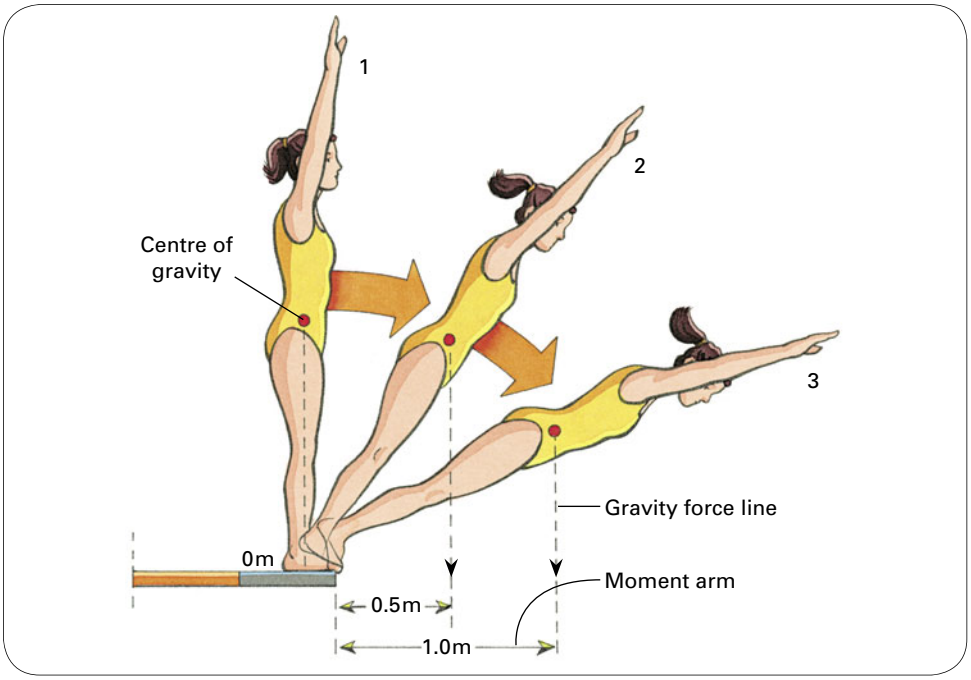

Figure 7.9
A diver letting the body simply rotate forward off the board with no leg drive

500 N, then the moment of force for the diver in position 2 would be 250 Nm, and 500 Nm in position 3. In position 3:

$$T = Fd$$
$$= 500\,\text{N} \times 1.0\,\text{m}$$
$$= 500\,\text{Nm}$$

When the diver drives off the board in a back dive (see figure 7.10), an additional moment of force is brought into play. The arrow in front of the diver represents the vertical force exerted by the diver, and the moment arm is the shortest distance from the force line to the centre of gravity. The sum of these two moments of force will give us the diver's total turning force—in this case 70 Nm, as shown below:

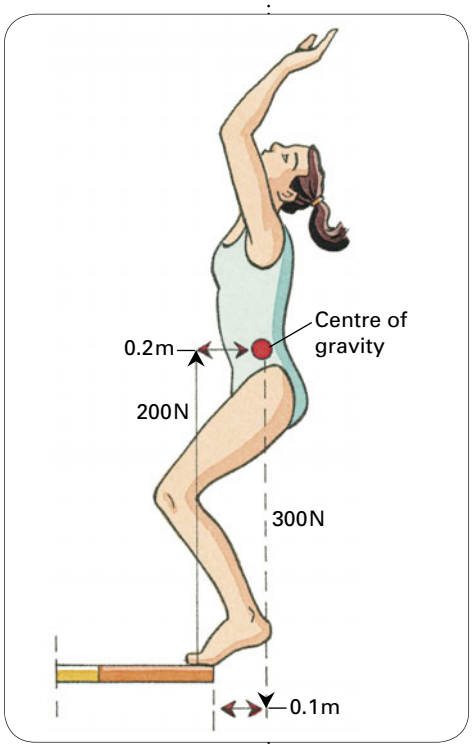

Figure 7.10
A diver pushing off the board in a back dive

Moment of force due to gravity	+	Moment of force due to leg drive
$T = Fd$ $= 300\,\text{N} \times 0.1\,\text{m}$ $= 30\,\text{Nm}$		$T = Fd$ $= 200\,\text{N} \times 0.2\,\text{m}$ $= 40\,\text{Nm}$

Learning experience

LABORATORY RESPONSE: MOMENT OF FORCE

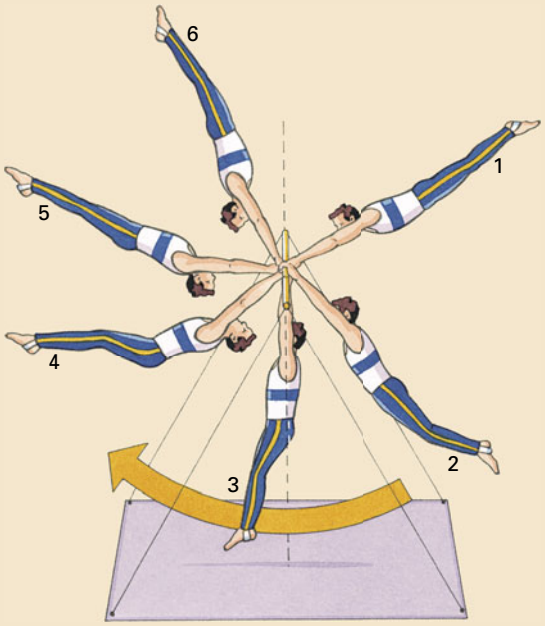

Figure 7.11 The diagram shows a gymnast performing a giant circle on the horizontal bar.

For each position 1–6 of the gymnast:

1. Mark the centre of gravity of the gymnast with a dot.
2. Draw a line vertically through the dot to represent the line of the gravity force (gravity line).
3. Draw a line horizontally from the gravity line to the vertical dotted line on the diagram. This horizontal line is the turning or moment arm.
4. To calculate the moment of force:
   - **a** Measure the length of the moment arm in millimetres. This raw figure can be used simply as a practice exercise in using the formula, or you can scale it up to a real figure. (Use a scale of 10 mm to 1 m.)
   - **b** Assume the gymnast has a gravity force of 700 N (this, will be the same for all positions).
   - **c** The moment of force of the gymnast can now be calculated for each position.

     Moment of force = force (gravity) × moment arm.

Remember, the figure for moment of force represents the acceleration of the gymnast at a given position and not the velocity.

Action and reaction forces

Linear motion

Newton's Third Law of Action and Reaction states that:

For every action force or momentum, there is an equal and opposite reaction force or momentum.

According to Newton's Law of Action and Reaction, the forces that two bodies exert on one another are:

- opposite in direction
- equal in magnitude.

Newton's Third Law of Action and Reaction ($F = -F$) states that every force produces an equal and opposite force.

Figure 7.12
When AC Milan's forward Marco Borriello heads a soccer ball, the ball receives a force from his head, and his head receives a force from the ball.

We have a general understanding of this law through our own everyday experiences. For example, heading a soccer ball that is wet and heavy can hurt your head. The ball not only receives a force from the head, but the head also receives a force back from the ball (see figure 7.12).

No direct contact

The action–reaction effect can occur without the objects actually coming into direct contact with each other. In the freestyle stroke in swimming (see figure 7.13), the action force of the hand causes a reaction force in the body, moving the body past the place where the hand applied the force. The reaction of the body equals the force applied by the hand.

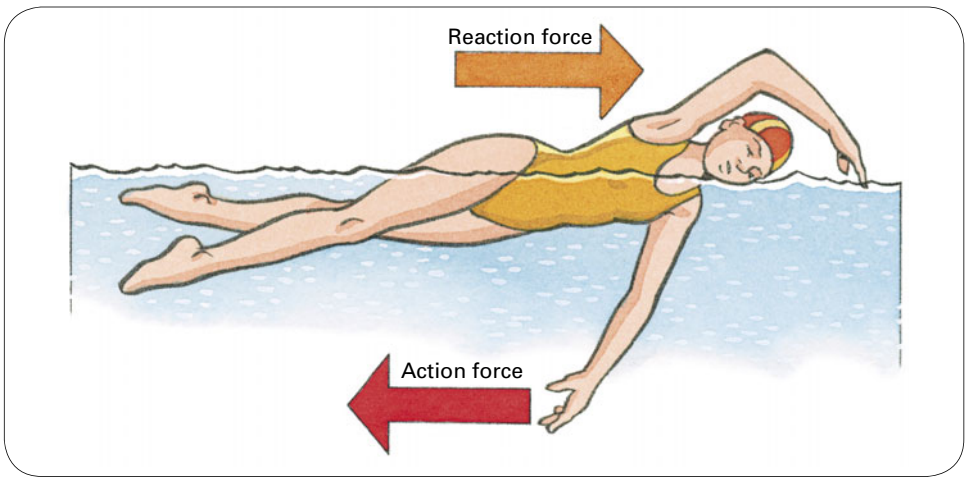

Figure 7.13 Action and reaction forces in swimming freestyle

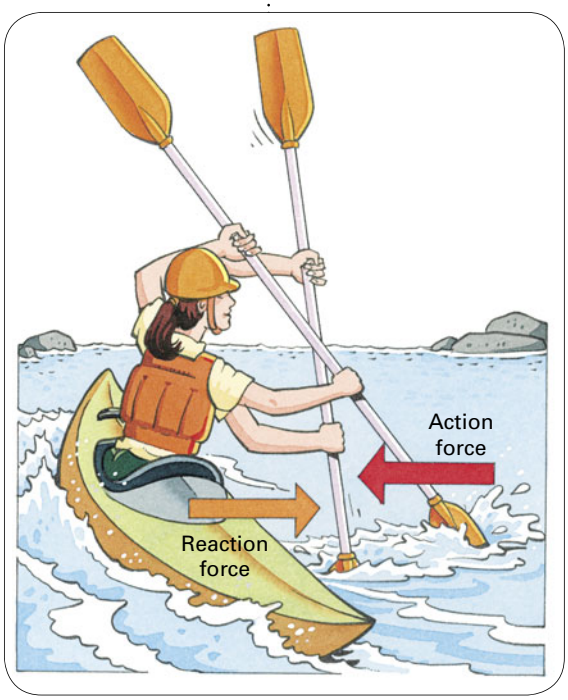

Figure 7.14
Action and reaction in the draw stroke in canoeing

The situation is similar for a canoeist performing the draw stroke (see figure 7.14). An action force is applied by the paddle as it is drawn towards the canoe; the canoe reacts by moving in the opposite direction towards the paddle. The reaction force of the canoe equals the force applied by the paddle.

Direct contact

Just before release of the ball in a throwing action (see figure 7.15), the hand exerts a linear action force on the ball and the ball reacts with a linear force of equal magnitude back onto the hand. The effect of the ball's reaction on the thrower's body is quite small because of the much greater mass of the body, but it will still cancel out some of the forward force being generated by the thrower. The thrower should therefore plant their feet firmly on the ground and stabilise them, adding the great mass of the ground to that of the body. This will help to overcome the effect of the reaction force.

Rotational motion

In rotational motion, the two objects involved in action and reaction are almost always body parts. This is because almost every sport skill requires rotational movements of body parts around a joint to create **momentum**.

Before an analysis of any rotational action–reaction effect, it is important to identify:

- the body part initiating the action
- the body part responding to the action
- the hinge around which both body parts rotate.

For example, when a soccer player jumps to head a ball, the upper body initiates the action, the lower body responds to the action, and the hips act as a hinge (see figure 7.16). Because the player initiates the action by deliberately forcing the upper body at the ball, this is known as the 'action force'. The response of the lower body is called the 'reaction force'.

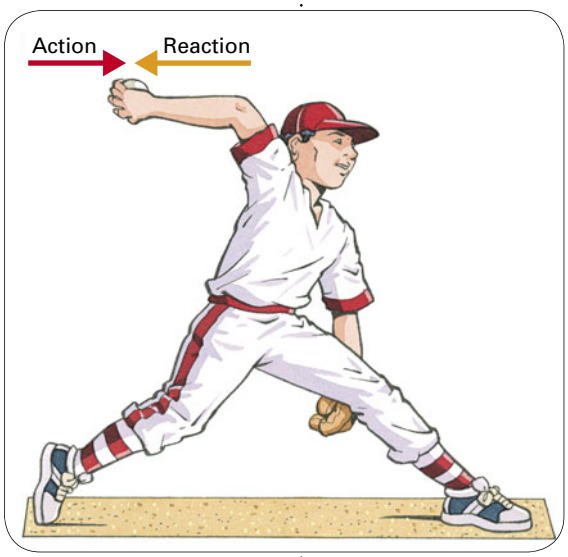

Figure 7.15 A baseballer throwing the ball plants the foot firmly on the ground to help overcome the reaction force.

Momentum is a quantity of motion. It equals the mass of a body multiplied by its velocity (momentum = mass × velocity).

Direction and magnitude

When one body segment hinges around another, action and reaction occur in the same pathway. Note that in rotational action and reaction, the direction of the forces are specified as clockwise or anticlockwise.

For example, if an action force is exerted in a clockwise direction by the upper body (e.g. in a soccer heading action), the reaction force in the lower body will act in an anticlockwise direction (see figure 7.16). However, if an action force is exerted in an anticlockwise direction by the upper body (e.g. when marking the ball in Australian Rules football), the reaction force in the lower body will act in a clockwise direction (see figure 7.17). The reaction of the lower body will be equal in magnitude to the action of the upper body and will occur in the same vertical pathway.

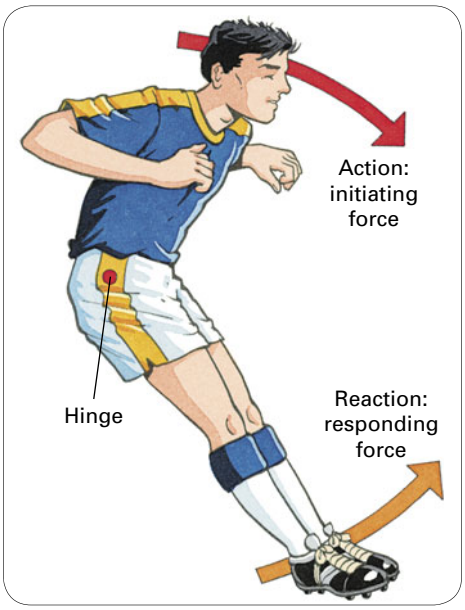

Figure 7.16 Action in the upper body and reaction in the lower body when heading a soccer ball

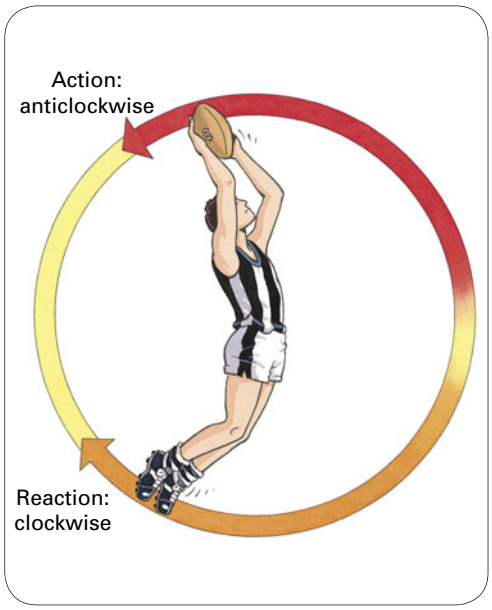

Figure 7.17 Action in the upper body and reaction in the lower body in a mark in Australian Rules football

SNAPSHOT

Figure 7.18
Mile Sterjovski, Australian soccer player

Mile Sterjovski is seen playing for Australia against Ghana at the Sydney Football Stadium and about to shoot for goal.

Here he is demonstrating a kicking technique that ensures optimum force while maintaining good balance. The kicking leg provides the action force while the upper body and arms provide the reaction force. This is achieved by twisting the arms and shoulders in the opposite direction to the kicking leg. Note how the fingers point in the direction of the shoulder turn, ensuring that they lead the dynamic turn in the opposite direction. In addition, the leg is performing the action in a near horizontal pathway and this is replicated, as it must be, by the arms also turning in a near horizontal pathway. The head is in the neutral position and the eyes are concentrating on the ball. A beautiful performance!

Balance

The action and reaction effect can be exploited to regain balance. For example, if the arms of a gymnast walking on the beam initiate an action force by rotating anticlockwise, the hips will react in a clockwise direction (see figure 7.19). This reaction will rotate the hips up and over the beam again.

In race walking, the arms counterbalance the legs (see figure 7.20). The leg in recovery has a slight outward then inward rotation. The reaction to this is an outward then inward rotation of the opposite arm. This serves to balance the walker and to make it easier to move in a straight line. This kind of action and reaction is very highly developed in speed ice skating, where the arms show an exaggerated movement in reaction to a very wide, exaggerated push from the legs.

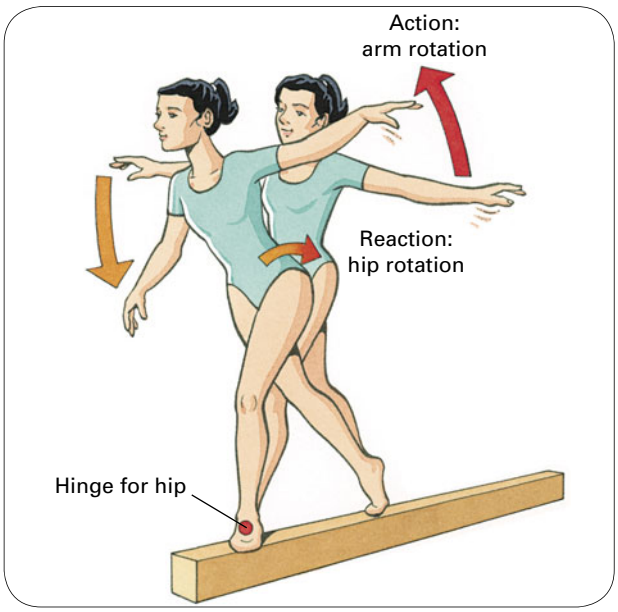

Figure 7.19 Action by the arms and reaction by the hips in a gymnast balancing on the beam

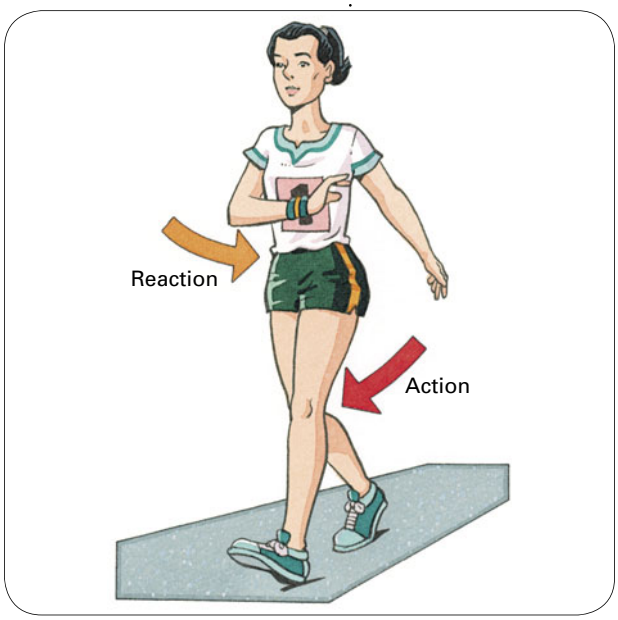

Figure 7.20 Action in the recovery leg and reaction in the opposite arm of a race walker

Learning experience

LABORATORY RESPONSE: ACTION AND REACTION

Figure 7.21 shows a cue ball in snooker sliding (no rotation) into a stationary object ball. This is an example of linear action and reaction.

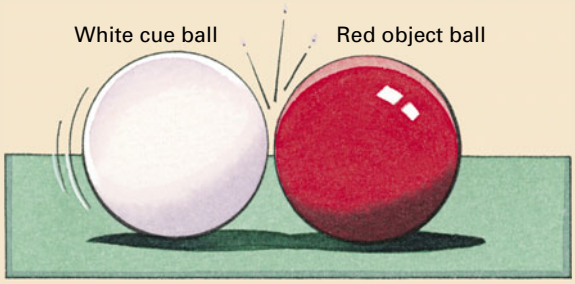

Figure 7.21
A cue ball hitting a stationary object ball in snooker

1. For the cue ball draw an arrow to show the direction of the action force and for the object ball draw an arrow to show the direction of the reaction force. Let the length of each arrow represent the magnitude of the action and reaction forces.
2. If the action force for the cue ball is 80 N what would be the reaction force of the object ball?
3. Describe precisely the behaviour of the cue ball and the object ball before, during and after the collision.
4. If the object ball receives a force of 90 N and it has a mass of 0.2 kg, what would be it's acceleration away from the cue ball?

The long jumper is shown performing a one and a half hitch kick. This is an example of rotational action and reaction. The hitch kick is designed to overcome the forward rotation of the body generated at take-off and place the jumper (in particular the legs) in the most desirable position for landing. The hitch kick is a skill based entirely on the action and reaction principle.

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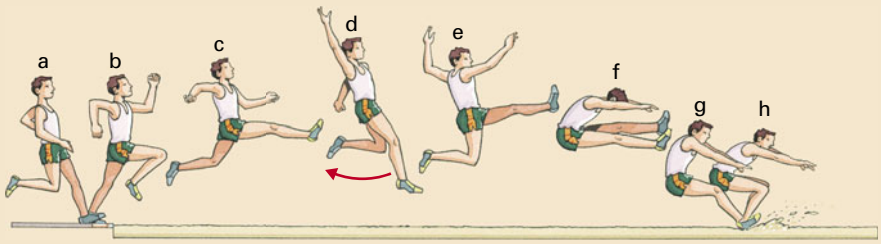


Figure 7.22
A long jumper performing a one and a half hitch kick

1 The hitch kick is initiated in position **d** with a strong backward drive of the foot and leg. The arrow shows the direction of the action force of the foot and leg as it drives backward. With an arrow show the direction of the reaction force of the upper body in response to this action force.
2 If the jumper used a cycling arm action, what would be its direction in relation to the direction of the action force of the foot and leg?
3 What is the purpose of the hitch kick and thereby the action and reaction forces in producing a longer jump? Consider the position of the feet and legs on landing.
4 Biomechanically, how could the jumper increase the action force of the leg and thereby the reaction force of the upper body? Give two examples.

Impact forces

This section focuses on collisions between a ball (or similar object, e.g. an ice hockey puck) and a striking implement, such as a racquet or bat.

The velocity with which a ball leaves a striking implement will be determined by the following factors:

- the elasticity of the ball and of the implement
- the materials from which the ball or implement is made
- the closeness of the ball to the centre of percussion or the 'sweet spot'
- the effective mass of the player's body or body segments.

Elasticity

In theory, a perfectly **elastic** ball would rebound to its original height. A perfectly **inelastic** ball will not rebound at all.

When a ball collides with a surface, it becomes compressed and then, due to its elasticity, expands back into its original shape and rebounds. If the ball were perfectly **elastic**, no energy would be lost during this compression and expansion and it would rebound to its original height. No such ball has yet been made, although a superball can rebound to almost its original height. If, on the other hand, the ball were made of putty, it would be perfectly **inelastic**, or plastic, and would not rebound at all (see figure 7.23). All its energy of motion (called 'kinetic energy') would be lost.

Coefficient of restitution

The **coefficient of restitution** of a ball is the square root of the rebound height divided by the drop height.

All balls and bats used in sport fall somewhere between these two extremes of elasticity. In everyday terms, the elasticity of a ball is measured by its bounciness, and a bat by its springiness. Technically, the elasticity of a ball or implement is known as its **coefficient of restitution** (e):

$$e = \sqrt{\frac{\text{height of rebound}}{\text{height of drop}}}$$

Coefficients of restitution of different kinds of balls dropped the same distance onto a rigid wooden floor are given in figure 7.24 (on page 119).

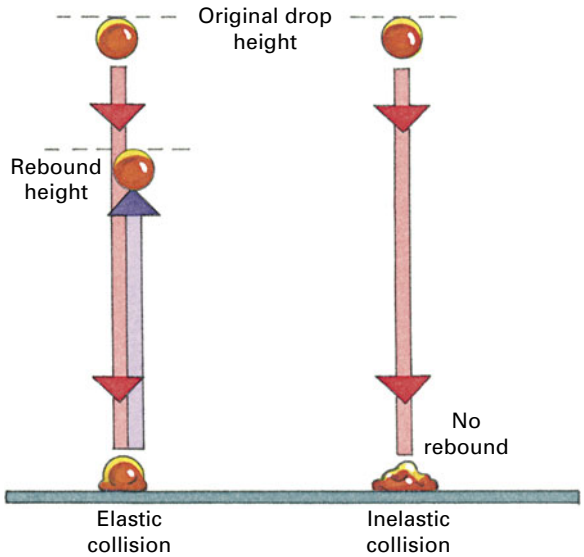


Figure 7.23 The difference between an elastic collision and inelastic collision

Figure 7.24 The coefficient of restitution of different types of balls dropped from a height of 1 m onto a rigid wooden floor

Type of ball	Coefficient of restitution *e* (height of drop 1 m)
Super ball	0.90
Table tennis ball	0.80
Soccer ball	0.75
Golf ball	0.60
Squash ball	0.50
Field hockey ball	0.30

As no ball or bat is perfectly elastic, some energy will be lost at impact. When a squash ball is hit against the front wall, the impact literally squashes and violently distorts the ball. The ball compresses and then tries to reassert its original shape, and in the process some small amount of elastic energy is lost. Some is converted to heat energy, as you will know if you have ever felt a squash ball during a game. The heat increases the pressure inside the ball and makes it play faster than when it is cold. However, even when hot, it will not be perfectly elastic.

The coefficient of restitution will increase when a ball:

- heats up
- hits a springy surface.

The coefficient of restitution will decrease when a ball:

- cools down
- gets older
- hits a surface at extremely high velocity.

Elastic materials

The materials from which a ball or implement is made will affect its bounciness or springiness. For maximum bounciness or springiness, the important issue is the ability of the ball or implement to restore itself rapidly to its original shape. For this to occur, a ball must be made from highly elastic materials (e.g. a golf ball with a titanium core) and/or it must have a high internal air pressure (e.g. a tennis ball).

A new type of soccer ball, called the 'Jabulani', was used in the 2010 World Cup in South Africa. This ball has fewer panels for power, is light and made of very elastic materials and so has a high coefficient of restitution.

Restoration of shape

The measure of a field hockey stick's springiness is not how far the shaft can be bent, but the ability of the shaft to rebound and return to the straight position before the ball has left the stick. In fact the shaft should not bend much at all!

A golf ball has an impact time of only 0.001 seconds. In this time the ball must compress and then expand or push back against the clubhead (i.e. restore its original shape), to force itself off the clubhead (see figure 7.25). You cannot make any swing adjustments at impact—you do not have enough time!

Figure 7.25
A golf ball is compressed at the moment of impact with the club. The impact time is only 0.001 seconds. This ball is highly elastic (i.e. it has a high coefficient of restitution).

If the ball is still in the process of restoring itself after the collision is over, then some of the energy required to force it off the clubhead will be lost. To stop this happening, golf balls are now made from high-compression materials, such as titanium. These distort less on impact and restore rapidly to their original shape.

Learning experience

LABORATORY RESPONSE: COEFFICIENT OF RESTITUTION

Aim

To determine the coefficient of restitution of various kinds of balls and surfaces, and the effect of impact velocity on coefficient of restitution.

Equipment

- superball
- field hockey ball
- golf ball
- volleyball
- basketball

Procedure

Task 1

1 Drop each ball from a height of 1 m onto a hard floor. (Do not apply any downward force to the ball.)
2 Note the height to which the ball bounces.
3 Determine the coefficient of restitution for each ball and record the values in the table below.

Type of ball	Height bounced	Coefficient of restitution
Super ball Field hockey ball Golf ball Volleyball Basketball		

Task 2

4 Drop a basketball from a height of 1 m onto various different surfaces, e.g. wood, concrete, grass and astroturf.
5 Note the height to which the ball bounces.
6 Work out the coefficient of restitution for each surface and record the values in a table like this one.

Type of surface	Height bounced	Coefficient of restitution
Wood Concrete Grass Astroturf Other		

>>

Task 3

7 Drop a basketball from increasing heights (given in the table below) to determine the effects of velocity at impact on the coefficient of restitution.

8 Note the height to which the ball bounces each time.

9 Determine the coefficient of restitution for each trial and record the values in the table below.

Distance basketball dropped (m)	Height bounced	Coefficient of restitution
1.00		
1.25		
1.50		
2.00		

Conclusions

1 Discuss the results of task 1 in terms of the differences in coefficient of restitution.

2 Describe the effect of different surfaces on the coefficient of restitution of the basketball in task 2.

3 **a** In task 3, what was the effect of increasing the drop height on the coefficient of restitution of the basketball?

b Explain this result in terms of the elasticity of the basketball on impact with the floor.

Centre of percussion

Centre of percussion or 'sweet spot' is the impact spot on an implement where in a collision between bat and ball the hands will experience no jarring effect.

When a player swings an implement, the linear velocity at any point on the bat will increase as the distance from the handle to the head increases. In theory then, the highest linear velocity of the bat would be at the very end or head of the bat, and this would seem to be the appropriate point at which to hit the ball.

However, in practice we know that a ball hit right at the end of a bat or towards the handle will jar the hands. We also know there is a spot just before the end of a bat where the impact seems to be free of any jarring effect and the ball seems to fly off the bat. This spot is known as the **centre of percussion** or 'sweet spot'.

When the ball is hit at the centre of percussion, the sensation is smooth and full, and is often referred to as hitting the ball off the 'meat' of the bat. This can be demonstrated by suspending a baseball bat from a piece of string and hitting it at various points on the barrel (see figures 7.26 and 7.27). Any jarring or vibrating movements in the handle, which would ordinarily be absorbed by the hands, will now be easily observed at the end of the handle.

When the bat is struck through the centre of percussion, there is no vibration or jarring effect. In this case, the contact spot is close to the centre of gravity, causing the bat to take up a small rotation and move backwards in a straight line. The small backward rotation at the end of the bat will produce a less severe forward rotation at the handle. When the forward rotation of the handle cancels the backward linear movement of the handle, no vibration will be experienced at the handle.

Hitting the ball at the centre of percussion will produce the 'sweetest' hit, both in terms of force and accuracy and will eliminate the vibration or sting many players feel when they hit the ball at a wrong spot on the bat.

However, although the centre of percussion produces the sweetest sensation, the ball is normally hit slightly further towards the head of the implement where the bat is travelling faster. A small vibration will be

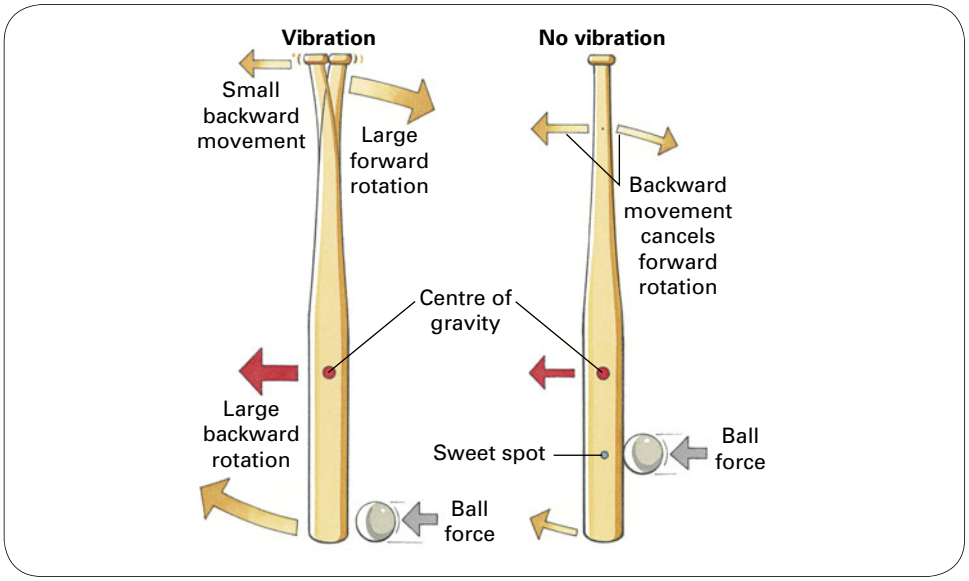


Figure 7.26
A suspended baseball bat is struck at the centre of percussion, or 'sweet spot' (right), and almost at the end of the bat (left)

tolerated to produce a faster swing velocity. In the case where little swing is evident, such as in a forward defensive shot in cricket, the best result will still be obtained by contacting the ball at the sweet spot.

Jumbo tennis racquets are so designed to increase the size of the sweet spot, a large area in the middle and towards the throat of the racquet. However, the sweet spot is only of practical value when the tennis ball is moving towards the racquet. When a tennis player serves, the ball is not moving from in-court towards the racquet, and therefore the sweet spot is irrelevant. It is now advantageous to hit the ball at the top of the racquet (referred to as the 'dead spot') where the racquet is moving with a higher velocity at the end of a longer lever, and momentum is simply transferred from the racquet to the ball (see figure 7.28 below).

Figure 7.27 Roger Federer hits a backhand volley on the 'sweet spot' of the racquet.

Figure 7.28 Serena Williams serving at the 2009 China Open, hits the ball on the 'dead spot' at the top end of the racquet. Note also how her non-racquet arm is held into the body, increasing the rotational velocity of the shoulders and the racquet arm.

Learning experience

LABORATORY RESPONSE: CENTRE OF PERCUSSION

Aim

To locate the centre of percussion, or sweet spot, of a baseball bat.

Equipment

- baseball bat
- string
- coloured sticky tape

Procedure

1. Balance a baseball bat horizontally on your finger to find the approximate location of the centre of gravity. Place a piece of coloured tape around the bat at this point.
2. Attach a loop of string to the top of the bat handle. Put your finger in the loop of string and suspend the bat so that it can swing.
3. Now take a solid object (e.g. another bat) and hit the baseball bat directly through the centre of gravity. Note what happens.
4. Hit the bat at the end of the barrel. Note what happens.
5. Hit the bat high up on the handle. Note what happens.
6. Now hit the baseball bat with the other bat, gradually working your way up from the end of the barrel. Note what happens in different positions.

Conclusions

1. What did you observe in relation to bat vibration in steps 3, 4 and 5?
2. In step 6, how did you know when you hit the bat through the centre of percussion?
3. Why is it important to hit the ball through the sweet spot on the bat?

Striking mass

Effective mass involves bracing a body part to ensure maximum transfer of force.

In the event that two footballers running at the same velocity collide with each other, then the player with the greater mass will overcome the player with the smaller mass. However, the situation is different if the defender has stopped running, propped and 'dug in'. Using the additional mass of the ground makes the smaller player's bracing action more effective. In this case, the **effective mass** encountered by the attacking player is therefore the defending player's mass plus that of the ground.

When a soccer player uses a straight approach to the ball, and kicks with the instep, the instep striking mass may be 3.9 kg. If the ball were to be kicked with the toe instead, the striking mass may be reduced to 2.4 kg, and ball velocity will have reduced by approximately one-third.

The concept of effective mass can also be applied to the number of body parts making a positive contribution to the impact. A tennis player performing a backhand volley (see figure 7.27) can hit the ball much harder if the arm and shoulder are braced before impact. The braced arm and shoulder, plus the racquet, constitute a more effective striking mass than if the arm and shoulder were more relaxed. In a roundhouse kick in tae-kwondo, it is important not only to develop high foot speed but also to brace the leg and ankle just before impact with the opponent's head. If the leg and ankle are not braced, and the opponent braces the neck muscles, then the kicker instead could injure their foot.

Balancing forces

Centre of gravity

It is important to know the position of the centre of gravity of a body so that its position can be tracked when the body changes shape or position. When a dancer moves at different angles to the floor, the centre of gravity will also be displaced in these directions (see figure 7.29). At the same time, changes to the shape of the body can cause the centre of gravity to change position in relation to the body mass. For example, in position A the centre of gravity is outside the body mass, whereas in position B it is within the body mass.

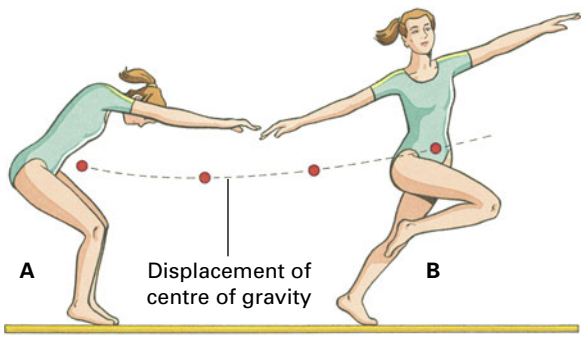


Figure 7.29
How the position of the centre of gravity changes as a dancer moves on the floor

When the dancer projects the body into the air, the path or direction of the centre of gravity cannot be changed unless an external force is applied (see figure 7.30). The path will be a symmetrical curve or parabola, with the angle at take-off being almost identical to the angle at landing (if air resistance is not taken into account).

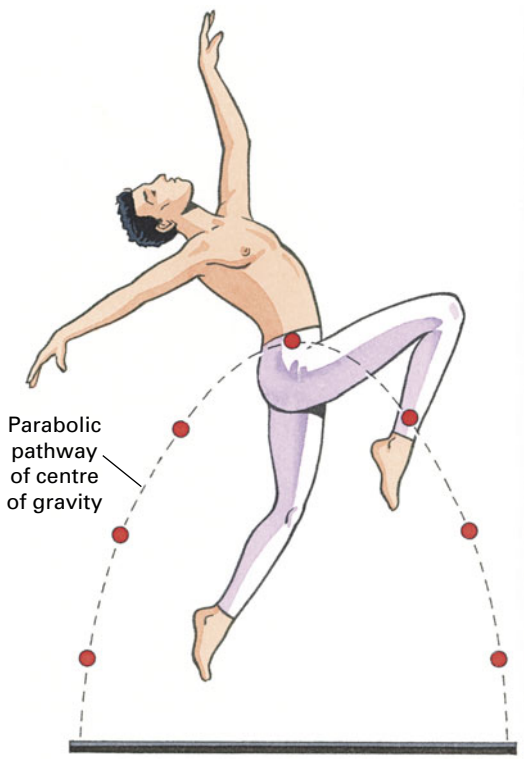


Figure 7.30
How the position of the centre of gravity changes as a dancer leaps into the air

The **effective base of support** is the distance between the gravity line and the pivot point over which the body destabilises.

Size of the base of support

To identify where the body weight is located in relation to the base of support, it is necessary to drop a plumbline, or gravity line, from the centre of gravity to the base of support (see figure 7.31). When this gravity line intersects the middle of the base, it tells us that the centre of gravity is centrally located and the balance should be secure. However, any movement of the gravity line towards the edge of the base would tend to make the balance more insecure.

The distance between the gravity line and the limit of the base is referred to as the '**effective base of support**'. This is because it is the actual or effective distance the body weight has to move before imbalance occurs.

The effective base of support will change if external forces are applied to the body (see figure 7.32). Two factors have to be considered:

- the direction of the force
- the pivot point over which the body rotates.

The pivot point may be a discrete point or a line joining two separate points. The pivot point in A and C is the side of the foot, whereas in B it is a line joining the heels of both feet. The body becomes unbalanced by rotating or hinging over these pivot points. As can be seen in figure 7.32, the pivot point changes according to the direction of the force.

When a rugby fullback wants to stop a slow oncoming forward, and perhaps even push the forward back in the opposite direction, the fullback needs to take up a very stable set position (see figure 7.33). To do this, the effective base must be enlarged by moving the body weight forward towards the front foot. This makes the effective base the distance from the gravity line (just inside the front foot) to the pivot point (the back foot). This is a very strong resistive base, and the forward would have to move the fullback's body weight a long way before destabilisation would occur.

A solid base like this would in some cases be inappropriate for the fullback, as a head-on collision with an oncoming player would involve such force that both players could be badly hurt. To remedy this situation, the fullback should move the body weight backwards in the direction in which the oncoming forward is travelling just before the instant of collision.

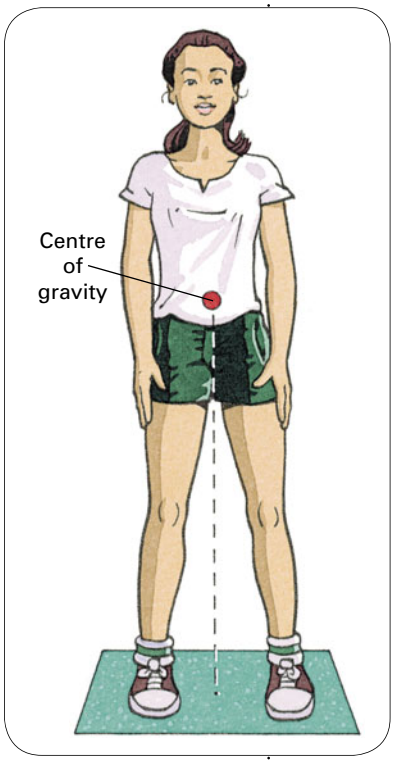


Figure 7.31
Determining the position of the gravity line in relation to the base of support

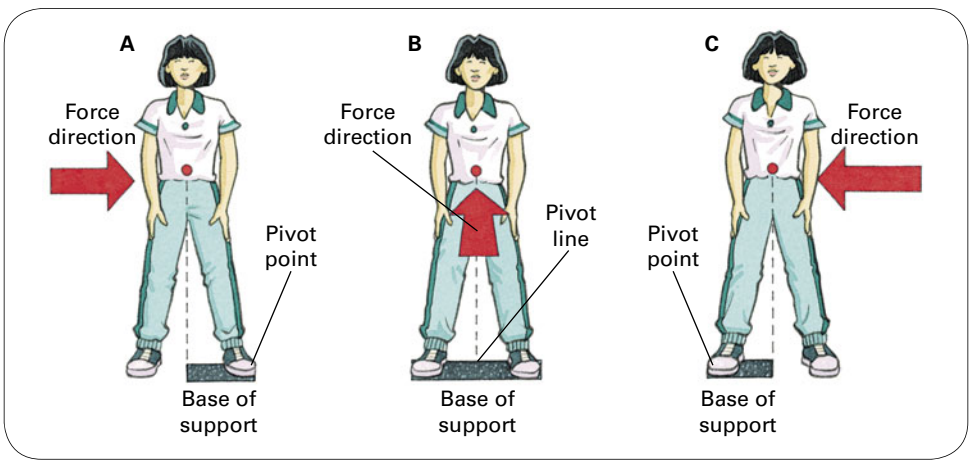


Figure 7.32
Changes in the effective base caused by external forces

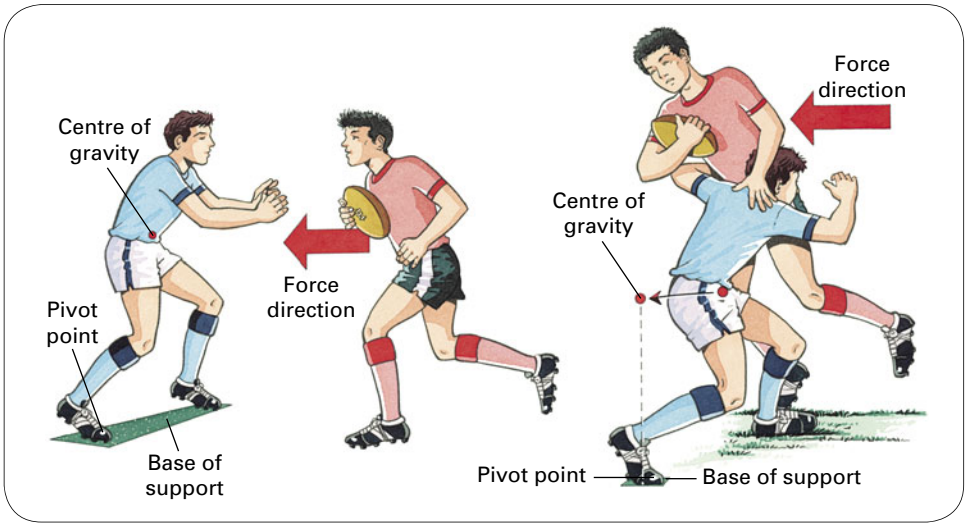


Figure 7.33
A rugby fullback tackling a slow oncoming forward

The tackle should be made at thigh level and slightly to the side so that the fullback falls backwards with the forward. This will still result in stopping and bringing the forward to the ground. In this case, the fullback is effectively decreasing his effective base and rotating over the pivot point, his back foot.

Figure 7.34
As a publicity stunt, two members of the English national ballet try to push over former English rugby union forward Jason Leonard. Note how he leans into the ballerinas by moving his body weight towards the front foot thereby increasing his effective base of support.

Height of the centre of gravity

The height of the centre of gravity also determines the security of the balance:

- The lower the centre of gravity, the greater distance the gravity line has to move before reaching the limit of the base, and therefore the more secure the balance.
- The higher the centre of gravity, the less distance the gravity line has to move before reaching the limit of the base, and therefore the less secure the balance.

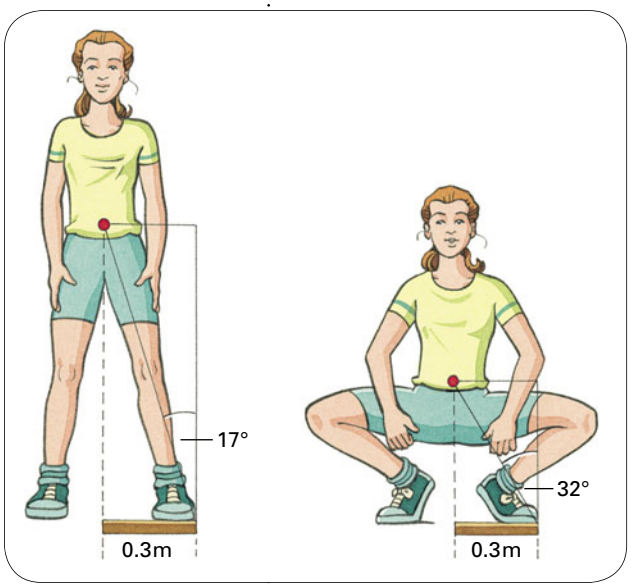


Figure 7.35
The relationship between security of balance and height of centre of gravity

The relationship between the height of the centre of gravity and the security of the balance can be explained in terms of the angle through which the body has to be rotated before it becomes unbalanced. The effective base of support for both bodies in figure 7.35 is the same, and it will be assumed that when the individual squats, the centre of gravity has not been displaced closer to the pivot point, the feet. As the diagram shows, the centre of gravity is lower in the squat position and has to rotate through a greater angle than the higher centre of gravity in the standing position to reach the point at which balance is lost. It is the angle through which the body rotates that is important, not the linear distance that the centre of gravity has moved.

Although mechanically a high centre of gravity is a less secure balance, this is usually more than offset by the performer's ability to sense an impending disaster and make appropriate corrections. For example, consider the gymnast in figure 7.36, who is starting to overbalance. By the time the whole body has moved through an angle of 20°, the free-moving end of the body (the head) has moved a much greater linear distance than any other body part. The relatively greater movement of the head permits the gymnast to sense the unbalancing movement almost immediately and make a correction at the earliest moment.

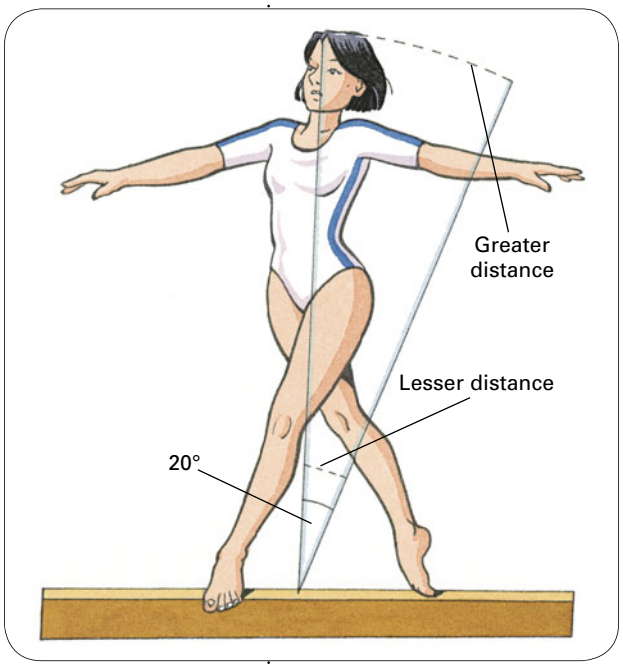


Figure 7.36
This gymnast senses the overbalance and makes an early correction.

A tennis player waiting to receive a serve can decrease the size of the effective base and slightly raise the centre of gravity by bringing the feet closer together. This will create an unbalancing effect, allowing the player to move quickly sideways to intercept the ball.

A runner must adopt an upright body position to gain the best muscular advantage from the legs, and the gymnast on the beam must display high extended positions to demonstrate good form. In both cases, the higher position facilitates balance adjustments.

However, in many team and combative sports, a low centre of gravity is preferred, as balance adjustments are not as important as resisting the force of an opponent. In this case, the sumo wrestler is designed to be an immovable object, with short muscular legs to provide power and to lower the centre of gravity of the body (see figure 7.37). To maintain this low centre of gravity, body bulk from the waist up, including the shoulders, has a higher proportion of fat, which is lighter than muscle.

When the centre of gravity is located below the base of support, the performer cannot be unbalanced. For example, a gymnast displaced out of a vertical hanging position will swing like a pendulum before settling back into the original vertical hanging position (see figure 7.38). The centre of gravity will come to rest when it finds its lowest point.

Figure 7.37 Sumo wrestler—the immovable object with a low centre of gravity

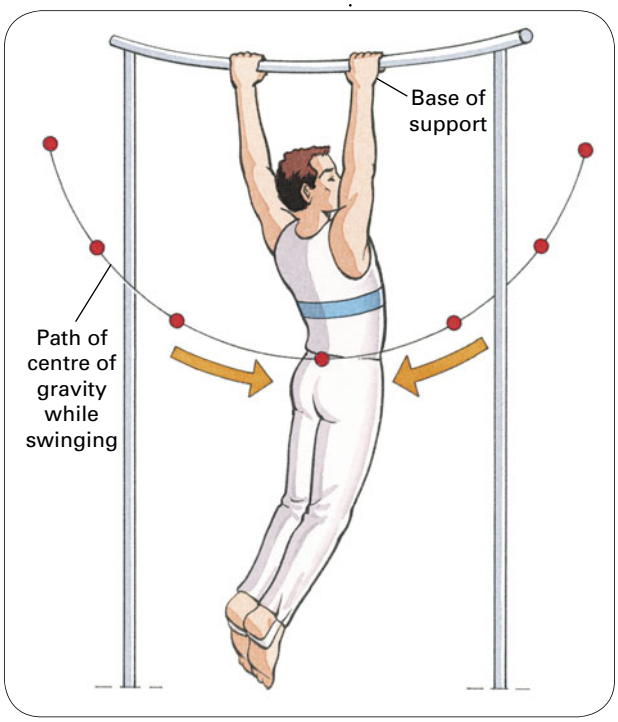


Figure 7.38 The centre of gravity of this gymnast in the vertical hang position is below the base of support, where the hands are on the bar.

Mass of the body

Until now we have referred only to the directional qualities of the gravity line or other external forces. However, the performer's weight will also determine the security of the balance. In general, the greater the weight pressing vertically downwards, the more difficult it is to unbalance the body.

In the World High Wire Championships (figure 7.39), the task was to negotiate an iron wire 30 mm thick and stretching 1000 m across the

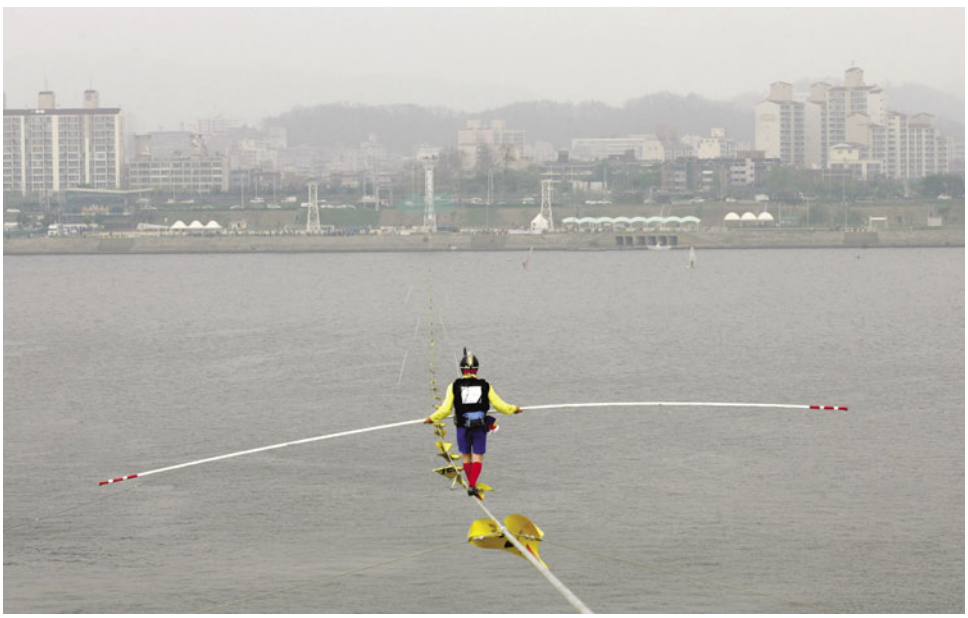


Figure 7.39 Pedro Carril of the USA, participating in the World High Wire Championships, in Seoul, South Korea

HanGang River in the fastest possible time. This exercise combines all the principles of balance. With the use of a long pole weighted at the ends, the walker can increase the overall mass, lower the overall centre of gravity and increase the rotational inertia. In the event of a slight overbalance, the range of movement at the end of the pole, due to its length, will be exaggerated, creating a more pronounced corrective action–reaction effect between the pole and the body. Finally, the erect stance (with slight flexion at the knees to ensure knee mobility) will ensure that any overbalance of the body will be detected and corrected early by the balance mechanisms of the ears.

Learning experience

LABORATORY RESPONSE: BALANCING

Aim

To understand the effect of height variables on balance.

Equipment

- baseball bat
- ruler
- practice beam
- pendulum
- beanbag

Procedure

1. Balance a baseball bat with the head of the barrel on the finger. Keep the eyes fixed on the handle.
2. Balance a ruler on the finger. Keep the eyes fixed on the top of the ruler.
3. Which object was easier to balance and why?
4. Now balance the baseball bat with the finger on the handle end.
5. What is the approximate location of the centre of gravity for both positions of the baseball bat?
6. Is the balance in step 4 easier than that in step 1 and if so, why?
7. Walk along a practice beam. Stop halfway along the beam and close your eyes.
8. Was the balance affected and if so, why?
9. Walk slowly along the beam. Keep the eyes focused on a pendulum being swung by your partner, standing at the other end of the beam.
10. Did the swing of the pendulum affect the balance and if so, why?
11. Walk slowly along the beam. Focus the eyes on a beanbag placed at the other end of the beam.
12. Did the placement of the beanbag affect the balance and if so why?
13. What could a beginning trampolinist learn from step 11?

Chapter review

Force

Know	1	State Newton's Second Law of Acceleration and Third Law of Action and Reaction.
Comprehend	2	Explain the link between force and mass that is common to both laws.
Apply	3	In Newton's Second Law of Acceleration, acceleration is inversely proportional to the mass of the object. Give an example of how this could be applied in the build structure of a bobsled.
	4	In Newton's Third Law of Acceleration, acceleration is also inversely proportional to the mass of the object. Give an example of how this could be applied in the case of heading a soccer ball with moderate force.
Analyse **Evaluate** **Synthesise**	5	The Australian diver Melissa Wu has a light frame giving her a high power to weight ratio. State two ways in which this will assist her in gaining height off the diving board and two measures that could be implemented in a conditioning program.
	6	The leg swing in the kicking action of soccer player Mile Sterjovski could be described as the action force. Discuss the body part(s) that may be used to react to this action force.

chapter 8

Momentum

Linear momentum

Linear momentum is the product of the mass and velocity of an object travelling in a straight line.

Linear momentum is the product of mass and velocity and implies a quantity of motion in a straight line. The relationship is expressed by the following formula:

$$M = mv$$

where M = momentum
m = mass
v = velocity

The term 'momentum' when used by itself in the rest of this chapter refers to linear momentum. Momentum is one of the most important concepts in biomechanics and is used frequently in sport biomechanics to describe and explain collisions and the generation of velocity in throwing and striking actions. The term 'momentum' is also commonly used in everyday language. For example, sports commentators are often heard to remark on the increased 'momentum' a team generated to get up and win a game. In this instance the term is used metaphorically to describe a quantity of motion or energy.

The greater the mass of an object, the greater its momentum will be. A shot used in the shotput, for instance, is very heavy and, once it is moving, tends to maintain its motion. The heavier the shot (i.e. the greater its mass), the greater its momentum will be, given a constant release velocity.

Consider a shot of a given mass, thrown at different velocities. The faster the shot travels, the greater its momentum will be.

Momentum can therefore be increased or decreased by increasing or decreasing mass or velocity. For example, in a game of tenpin bowls, one player may have a heavier bowl than the other. If both bowls are released at the same velocity, the heavier bowl will have the greater momentum, or quantity of motion, at impact. It will therefore scatter the pins more dramatically.

In a game of Rugby Union, a player of a given mass can change momentum by changing velocity. Different players, however, have varying masses. Heavier players will have greater momentum at the same velocity than lighter players. Conversely, a small, fast-moving player can have the same momentum as a slow, massive player.

For example, consider the athletes in figure 8.2. The momentum of athlete 1 is:

$$\begin{aligned} M &= mv \\ &= 75\,\text{kg} \times 2\,\text{m/s} \\ &= 150\,\text{kg m/s} \end{aligned}$$

The momentum of athlete 2 is:

$$\begin{aligned} M &= mv \\ &= 50\,\text{kg} \times 3\,\text{m/s} \\ &= 150\,\text{kg m/s} \end{aligned}$$

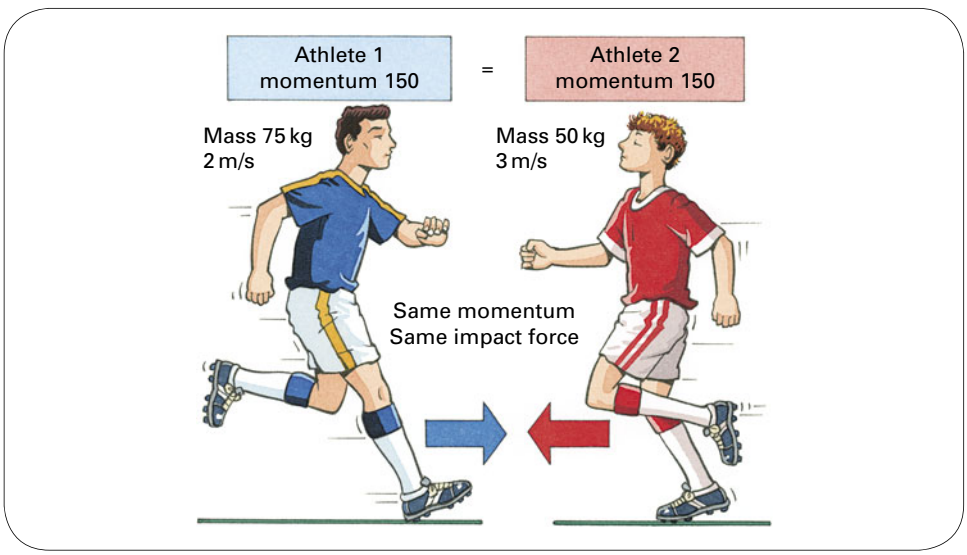


Figure 8.2 The momenta of two athletes with different masses travelling at different velocities

Figure 8.1
The players in the foreground are all moving with the same velocity. The player in the centre would have the greatest momentum, as he has the greatest mass.

Conservation of linear momentum

When an object is moving, it has a momentum. As long as no external force is applied to increase or decrease the velocity of the object, its momentum is said to be conserved. True **conservation of momentum** occurs only in theory, because there are always other forces acting on a moving object. At the very least, a moving object is slowed down by the force of air resistance. However, when putting the shot, the effects of air resistance may be negligible. The heavy mass of the shot relative to its surface area enables it to easily push the air aside. In a put of just over 18 m, approximately 5 cm is lost because of the slowing effect of air resistance. We could say that the momentum of the shot is almost totally conserved.

Conservation of momentum is the preservation of momentum, e.g. in any collision between two objects, momentum cannot be created or destroyed, but it can be transferred from one body to another.

In a collision between two players, or between a player and an object, the principle of conservation of momentum also applies. For example, a Rugby Union player with a large body mass and running at high velocity has a high momentum. In a collision with a stationary defender, the momentum of the attacker will not just disappear. Instead, some momentum will be transferred to the defender and some retained by the attacker; the defender will probably

be thrown backwards, and the attacker will continue to travel forwards, but with a decreased velocity. Whatever happens, the total momentum before the collision will equal the total momentum after the collision.

The momentum built up by a runner is, in reality, mainly not conserved. It is reduced by air resistance, and by the friction between the runner's feet and the ground (see figure 8.3). If the aim is to keep momentum constant, a runner has to apply enough force with their legs to move at a velocity high enough to make up for the loss of momentum due to air resistance and friction.

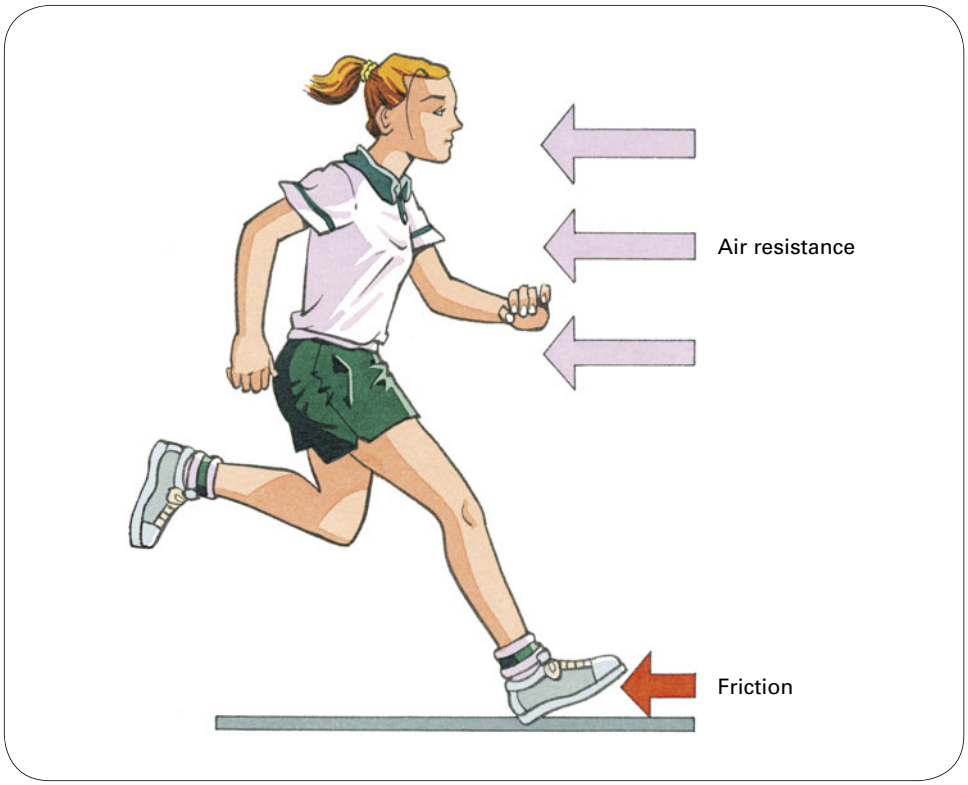


Figure 8.3
The momentum of a runner is continually reduced by air resistance, and by friction between the feet and the ground.

Impulse

Impulse is the product of a force and the time interval over which the force acts.

Impulse is the change of momentum that occurs when a force is applied to an object, such as when a bat hits a ball, or when a diver hits the surface of the water. For example, when a field hockey player pushes a dead ball (see figure 8.4), the ball's momentum will change from zero to a given momentum before it leaves the stick. The change of momentum that occurs while the ball is in contact with the stick is known as the 'impulse' and is calculated by using the following formula:

$$I = Ft$$

where I = impulse
F = force
t = time

Impulse occurs in any pushing, striking or throwing skill in which a player changes the momentum of an object. The momentum of the object

can therefore be changed by varying the force applied or the length of time it is applied or both. For example, by keeping the ball in contact with the stick for the longest possible time, the hockey player can apply force for a longer time and maximise the ball's impulse.

The concept of impulse underlies the development of the hinged 'clap' skates which have replaced fixed blade skates in speed skating (see figure 8.5). At the end of the push-off, the back of the fixed blade skate would normally begin to lift off the ice as the heel lifts. However, the clap skate has a spring hinge between the blade and the boot so that when the foot lifts, the blade stays in contact with the ice fractionally longer and therefore force can be applied for a longer time. This maximises the impulse given to the skater. When the blade finally leaves the ice, it snaps up underneath the boot, making the noise that has given rise to the name 'clap' skate.

Consider the example of a diver who is performing a back dive with somersault from the 3 m board (see figure 8.6). On impact with the water, the diver will experience an impulse or change in momentum that will eventually bring the momentum back to zero. It is therefore important to use an entry technique such as the 'rip entry'. (This entry with no splash is so called because it sounds like someone ripping a piece of paper.) Such an entry will create a hole in the water so that momentum can be dissipated gradually. The yielding nature of the water will ensure that the diver will not experience an unpleasant amount of force on impact with the water.

Figure 8.4
A hockey player pushing the ball applies a force to the ball for the longest possible time.

Figure 8.5
A speed skater on clap skates

A boxer who receives a blow to the head (see figure 8.7) may experience the same impulse as the diver, but, in this case, the time the blow takes and the amount of force applied in that time will have a more dramatic effect on the recipient. If the boxer does not have time to sway away from the stinging jab, the total force is received in a very short period of time, resulting in an almost instantaneous change of momentum. In this case, an injury may be sustained.

When a tennis racquet hits a tennis ball, the collision is over in an instant. For the racquet to impart maximum force and a large change of momentum to the ball, the tension of the strings must be such that they are fully restored to their original position at the moment the ball leaves the racquet. Also, the ball must be fully restored to its original shape at the moment it leaves the strings. This time period between the racquet hitting the ball and the ball leaving the strings must be just right, or optimal, to apply the maximum impulse.

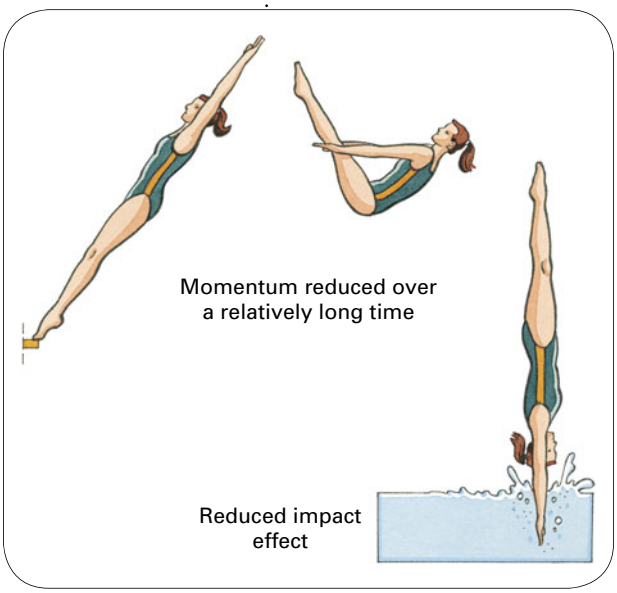


Figure 8.6 A diver experiences an impulse on impact with the water, decreasing the body's momentum over a relatively long period of time.

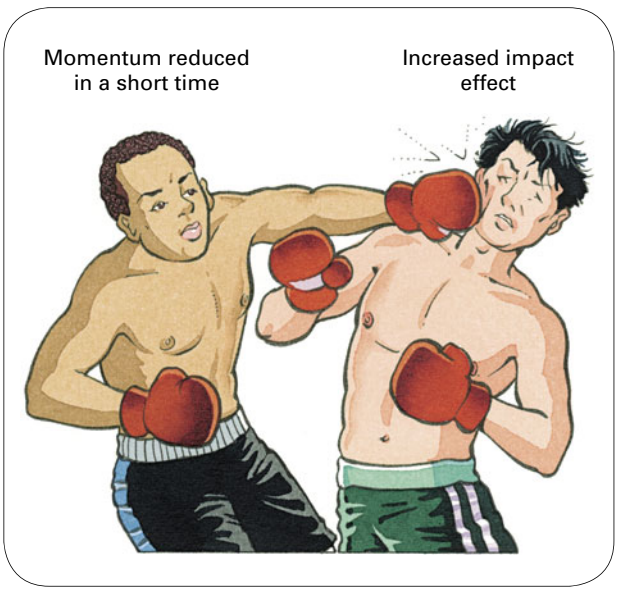


Figure 8.7 A boxer receiving a blow to the head experiences an impulse over a very short period of time.

Summing momenta

As already discussed, momentum can be used to advantage in collision or impact situations, or when developing velocity in particular body parts. When the performer needs just a small amount of momentum to accomplish a task, the number of body parts moved should be kept to a minimum. For example, the small amount of momentum required for the golf putting action is more than amply supplied by just moving the arms and hands. However, in activities such as the javelin throw, and throwing a cricket ball from the outfield, maximum momentum is required. The whole body needs to contribute, with the momenta of different parts of the body summed to achieve the highest possible hand velocity.

Stabilisation

The momentum generated in the javelin run-up has to be transferred effectively into the throwing action at the moment the javelin thrower props in the final stride. The leading leg is set in position and stabilised so that no further movement of the leg can occur until after the release of the javelin.

This **stabilisation** is essential, not only to avoid fouling the throw line, but also to enable the flow through of energy from the run-up into the body. Once in this stabilised position, the body has a solid pivot around which maximum momentum can be generated by all available body parts.

Stabilisation is a necessary element in all throwing and striking skills. As well as being necessary for maximising the momentum of the object being thrown or struck, stabilisation serves to hold the different parts of the body accurately in position. For example, a tennis player wishing to minimise leg movements and hence optimise target accuracy in a slice backhand will stabilise in the flexed leg position (see figure 8.8). This also provides a basic height setting for the skill, as the flexed leg in this case will permit a flatter return.

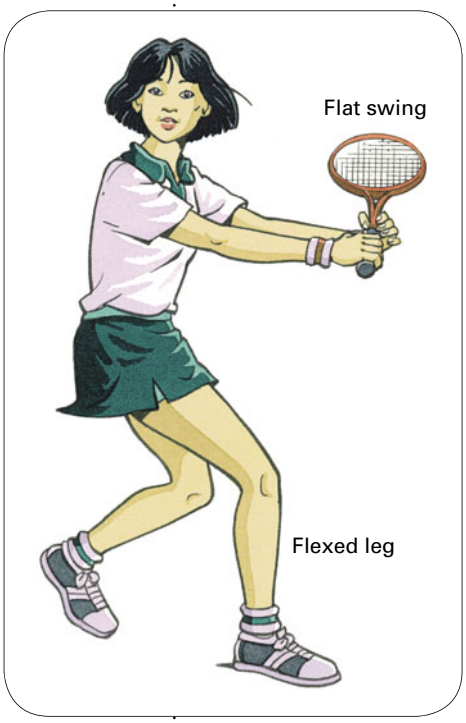


Figure 8.8
Stabilisation in the flexed leg position optimises the accuracy in a slice backhand.

After the body is stabilised, the total momentum in a throwing or hitting action is the sum of the individual momenta of different body parts. Generating high momenta is of critical importance in developing maximum ball and implement velocity.

Stabilisation refers to the setting of the body's base of support so that it can act as a foundation for the generation of momentum of body segments.

Use of body parts

To generate maximum momentum in an object being thrown or hit, as many body parts as possible must be used. For example, in a baseball pitch (see figure 8.9) the body parts contribute to the action in the following sequence: hips, spine, shoulders, upper arm, forearm and wrist. In the golf power swing, bending the lead arm in the downswing will add an additional segment and potentially produce greater momentum.

Optimum stretch

As each body part is brought into play in a throwing or hitting action, the muscles involved must be stretched to optimal length. For example, when the trunk rotates to the front in a baseball pitching action, the muscle attached to the humerus (i.e. the pectoralis major) is stretched. Positions of optimum stretch will enable the pitcher to contract the muscles with maximum force.

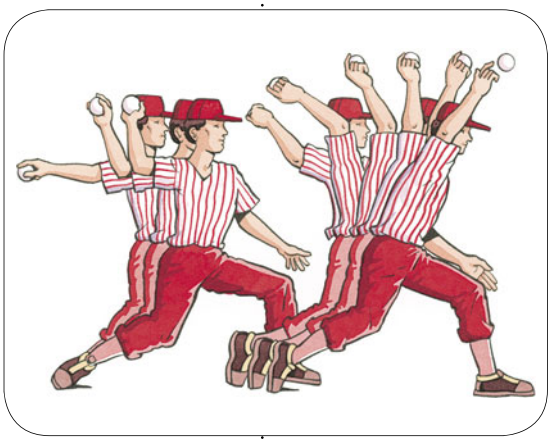


Figure 8.9
The sequential movement of body parts in a typical throwing action (exploded diagram)

Sequence of movement of body parts

To generate maximum momentum, the small body parts that are capable of moving fast (e.g. the arms and hands) must be used last in the sequence.

However, the larger, slower parts that move earlier in the sequence (e.g. the hips), play an important role in generating large amounts of momentum. The smaller parts will feed off this momentum later in the sequence to produce fast, dynamic movements.

Optimum contribution of body parts

It is important that each body part makes its optimum contribution at exactly the right time before the next body part begins to move. For example, in the baseball pitch or overarm throw, the hips must have rotated as far as possible to the front before the next part—the trunk—begins its rotation to the front.

Range of motion

To achieve the maximum velocity of the object being thrown or hit, the body parts must track over the greatest possible range of movement. For example, the more body parts that contribute to a squash backhand, the greater will be the range of motion of the last segment—the lower arm and racquet (see figure 8.11). The greater the range of motion of the lower arm and racquet, the higher the velocity of the racquet head when it connects with the ball.

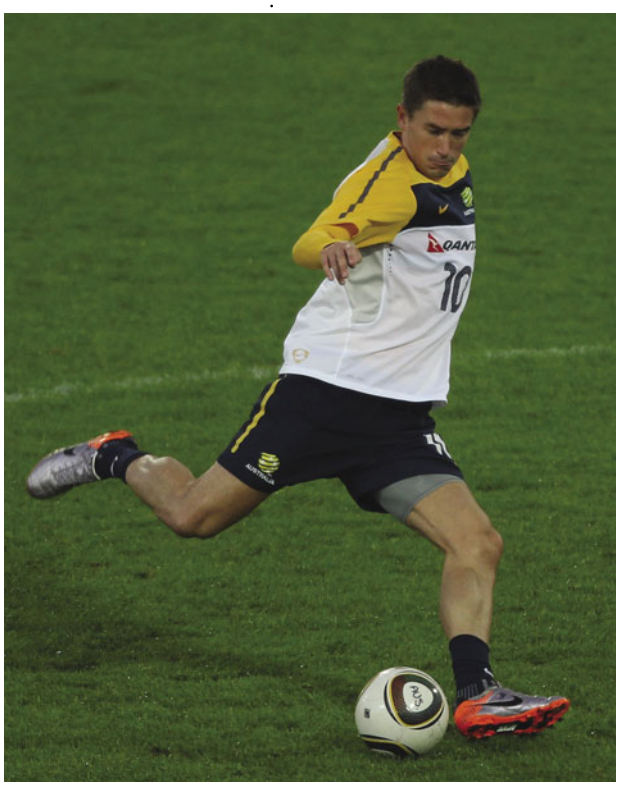


Figure 8.10 Harry Kewell demonstrates the contribution of many body parts, with hip rotation preceding thigh drive, which in turn, precedes lower leg drive.

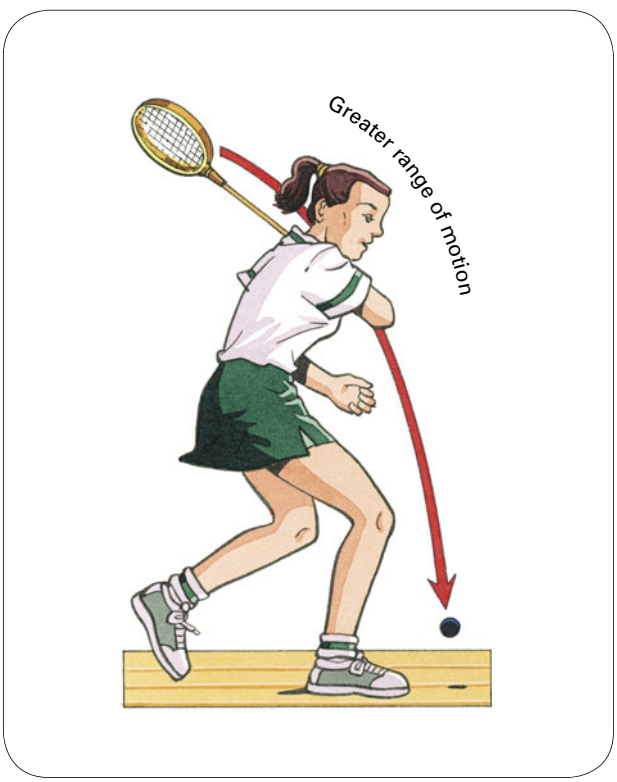


Figure 8.11 The greater the range of movement in a squash backhand, the more powerful the stroke.

The summation sequence could typically be described in the following way for a striking skill, such as a straight drive in cricket.

Setting the base

Step: Set the body in position.

Stop: No further movement of the hips and legs.

Stabilise: Lock the base into position.

Summing momentum

Segments (body parts) are put on optimum

Stretch and move in a

Sequence large to small in a

Smooth well-timed action to

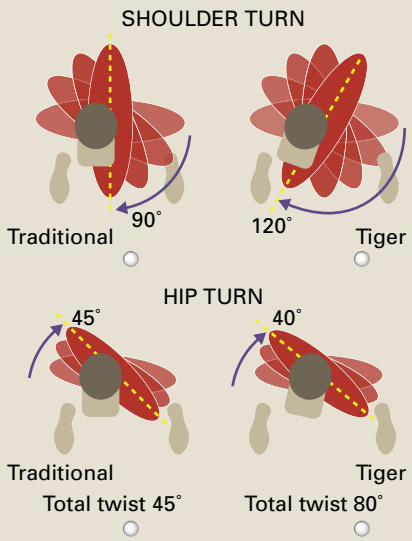
Sum momentum and generate the highest bat

Speed possible

SNAPSHOT

Tiger Woods exploded on to the professional scene late in 1996, and since that time has won a record 29.7% (71 out of 239) of his professional starts on the PGA Tour. Woods is the only player to have won all four professional major championships in a row, accomplishing the feat in the 2000–2001 seasons. This feat became known as the 'Tiger slam'.

Tiger is one of the longest hitters on the tour, and to achieve this feat he sums momentum using the torque or stretch between his hips and shoulders. Traditionally, golfers are taught to turn their hips 45° and their shoulders 90°, creating a 45° differential. He turns his hips 40° (keeping them more square to the front) and his shoulders 120°, giving him a whopping 80° twist. The additional tension this delivers results in a more-explosive turn and subsequently increased club velocity to the ball.



Source: *The Age*, 10 December 1998, p. 6

Accuracy

When hitting or throwing any object, maximising momentum and velocity must always be balanced by the need for accuracy. In general, accuracy can be broken down into two components: height accuracy and sideways accuracy. Both must be achieved to achieve maximum target accuracy.

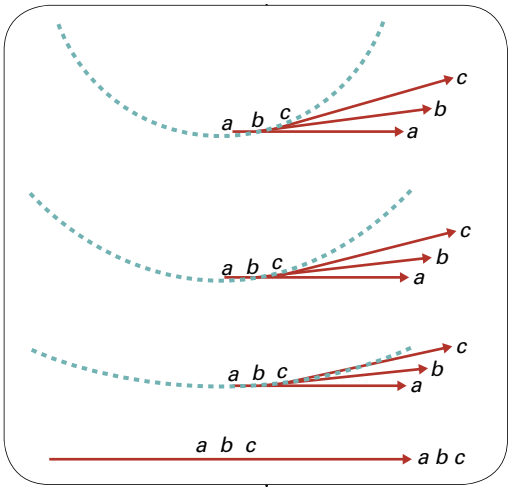


Figure 8.12
The relationship between point of impact of a hit, or release of a throw, and the ball reaching the target at the correct height

Height accuracy

Height accuracy in a throw or hit can be achieved if release or impact is made at any point on a straight or direct line to the target (see figure 8.12). If the hand in a throwing action can be made to move in a straight line towards the target, then it does not matter where the ball is released on that line—the ball will fly to the target at the correct height.

In the hockey drive, where body parts and the stick have to rotate around an axis to generate momentum, height accuracy is more difficult to achieve than in a throw (see figure 8.13). Nevertheless, the player can still achieve height accuracy if the ball is hit at one precise point at the middle or bottom of the swing arc. Contact at this point will send the ball off on the correct horizontal pathway along the ground.

The need to hit the ball at a precise point at the bottom of the swing arc leaves little margin for error. Better results can be obtained if the stick is made to travel in a flatter horizontal pathway just before and through impact, e.g. by flattening the arc of the swing. The stick can therefore contact the ball at many points on the flattened section of the 'arc' and still achieve optimum height accuracy.

Flattening the arc of a softball pitch (see figure 8.14) can be achieved by:

- a forward and downward movement of the shoulder
- a laying back of the hand during the forward movement
- the rotation and forward movement of the hips.

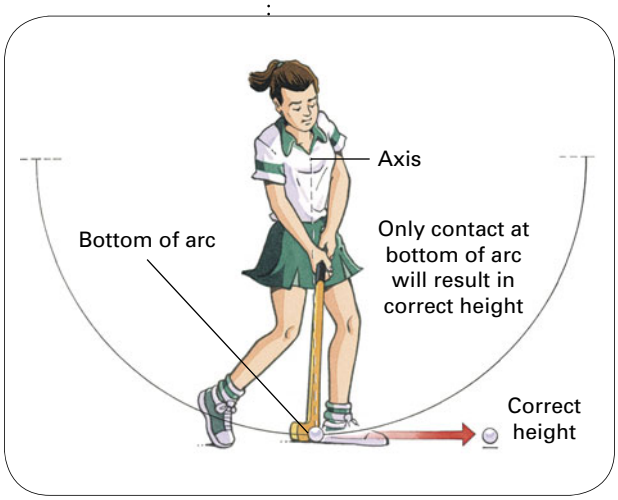


Figure 8.13 Achieving height accuracy in a hockey drive

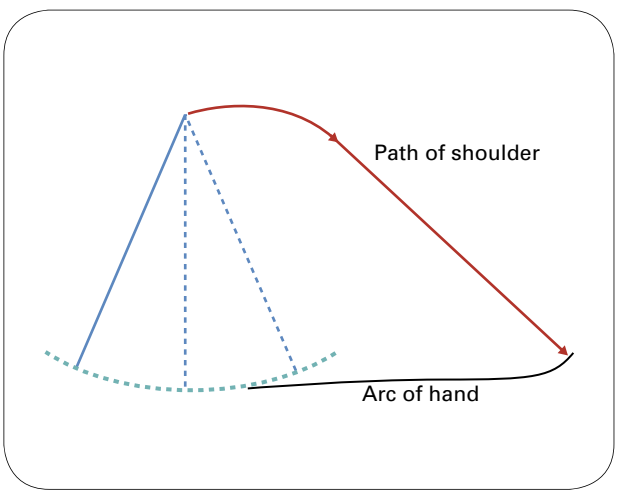


Figure 8.14 Flattening the arc of a softball pitch

Sideways accuracy

Sideways accuracy can be achieved if the arc of the swing is kept in vertical alignment with the target. This can be achieved easily in the cricket bowl (see figure 8.15).

In other skills, such as the hockey drive (see figure 8.16), the rotational movements of the body make sideways accuracy much more difficult to achieve. However, it can be achieved if:

- the ball is hit at one precise point at the middle or bottom of the swing arc, when the stick is travelling in the correct direction

- the player keeps the stick in its optimal alignment just before and during impact, to minimise any movement inside or outside the line of the swing
- the face of the stick is square relative to the target so that the ball is hit through the desired line.

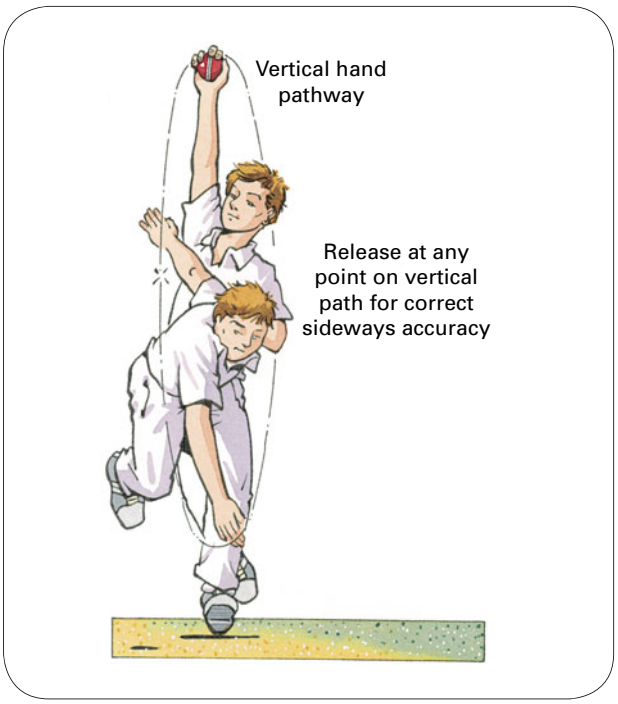


Figure 8.15 Achieving sideways accuracy in a cricket bowl

Figure 8.16 Achieving sideways accuracy in a hockey drive

Learning experience

LABORATORY RESPONSE: SUMMING MOMENTA

Aim

To understand and measure the effects of summing body momenta.

Equipment

- tennis balls or beanbags

Subjects

Perform all activities with a partner, one person throwing and one marking.

Condition A

Take up a long sitting position against a wall. Keep the shoulders and hips tight against the wall.

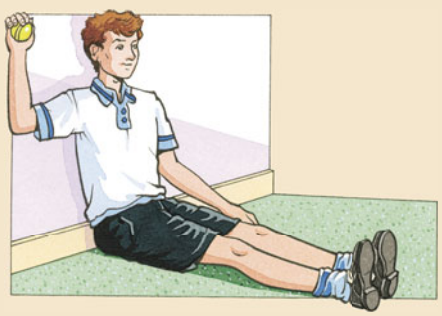


Figure 8.17
The long sitting position, hips and shoulders tight against a wall

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Procedure

1. The task is to throw a tennis ball or a beanbag with maximum effort and over the greatest possible distance under a variety of conditions as listed below. Keep the angle of release as consistent as possible, using a hoop or other height marker. In the gymnasium, the junction of the wall and roof may be used as a marker to keep the angle of release consistent.
2. Measure the distance of the throw, using paces.
3. Record the distance of each throw.

Condition B

Move 1 m away from the wall but remain in a long sitting position. Rotate the shoulders and arm back as far as possible to make the throw, but keep the body upright, not leaning back. Throw the ball using the shoulders and arm only.

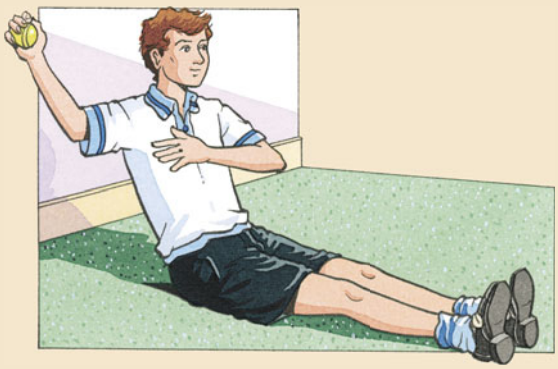


Figure 8.18
Move 1 m away from the wall but remain in a long sitting position.

Condition C

Move 2 m away from the wall and stand square to the direction of the throw. Rotate the hips and shoulders as far back as possible to make the throw. The feet must remain in contact with the ground and must not twist around. Throw the ball using the hips, shoulders and arm only.

Figure 8.19
Move 2 m away from the wall and stand square to the direction of the throw.

>>

Figure 8.20
Stand 2 m away from the wall in the side-on position.

Condition D

Stand 2 m away from the wall, side-on to the direction of the throw, with the feet shoulder-width apart and the back knee straight. To make the throw, rotate the trunk as far back as is comfortable.

Throw the ball using the hips, shoulders and arm, but make sure that the body weight has been transferred forwards before the arms begin to move. Both feet should remain in contact with the floor throughout the throw.

Figure 8.21
Repeat condition D but now take a step forward and throw.

Condition E

Repeat condition D, but now take a step forward and throw the ball. The back foot should be free to move or slide forward during the throw.

Conclusions

1 Do the results show a progressive increase or decrease in the distance of the throw?

2 **a** List the body parts used in the throw made under each set of conditions.

b List the order in which these body parts should be used in a correct throwing sequence.

3 Using the principle of momentum summation, what general observation can be made regarding the mass of the body parts used in the throwing sequence?

4 **a** Explain why the side-on position (used in conditions D and E) permits the production of greater force in the throw.

b Which concept in momentum summation underlies this explanation?

Newton's Law of Inertia

Newton's Law of Inertia ($\Sigma F = 0$) states that a body will continue at rest or in uniform motion unless acted upon by an applied force. If there are no forces there is no change in movement.

Newton's Law of Inertia states that:

> *A body will continue in its state of rest or uniform motion unless acted upon by an applied force.*

Inertia refers to the degree of difficulty in getting a stationary object to move, or a moving object to stop. It is related to the magnitude of the object's mass. The heavier the object, the more difficult it is to get that object to move, or to stop it when it is moving.

Conversely, the lighter the object, the easier it is to get that object to move, or to stop it when it is moving. In more general terms, we can say that inertia refers to an object's responsiveness or resistance to attempts to change its motion.

In practical terms, inertia affects many aspects of sport. For example, when a soccer ball becomes wet, its additional mass will give it higher inertia. This will make it more difficult for players to:

- start the ball moving when it is stationary
- slow the ball down or speed it up when it is already moving
- stop the ball when it is moving.

In indoor soccer, where the game is played in a confined area, players use a smaller, lighter ball with lower inertia than a normal soccer ball. This makes it easier for players to change the motion of the ball.

Rotational inertia

As discussed above, a body's inertia is its resistance to change of motion and is directly related to the magnitude of the mass of the object. If the motion is rotational, e.g. turning around an axis, not only the object's mass has to be considered, but also the distance of the mass from the axis of rotation. Examples of rotational motion are swinging around a gymnastics bar, swinging a golf club, and the hammer throw (see figure 8.22).

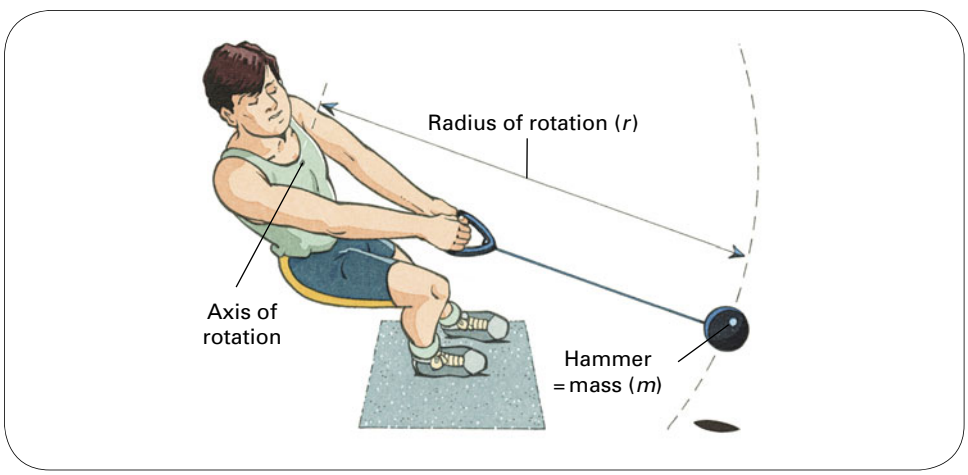


Figure 8.22 The rotational inertia of the hammer in a hammer-throwing action is determined by its mass and its radius of rotation.

The **rotational inertia** of an object is determined by its mass and its radius of rotation. It can be calculated using the following formula:

$$I = mr^2$$

where I = inertia
m = mass
r = radius of rotation

Rotational inertia is a body's resistance to change due to the magnitude of the mass of the object, and its distance from the axis of rotation.

Mass

The larger the mass of an object, the greater is its resistance to rotational movement, and the greater will be its persistence once it does start moving. For example, a heavy cricket bat will have higher rotational inertia and be more difficult to swing than a light cricket bat, but once it starts moving it will be more difficult to stop.

Radius of rotation

The further the mass of an object is distributed away from the axis of rotation, the greater is its resistance to rotational movement, and the greater will be its persistence once it does start moving. For example, the axis of rotation of a cricket bat is where the hands grip the bat. The further the mass of the bat is distributed away from the hands, the harder the bat will be to swing. If the bat is weighted more at the end than near the handle, it will be more difficult to swing than a bat of the same mass which is not weighted at the end. Conversely, 'choking the grip' by dropping the hands further down the handle will bring the mass closer to the axis of rotation and make the bat easier to swing.

Figure 8.23
Lauren Mitchell performs a 'low rotational inertia' twist in the floor event during the London World Championships in 2009. Note the clasped hands and elbows held in, together with overlapping big toes to ensure a tight body position around the long axis of the body.

Changing rotational inertia

As mass is difficult to adjust, changes in the rotational inertia of an object are usually made by adjusting the radius of rotation. In sport, radius adjustments can be made at will during the performance of a skill.

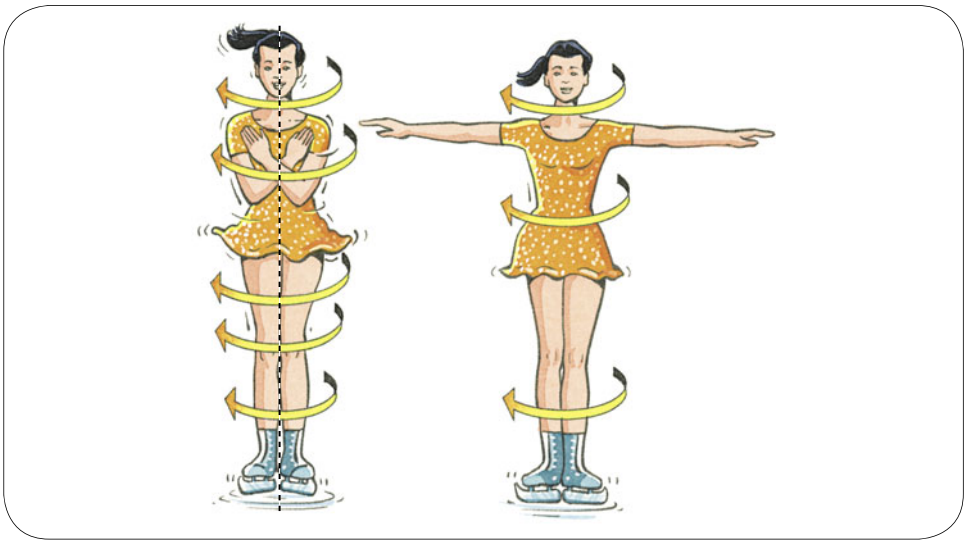


Figure 8.24
A skater spinning with arms outstretched has higher rotational inertia than when spinning with the arms clasped across the chest.

Figure 8.25
This dancer with the National Ballet of China demonstrates how the arms (lower rotational inertia) and the right leg (higher rotational inertia) can be used to control the rate of rotation in a pirouette.

For example, a spinning ice skater can increase the radius of rotation by extending the arms (see figure 8.24), and a cricketer can reduce the radius of rotation by moving the hands down the grip. Mass changes can be made only by using objects of different mass (e.g. a heavier softball bat) or, in the case of parts of the body, by changing muscle bulk over an extended time.

A body with high rotational inertia will have all the following characteristics, although not all of these may have a practical application within one specific sports skill. The body will be:

- resistant to changes in rotational motion, e.g. a rotating hammer thrower
- steadier, e.g. a skater spinning with arms extended
- hard to accelerate and decelerate, e.g. a golf club at the beginning of the backswing
- slow-moving, e.g. a layout somersault compared to a tuck somersault
- hard to stop, e.g. a swinging softball bat just before impact with the ball.

In practical terms, rotational inertia affects many aspects of sport. For example, in archery (see figures 8.26 and 8.30), the use of weighted rods or stabilisers on the bow will increase the rotational inertia of the bow by taking the mass further away from the axis point at the shoulders. The total mass is also greater, increasing the rotational inertia and dampening any rotational motion in the bow. The effect is thus to reduce tremor and steady the bow.

In a golf club, the mass is concentrated approximately in the middle of the clubhead. When the club is extended just before impact, it has high rotational

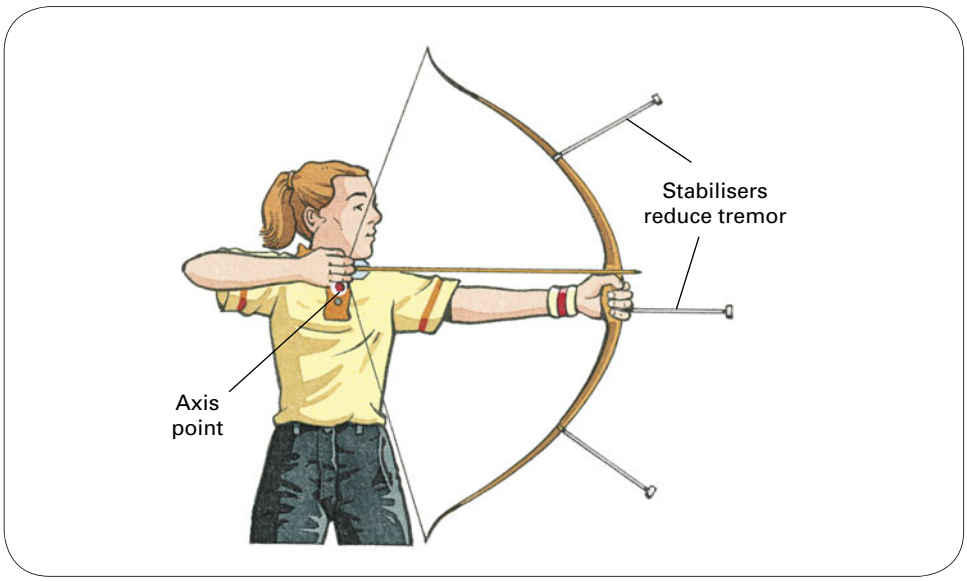


Figure 8.26
Weighted rods are used as bow stabilisers to reduce tremor in the bow.

inertia and hence will resist changes in motion. Its momentum will be maintained and it is unlikely to deviate from its chosen pathway, which makes for a more forceful and accurate shot.

A body with low rotational inertia will have all the following characteristics, although not all of these may have a practical application within one specific sports skill. The body will be:

- responsive to change in rotational motion, e.g. a runner's flexed recovery leg
- less steady, e.g. a gymnast pirouetting on the Olympic beam
- easy to accelerate and decelerate, e.g. a child's cricket bat, compared to a full-size bat
- fast-moving, e.g. an ice-skater spinning in a tuck position
- easy to stop, e.g. a spinning golf ball with greater mass in the core than on the softer cover.

There are numerous examples of sports skills that use decreasing rotational inertia to advantage. In almost every case, rotational inertia is decreased by drawing the mass closer to the axis of rotation. For example, the ice-skater moving into a pirouette quickly brings the limbs as close as possible to the long axis of rotation, which in this case is a line drawn through the body from head to toe (see figure 8.24). The result of this decrease in rotational inertia will be a much faster spin rate and a greater number of rotations.

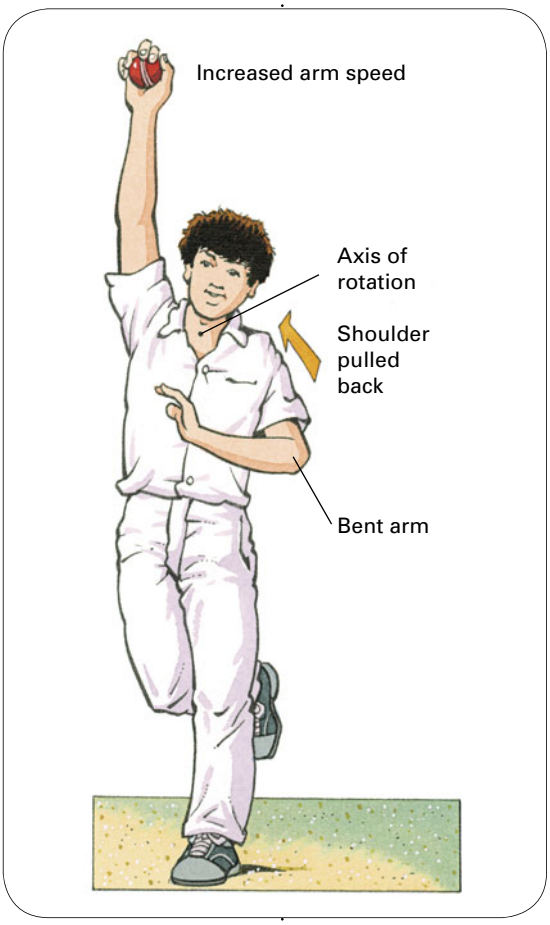


Figure 8.27
A bowler in cricket bends the non-bowling arm into the chest to increase the rotational velocity of the bowling arm.

In a more complex example, the bowler in cricket quickly snaps the non-bowling arm into the chest, reducing the length of the arm and shoulder lever, and hence the radius of rotation (see figure 8.27). This results in faster shoulder rotation, and so the bowling arm has a higher rotational velocity.

Squared effect

In the formula for rotational inertia ($I = mr^2$), the radius of rotation is squared. This means that changes to the radius will result in more dramatic velocity changes than changes to mass. For example, when a baseballer throws the ball from the infield over a relatively short distance, the throwing arm will be flexed. Using easy numbers, if the length of the arm is reduced by half, then the rotational velocity of the arm will increase four times (see figure 8.28). In situations where velocity is crucial, this technique is very important.

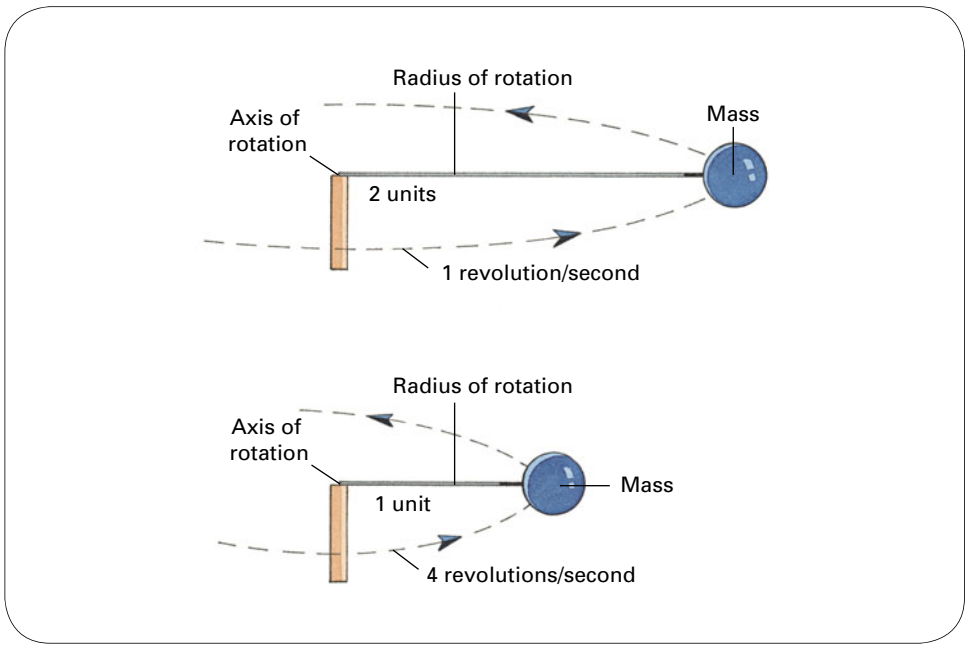


Figure 8.28
Reducing an object's radius of rotation from 2 units to 1 unit will decrease its rotational inertia by a factor of 4 and increase its velocity by a factor of 4.

Inertial velocity and leverage

It is important to differentiate between the high velocities that are generated from decreasing the rotational inertia of an object and the high velocities that are generated at the end of a longer lever. For example, the lever in a golf swing consists of the upper body, the arms and the club. At the beginning of the downswing, the lever is shortened by flexing the wrists, and so the whole lever will have a high rotational velocity due to its decreased rotational inertia (see figure 8.29). The head of the club may not, however, be travelling at high velocity. The lever becomes longer as it unhinges and straightens just before impact with the ball. This longer lever will produce progressively higher velocities at the end of the lever as the whole lever straightens, even though the increased rotational inertia may not alter the swing velocity of the whole lever unit.

In the golf swing illustrated in figure 8.29, the addition of the club lever (*BC*) to the arm lever (*AB*) doubles the total length of the lever. This means that the clubhead travels double the distance travelled by the hands in the same time, effectively doubling its velocity. In an efficient action the wrists open just before impact, whipping the clubhead through an even greater distance and causing further velocity increases.

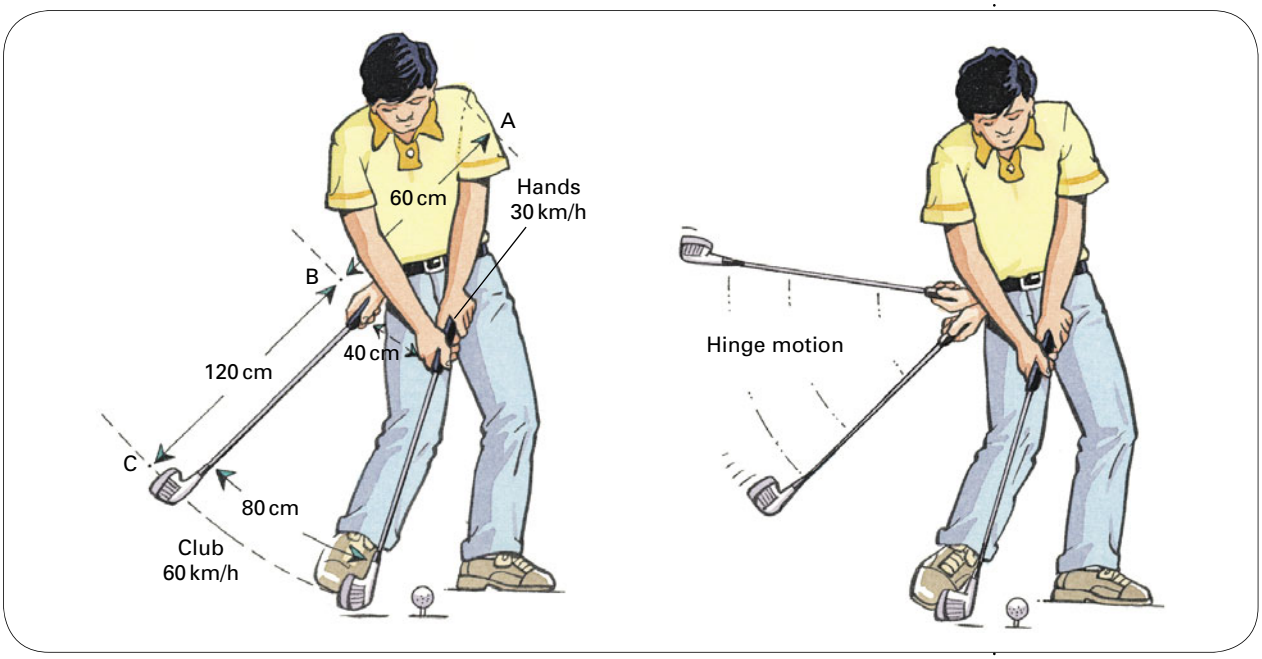


Figure 8.29
Inertia, velocity and leverage in a golf swing

SNAPSHOT

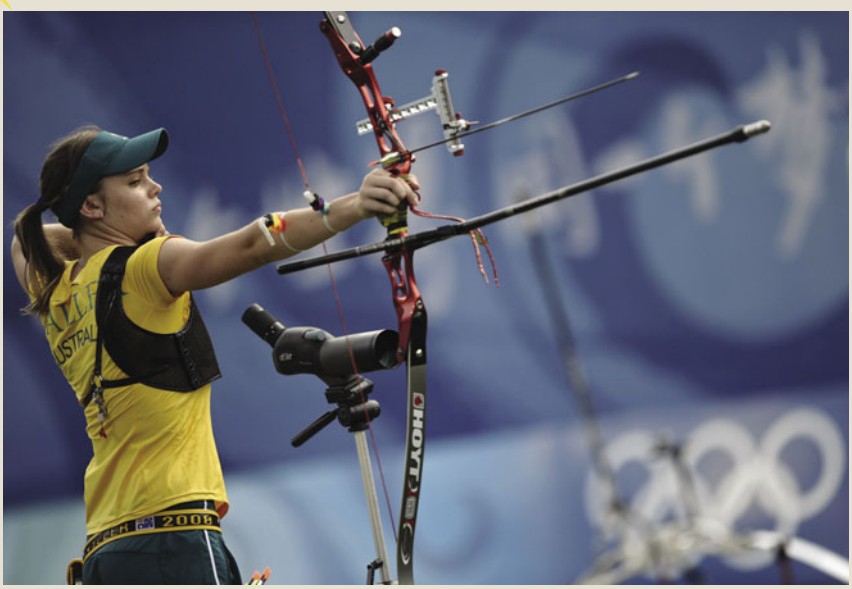


Figure 8.30 Jane Waller

Queensland teenager Jane Waller is the world junior champion and is looking forward to competing in the London Olympics In 2012. She trains five hours a day and shoots about 270 arrows every session. According to Waller the secret in archery is to stay relaxed. People say to her 'you only do archery', but how many people could hit a 12 cm circle from 70 m? Note the 'high rotational inertia' stabilisers on the bow, pointing to the front and to the side, and designed to dampen any vibration in the bow.

Levers

A **lever** is a rigid rod or body segment that rotates around an axis.

A **lever** is a rigid rod that is rotated about a fixed point or axis. Levers are used to move loads and produce rotation of a body segment. A lever is acted on by two forces: an effort force and a resistance force. There are two lever arms: the effort arm and the resistance arm.

There are three types of levers:

- first-class levers, in which the axis is located between the effort force and the resistance force (see figure 8.31)
- second-class levers, in which the resistance force is located between the effort force and the axis (see figure 8.32)
- third-class levers, in which the effort force is located between the resistance force and the axis (see figure 8.33).

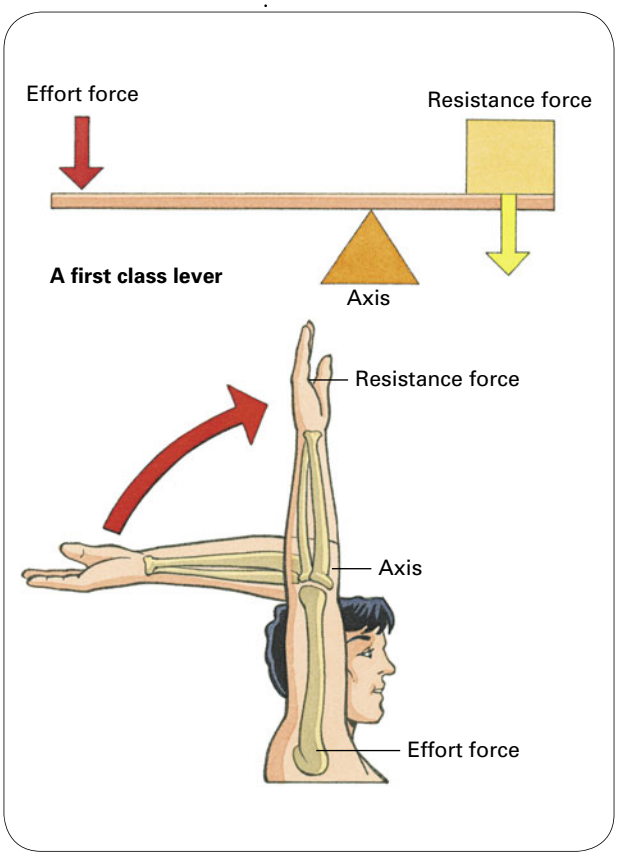


Figure 8.31 The arm acts as a first-class lever in a basketball lay-up.

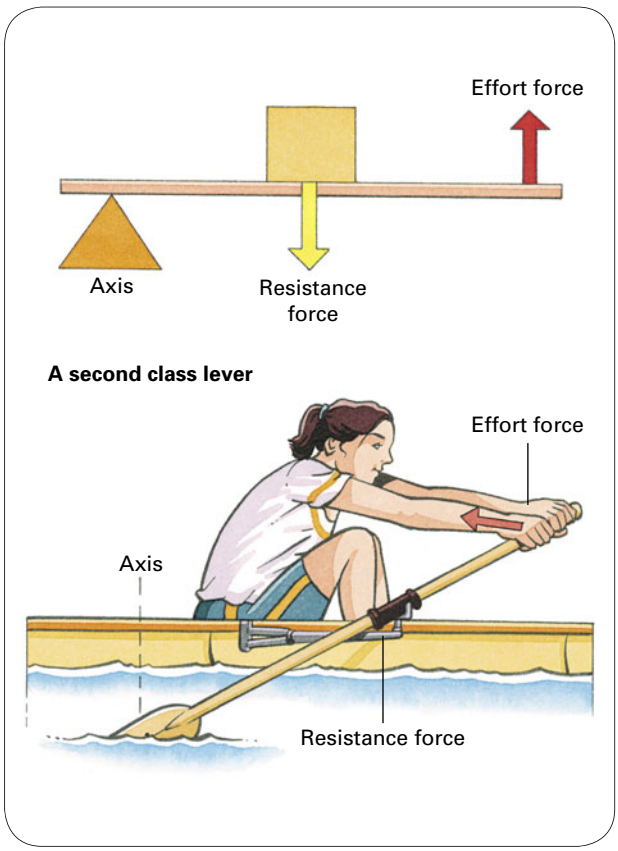


Figure 8.32 In rowing, the oar is a second-class lever.

Third-class levers have a long resistance arm that facilitates speed of movement of the lever. They are the most common type of lever used in sport. This is because the levers used in sport are musculoskeletal. The muscle provides the effort force, and the relevant joint is often the axis. The muscle attachments are closer to the joint axis than is the resistance force.

The longer the resistance arm, the greater the velocity of the lever, as long as the increased weight of the lever is manageable. Advantage will be gained

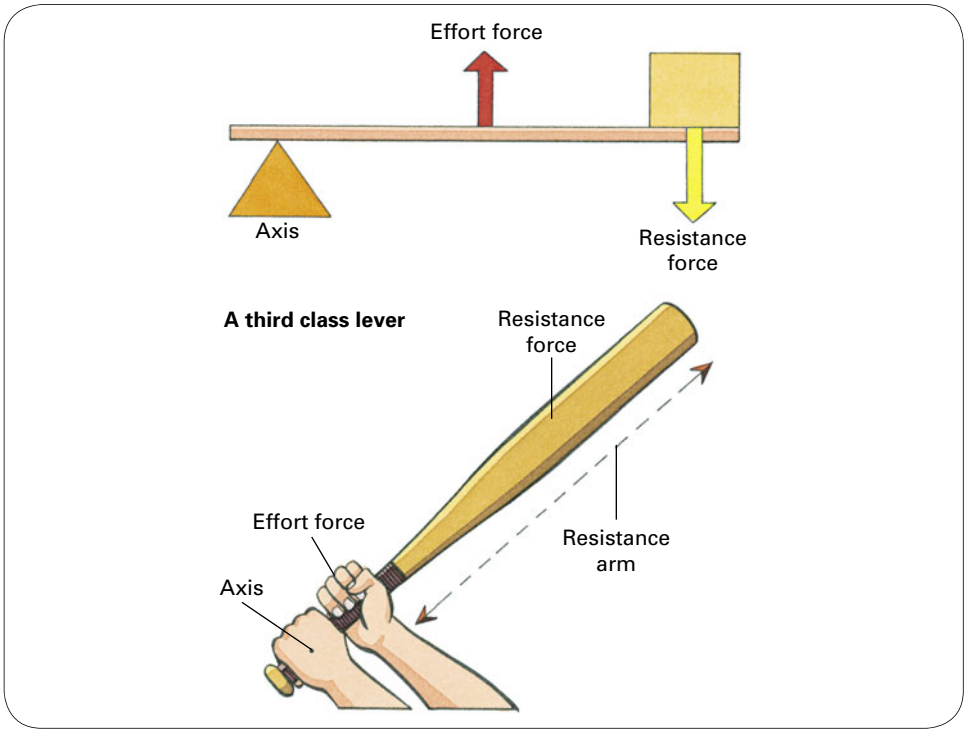


Figure 8.33
The baseball bat is used as a third-class lever.

because of the increased range of motion, especially if the weight of the lever is relatively light (see the previous section 'Inertial velocity and leverage'). For example, an aluminium baseball bat can be longer than a wooden bat, but because it is hollow, still retain its lightness. Its length and lightness enable the batter to get the bat to the ball more quickly.

Rotational momentum

Changes in the linear momentum of an object are normally the result of changes in velocity, as the object's mass remains constant. However, changes in **rotational momentum** may be due not only to increases or decreases in rotational velocity, but also—very importantly—to changes in the distribution of mass around an axis point and, consequently, to changes in rotational inertia. Rotational momentum can be calculated by using the following formula:

Rotational momentum is the product of rotational inertia and rotational velocity.

$$L = I\omega$$

where L = rotational momentum
I = rotational inertia
ω = rotational velocity

A diver performing a forward tuck somersault (see figure 8.34) cannot change the rotational momentum of the body after take-off. (This is because the force used for the dive is generated by the diver pushing against the diving board. In mid-air, there is nothing to push against to create such a force). Although the rotational momentum of the body cannot change, it is possible to change the rotational inertia of the body, which will in turn change its rotational velocity. For example, the rotational inertia of the body is increased when the whole body is extended, e.g. in a layout position in a somersault.

The gymnast performing a tsukahara vault (see figure 8.35) must apply a large force at take-off to generate a linear momentum sufficient to carry the body over the required distance before landing. A forward lean at take-off will also initiate a rotational momentum that will remain constant until the gymnast applies a further force on push-off from the horse.

In position 2, during pre-flight, the extended body has a high rotational inertia around the centre of gravity and a low rotational velocity, with the rotational momentum remaining constant. In position 3, the gymnast pushes off from the horse, increasing the rotational momentum, which then remains constant during post-flight until landing. From position 4 to position 5, the rotational inertia decreases and the rotational velocity increases, with no change in the rotational momentum. When the gymnast lands all rotational momentum is lost.

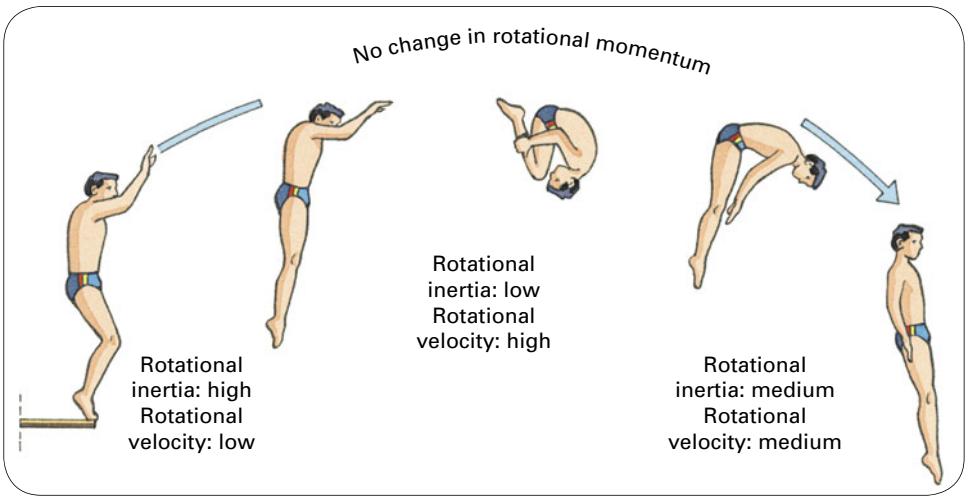


Figure 8.34 Rotational momentum during a forward tuck somersault

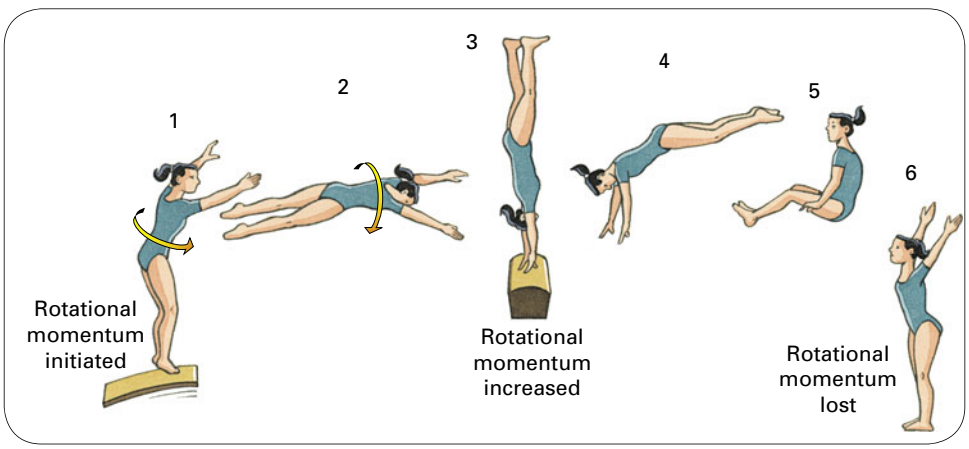


Figure 8.35 Rotational momentum during a tsukahara vault

Conservation of rotational momentum

A small amount of rotational momentum is lost because of air resistance, but the remainder is conserved. We can say that, for all intents and purposes, rotational momentum is conserved until a force, such as contact with the floor, is applied to change it.

In the example in figure 8.35, rotational momentum is initiated at take-off, and in pre-flight that rotational momentum is conserved. During the push-off from the horse, rotational momentum is increased and in post-flight that rotational momentum is conserved. During landing, all rotational momentum is lost. Remember that in flight there may be changes in rotational inertia and rotational velocity, but rotational momentum will be conserved.

Learning experience

LABORATORY RESPONSE: ROTATIONAL INERTIA

Aim

To investigate the relationship between the rotational inertia of an object and its rotational velocity.

Equipment

- hollow cylinder or cone
- piece of string with a small weight (e.g. several washers) tied to the end

Note: Attach the weights securely to the string. Do not swing the weighted string near any other people.

Task 1

Procedure

1 Thread the weighted string through the cylinder.
2 Hold the cylinder with one hand and use the other hand to hold the non-weighted end of the string.
3 Start the weight rotating. Pull on the string to draw the weight towards the cylinder, shortening the rotating length of string (see figure 8.36).
4 Experiment with lengthening and shortening the rotating length of string.

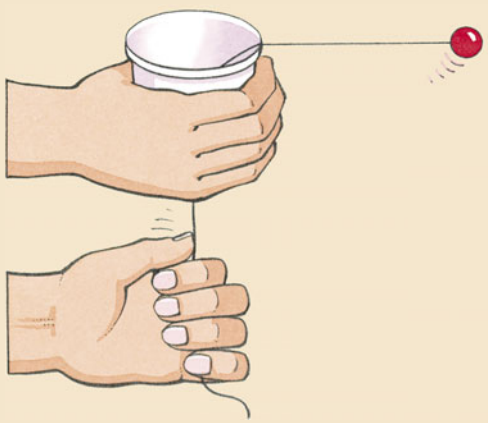


Figure 8.36
Using a hollow cylinder to vary the rotating length of a weighted string

Results

1 What happens in step 3 when you shorten the length of string that is rotating?
2 What did you observe about the speed of the weight in step 4?

>>

Note: A version of this experiment can be carried out by a person sitting in a swivel chair. The person sets the chair rotating and changes the position of the arms and legs from being tucked in close to the body to being extended at varying distances away from the body. Note the variation in speed of rotation.

Task 2

Procedure

1 Release the string so that the weight is suspended on a long length of string. Start the weight swinging in a wide arc like a pendulum.

2 Quickly pull in the string to draw the weight towards the cylinder (see figure 8.37).

Results

What happened to the speed of the weight when you pulled in the string?

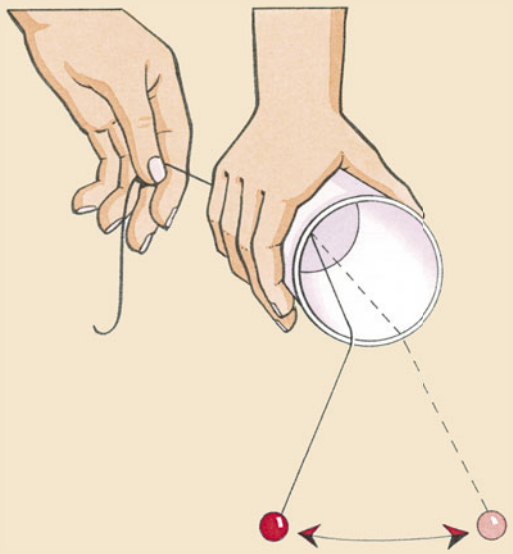


Figure 8.37 Using a hollow cylinder to vary the rotating length of a weighted string after it has been set in motion to swing as a pendulum

Chapter review

Momentum

Know	1	State Newton's Law of Inertia.
Comprehend	2	Give the possible applications of inertia in relation to the ability to get an object to move.
Apply	3	The mass of a soccer ball together with its design and materials will affect its inertia. Discuss this with respect to the new 'Jabulani' soccer ball used in the 2010 World Cup.
	4	The ballet dancer can use high and low rotational inertia positions to vary the velocity with which turns can be made in a pirouette. Describe the possible body configurations that enable the dancer to control the rate of rotation.
Analyse Evaluate Synthesise	5	An archer wishes to invent and construct a bow that is stable (no tremor) in all directions. Using the inertia principle, describe the changes that could be made to the bow. Make reference to the mass and radius of rotation of the bow as well as its material make-up and coefficient of restitution.

Air and water forces

Chapter 9

What is a projectile?

A projectile is an object propelled into the air or water by an external force. A projectile can be an object (such as a discus, football or arrow) or the human body performing gymnastic, water skiing or diving skills. Two naturally occurring forces act on a projectile: air resistance and gravity. Air resistance is important in such sports as alpine ski jumping and skydiving, where air or wind exerts very large forces against the body. In discus throwing, javelin throwing and golf, air resistance affects the aerodynamic characteristics of the projectile. In the shotput, however, air resistance will result in a loss of distance of only approximately 5 cm in a put of just over 18 m.

Factors affecting the flight of a projectile

The flight path of a projectile is determined by its:

- angle of release
- height of release
- speed of release.

The flight path cannot be altered during flight. This means that the distance a projectile travels and the time it spends in the air cannot be altered after take-off (unless additional external forces are applied).

Angle of release

The angle of release of a projectile determines the:

- time the object stays in the air
- horizontal distance the object moves.

If a cricket ball is thrown vertically into the air (i.e. if it is thrown with vertical force only) it will stay in the air for a considerable time. However, the ball will not move any horizontal distance because no horizontal force has been applied. When the ball is thrown at a certain height above the ground with horizontal force only, it will move a considerable horizontal distance, but will spend little time in the air.

Vertical force therefore gives the ball time in the air, and horizontal force makes the ball travel a horizontal distance over the ground. An equal amount of both horizontal and vertical force gives an angle of projection of 45°, which is the ideal angle of projection from ground level to cover the maximum range (see figure 9.1).

In the absence of air resistance, a ball thrown into the air with both horizontal and vertical force will follow a symmetrical curved pathway called a 'parabola' (see figure 9.2), in which the angle at release or take-off is the same as the angle on landing. However, air resistance will distort this pathway, particularly in the case of a lighter projectile with a larger surface area. For example, a volleyball is relatively light and will be affected by air resistance. Its flight path will therefore fall short of a true parabola.

A ball thrown or hit at an angle of release of 45° + x° or 45° − x° will cover exactly the same horizontal distance (see figure 9.3). For example, a ball projected into the air at an angle of 45° + 15° = 60° will travel the same horizontal distance as one projected into the air at an angle of 45° − 15° = 30°. The ball projected at 60° will be in the air longer, but travel the same horizontal distance as the ball projected at 30°. This means that the loss in horizontal distance at 60° is equivalent to the loss of horizontal distance at 30°. This relationship applies for all angles of release that are equal displacements above or below 45°.

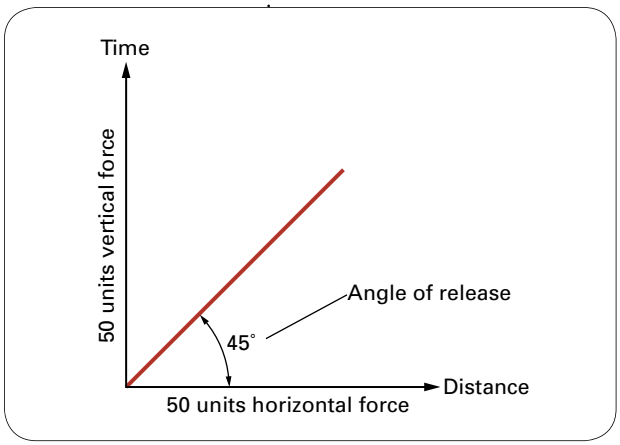


Figure 9.1 The relationship between the time a projectile spends in the air, the horizontal distance it travels and the ideal angle of release

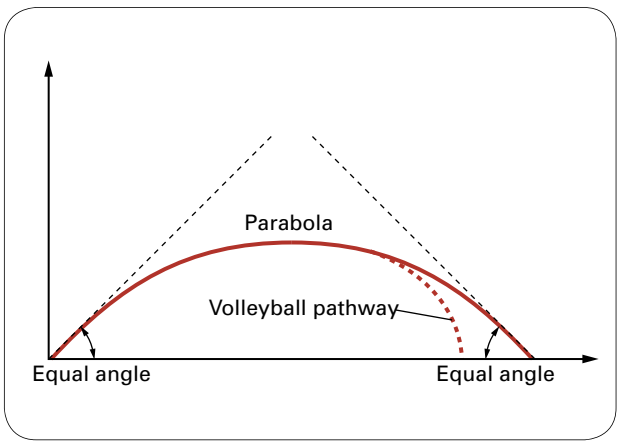


Figure 9.2 In reality, the flight path of a projectile is not a true parabola, due to the effect of air resistance.

When a cricket ball is hit from ground level with the aim of travelling the maximum distance, the ideal angle of projection is 45°. However, in most other sports skills, there are other variables (e.g. the height of release and speed of release) that have to be taken into account, resulting in a release angle that is somewhat less than 45°.

In the shotput, the optimum angle of release ranges from 39° to 42°. When the shot is projected at smaller angles, the distance it travels is decreased. Figure 9.5 shows the increases in distance that the shot travels when released at different angles, but at the same height (2.2 m) and the same velocity (13.7 m/s).

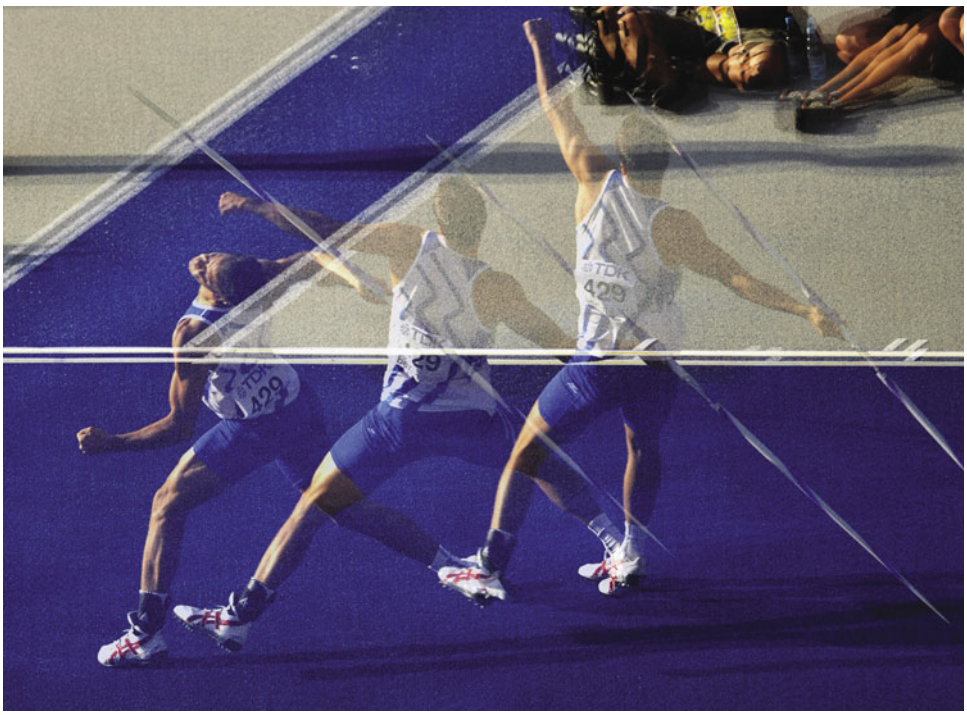


Figure 9.3 Finland's Tero Pitkamaki in his final throwing stride at the 2009 IAAF Athletics World Championships in Berlin. Note that in the final frame, the angle of release of the javelin is approximately 42°.

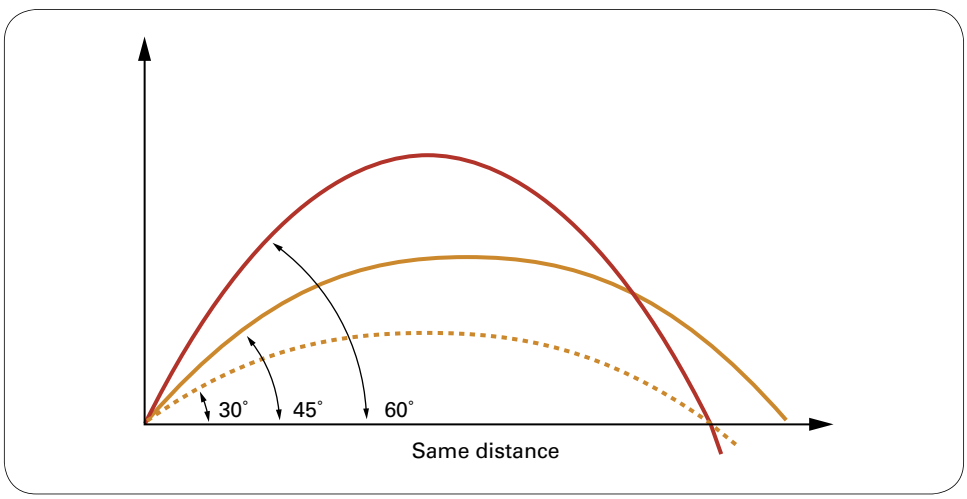


Figure 9.4 Horizontal distance travelled by a projectile in relation to angle of release

Figure 9.5 Increases in horizontal distance a shot travels with increasing angle of release

Angle of release	Distance	Increase in distance
36°	21.1 m	—
39°	21.4 m	0.3 m
42°	21.5 m	0.1 m

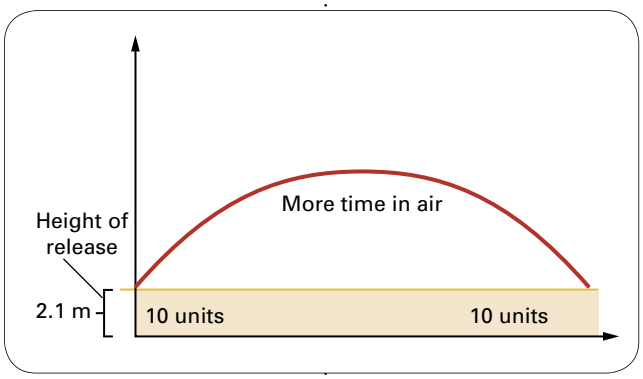


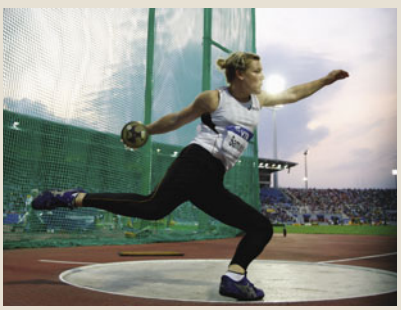
Figure 9.6
The relationship between height of release of a projectile and its time in the air

Height of release

Many sports skills (e.g. the shotput, baseball hit and cricket throw) involve projecting the ball from a given height above ground level and the ball then landing at ground level. In most cases, the height of release varies between 1.8 m and 2.4 m above ground level.

If a cricket ball is thrown from a height of approximately 2.1 m above the ground, a release angle of 45° may not be optimal. Because of its release height, the ball will already have extra time in the air (compared to a ball released at ground level). Therefore, the athlete can concentrate on releasing the ball at a lower angle and making it travel a greater horizontal distance.

SNAPSHOT



Dani Samuels of Australia is shown here in action in the women's discus throw at the IAAF World athletics final in Greece in 2009. She won the gold medal with a throw of 65.44 m, 2.5 m further than she had ever thrown in her life. The previous best result for an Australian at a world championship was a silver medal in 1993. Dani remarked that the throw had been 'effortless, so perfect' and 'I didn't force it at all and it shows how important technique is'. A lesson for all up-and-coming athletes whatever the sport.

Figure 9.7
Dani Samuels, Australian discus thrower

The following generalisations can be made about the relationship between height of release of a projectile, its angle of release and the horizontal distance it covers:

- The greater the height of release of a projectile, the greater the horizontal distance it will cover, as long as the force applied at release is the same. This means that, when trying to throw or hit a ball over the greatest possible distance, a taller athlete will have a distinct advantage over a shorter athlete.
- As the height of release of a projectile increases, its optimal angle of release decreases.

Actual increases in horizontal distance travelled by a projectile released at increasing heights are given in figure 9.8. The angle of release is the same in all cases (42°), as is the speed of release (13.7 m/s).

Figure 9.8 Increases in horizontal distance a projectile travels with increasing height of release

Height of release	Distance	Increase in distance
2.1 m	21.3 m	–
2.3 m	21.5 m	0.2 m
2.4 m	21.6 m	0.1 m
2.6 m	21.7 m	0.1 m

Speed of release

The higher the speed of release, the greater the distance a projectile will carry, given that the angle and height of release remain constant. The speed of a projectile at release is far more important than the angle or height of release in maximising the distance travelled. The distance covered when a ball is released at different speeds is given in figure 9.9. The angle of release is the same in all cases (42°), as is the height of release (2.2 m).

Figure 9.9 Increases in horizontal distance a projectile travels with increasing speed of release

Release speed	Distance	Increase in distance
13.1 m/s	19.8 m	–
13.4 m/s	20.6 m	0.8 m
13.7 m/s	21.5 m	0.9 m
14.0 m/s	22.4 m	0.9 m

Other factors

Other factors can influence the angle and speed of release:

- In throwing and hitting movements, muscles (such as the chest muscles) operate more efficiently in a horizontal direction; therefore, a lower rather than higher angle would be preferred.
- In the long jump, the fast run-up reduces the angle of take-off to approximately 22°, as the horizontal forces cannot be converted into vertical forces in the limited time available.
- A very heavy object (e.g. a shot) will always be projected at an angle of less than 45°, due to difficulties in handling its weight in the arm push stage.

In summary, when throwing and hitting projectiles in sport, it is generally best to make the angle of release lower rather than higher.

Movement in air

Air resistance

Resistance is exerted by any fluid (e.g. air or water) on an object moving through it. When the object attempts to cleave its way through the fluid, it is opposed or resisted by the fluid. The resistance, or drag, thus slows down the movement of the object. However, although such resistance can be a hindrance, it can also be a help to a sportsperson. For example, the air hitting against the front of a ball may slow it down, but the resistance of the air can enhance its spin or swerve.

Features of both the front and back of an object affect the amount of drag, or air resistance, it encounters. The amount of resistance depends on the following characteristics of the object:

- size
- shape
- smoothness
- speed.

For example, a gridiron football when kicked end over end effectively becomes a relatively large object that meets with significant resistance (see figure 9.10). However, when kicked or thrown torpedo-style, the football's shape helps to reduce the amount of resistance it experiences.

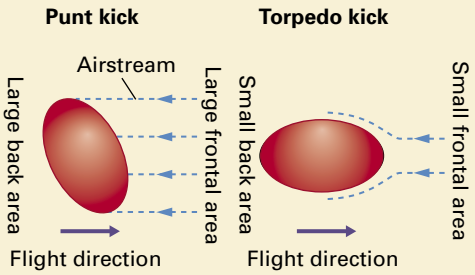


Figure 9.10
Air resistance encountered by a gridiron football travelling end over end, and torpedo-style

If a ball has a smooth surface, there will be less friction between the airstream and the ball's surface. The ball will not lose as much speed due to air resistance as a ball with a rougher surface.

It is important to understand that differences in air pressure can also affect the speed of a ball through the air and how it spins or swerves. These pressure differences were first discovered by a scientist called Bernoulli, who found that where air flow velocity is fast, the air pressure is low, and where the air flow velocity is slow, the air pressure is high. The **Bernoulli principle** can be illustrated using an airfoil (cross-section of an aeroplane wing) as shown in figure 9.11. As air flows past the airfoil, it is diverted over the upper curved surface and has to travel further than the air flowing underneath the flatter surface below. As molecules of air A and B must move from point A_1 to A_2 and B_1 to B_2, respectively, in the same time, molecule A therefore has to travel faster; thus the velocity of A is greater than that of B, creating a lower pressure on the top of the airfoil than underneath. The resultant higher pressure under the airfoil forces it upwards, giving the aeroplane lift.

The **Bernoulli principle** explains the lift generated by an aerofoil. Air moving at low velocity under the wing generates a higher pressure than air moving at higher velocity over the top of the wing.

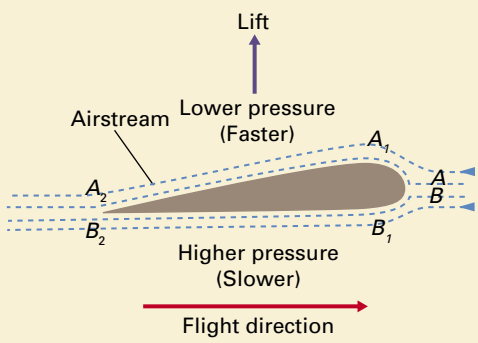


Figure 9.11
The Bernoulli principle as applied to an airfoil

When a round ball is kicked into the air, the air is forced against the front of the ball, creating resistance (see figure 9.12). The air then streams out and around the surface of the ball. When the air arrives at the back of the ball, the flow

breaks up, forming swirls of turbulent, faster moving air. In keeping with the Bernoulli principle, this turbulence creates a region of lower air pressure behind the ball. The higher pressure at the front of the ball then pushes against the ball, slowing it down even more. It should be noted that objects will always be forced to move from areas of high pressure to areas of low pressure. In general, turbulence behind a ball will account for most of the drag the ball encounters.

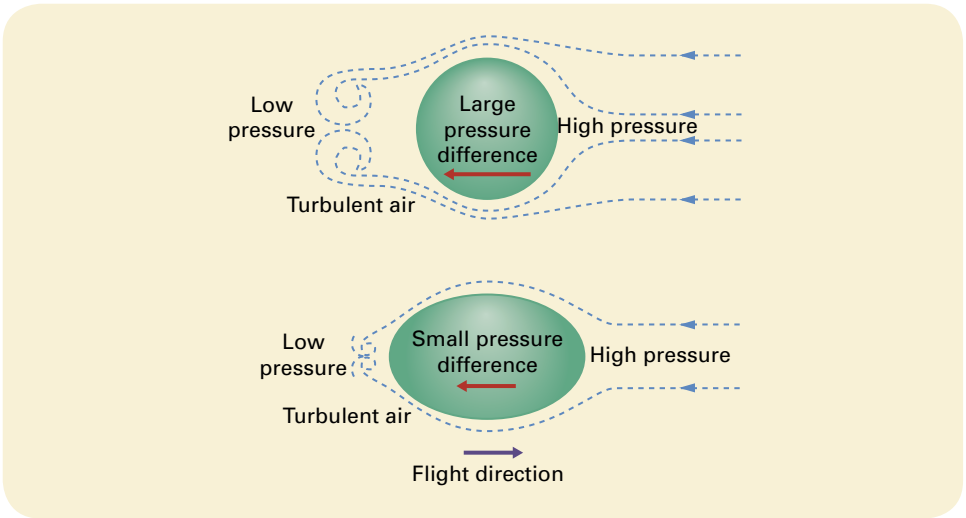


Figure 9.12 The different amounts of air resistance and air turbulence experienced by a round ball and an egg-shaped ball

An egg-shaped ball, such as a rugby football, can cut through the air more cleanly than a round ball (but only if it is moving with a pointed end in front and is not spinning). The air can flow with much less resistance over the nose of the ball. The tapered tail fills more space behind the ball and so there is less turbulence. Consequently less energy is lost by the ball.

The faster a ball moves through the air, the more difficulty the airstream has clinging to the ball, and the earlier it breaks up, producing a greater amount of turbulence at the rear of the ball, and increasing the pressure difference from the front to the back of the ball (see figure 9.14). This causes the ball to slow even more.

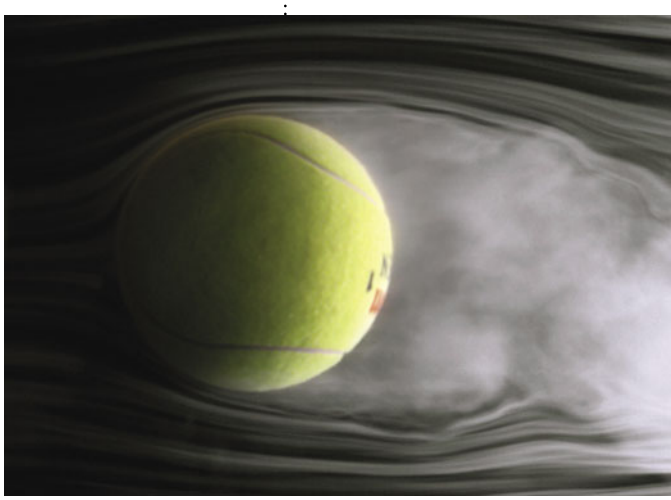


Figure 9.13 A tennis ball with no spin in a wind (smoke) tunnel at NASA, and flying from right to left. Smooth stream lines of smoke pass up and around the ball, breaking up and creating turbulence as they reach the back of the ball.

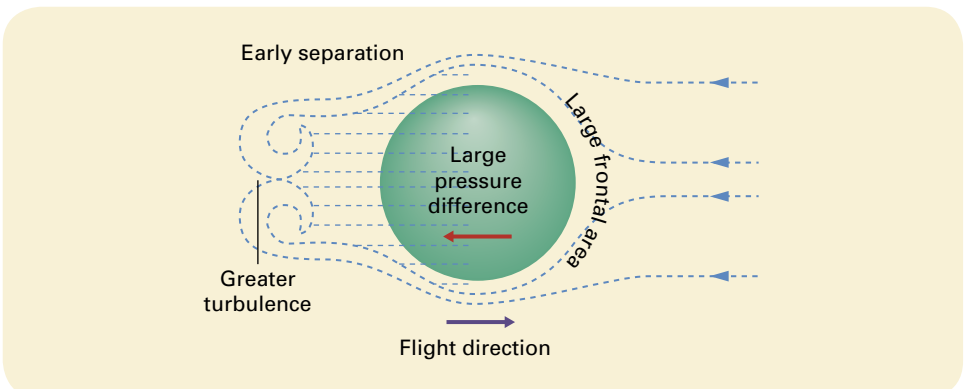


Figure 9.14 A fast-moving ball encounters greater air resistance and turbulence than a slower moving ball

Spin and swerve

Objects will swerve during flight as a result of spin or, in the case of a ball with stitching on it, due to a seam that disturbs the airflow. For example, a tennis ball dips under the influence of topspin (see figure 9.15) and a cricket ball seam swings.

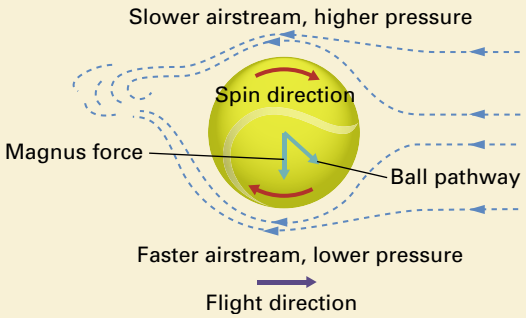


Figure 9.15
Side view of a tennis ball under the influence of heavy topspin

As the tennis ball spins (see figure 9.15), the airstream flowing over the top of the ball is moving in the opposite direction to the ball spin. This tends to deflect or push the airstream off the surface of the ball very quickly. However, the airstream that is flowing under the ball and moving in the same direction as the ball spin is attracted to the ball's surface and travels much further and faster around the ball's surface.

Because slow-flowing air has a higher pressure than faster moving air, the ball with topspin is therefore forced downwards by the higher pressure above the ball. (This force is known as the '**Magnus force**'.) A ball with underspin, on the other hand, is pushed upwards, whereas a ball with sidespin is pushed to the side.

Magnus force is a force effect using the Bernoulli principle which causes a spinning ball to swerve in the air.

A right-handed golfer hitting the ball with slice (fade) will impart some underspin and a lot of sidespin, so that the ball will fly high and carry away to the right of the player. A draw (hook) shot with some topspin and a lot of sidespin will fly lower and carry away to the left of the player. An object that is not spinning can also swerve in flight. In the case of a cricket ball, the prominent stitched seam creates the conditions necessary for swerve to occur (see figure 9.16).

When the air hits the front of a cricket ball, some of the airstream is diverted around the smooth side of the ball, and some around the seamed side of the ball. As the airstream meets the seam, it becomes turbulent and begins to swirl back onto the surface of the ball.

The swirling air is repeatedly forced back onto the ball's surface as the airstream continues its flow around the ball, enabling the airstream on this side to cling to the ball's surface over a greater distance than the airstream on the opposite side of the ball. This makes the airstream travel faster, and it develops a lower pressure.

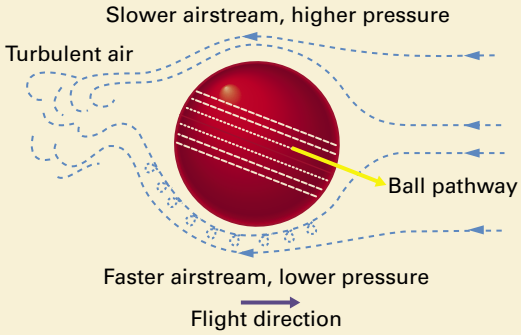


Figure 9.16
A cricket ball can be made to swerve in the air by turbulence created by its seam.

On the opposite side of the ball, the pressure is relatively high, so the Magnus force pushes the ball towards the seam side. A cricket ball will therefore always swing in the direction the seam is pointing.

To create a reverse or 'Irish' swing, the ball is roughened on the front side (i.e. the smooth side that will be at the front facing the direction of travel when the ball is bowled). This makes the ball act as if the seam is on the opposite side of where it actually is, and so the ball swings in the opposite direction.

The amount of swerve is increased by:

- spinning a ball faster, e.g. by imparting a heavier topspin to a tennis ball
- keeping the spin speed the same but using a larger ball, e.g. spinning a softball creates a greater swerve than spinning a cricket ball at the same speed
- reducing the linear speed of the ball so that the main force acting on the ball is a spin force—e.g. in baseball, a slow curve ball swerves more than a fast curve ball
- playing in air of higher density, where the airstreams can exert more force against the contours of the ball, e.g. a bigger swerve can be created by spinning a volleyball in Melbourne than it can in Mexico City, which is at a much higher altitude and where the air is 'thinner'.

Spin: angle of approach and rebound

A ball with no spin approaching a surface (see figure 9.17) will be robbed of some of its energy as it hits and rubs across the surface. Friction will cause the underside of the ball to be pulled backwards and the top of the ball forwards, thus initiating some forward spin on the ball. The rebound angle will therefore be less than the approach angle.

A ball with topspin approaching a surface (see figure 9.18) will rebound off that surface faster and lower than a ball with no spin. When the ball hits the surface, the dramatic backwards movement of the underside of

the ball against the surface results in an opposite forwards force that converts some of the ball's rotation into linear movement. The additional forwards force increases the linear speed of the ball and reduces the angle of rebound.

A ball with backspin (see figure 9.19) behaves in the opposite way to a ball with topspin. The ball will come off the surface slower and higher. The underside of the ball is moving forwards in relation to the surface, creating a forward force against the ground. This results in an opposite backwards force that makes the ball slow down and sit up, increasing the angle of rebound.

A ball with sidespin will deviate to the side on the rebound, as long as it does not land on its long axis point (see figure 9.20). If the ball with sidespin does land on its axis point, no additional forces are created. The ball then behaves as if it has no spin and will not deviate to the side. This confuses many inexperienced players, particularly if the sidespin is combined with topspin or backspin.

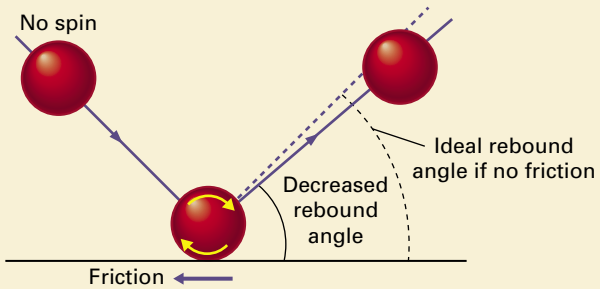


Figure 9.17
The angle of approach and rebound of a non-spinning ball

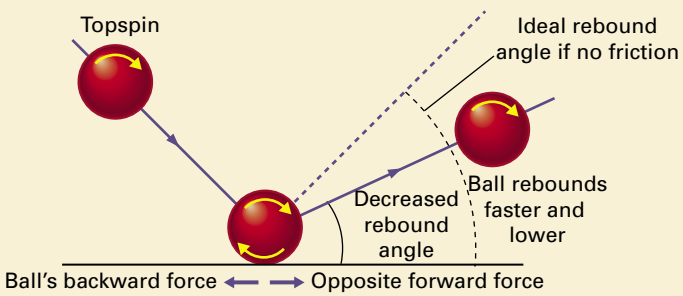


Figure 9.18
The angle of approach and rebound of a ball with topspin

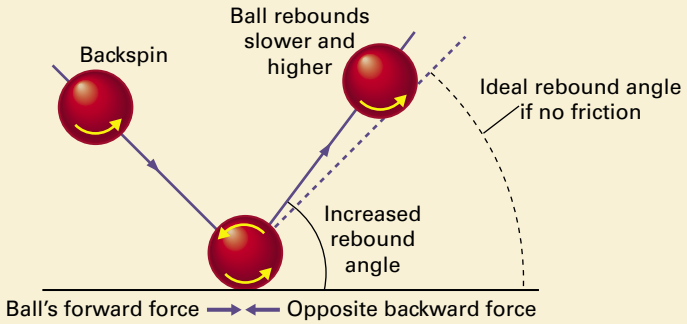


Figure 9.19
The angle of approach and rebound of a ball with backspin

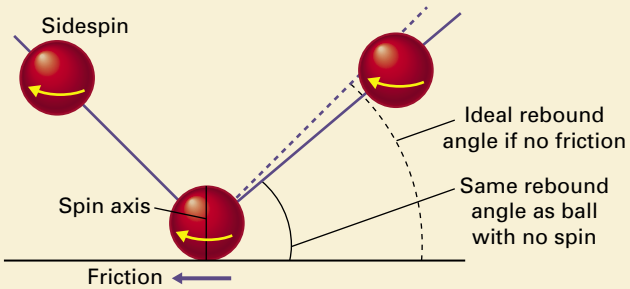


Figure 9.20
The angle of approach and rebound of a ball with sidespin

Learning experience

LABORATORY RESPONSE: MOVEMENT IN AIR

Task 1

Aim

To investigate the effect of different types of spin on a ball.

Equipment

- table tennis bat
- table tennis ball

Procedure

1 Stand 3 m from a suitable wall and hit the ball against the wall with:
   - **a** no spin
   - **b** topspin
   - **c** backspin.

2 What did you observe about the way the ball rebounds off the wall?

Task 2

Aim

To investigate the relationship between angle, height and speed of release of a projectile and the distance it travels.

Equipment

- garden hose connected to a tap

>>

Procedure

1 Holding the end of the hose, turn on the tap and direct a stream of water just above ground level to cover the greatest distance possible.
2 At approximately what angle should the stream of water be directed to cover the greatest distance possible?
3 Draw a diagram showing the shape of the path followed by the water stream.
4 How would you describe the shape of this path?
5 Repeat step 1, but hold the nozzle of the hose at hip height.
6 To cover the greatest distance possible, does the water need to be directed at a higher or lower angle than for step 1?
7 Draw a diagram showing the shape of the path followed by the water stream.
8 What general statement can you make about the effect of height of release on the angle of projection?
9 Repeat step 5, keeping the angle of projection the same, but increasing the velocity of the water stream.
10 Draw a diagram showing the shape of the path followed by the water stream.
11 What differences do you note between the paths?

Task 3

Aim

To show how the Magnus force makes a ball spin or swerve in the air.

Materials

- 2 table tennis balls
- funnel
- thread
- dowelling
- drinking straws
- sheet of A4 paper
- 2 books of the same thickness

Procedure

Work in groups on this laboratory.

1 Place a table tennis ball inside a funnel with the flared end pointing upwards.
2 As you turn the funnel upside down, blow as hard as you can into it (see figure 9.21).

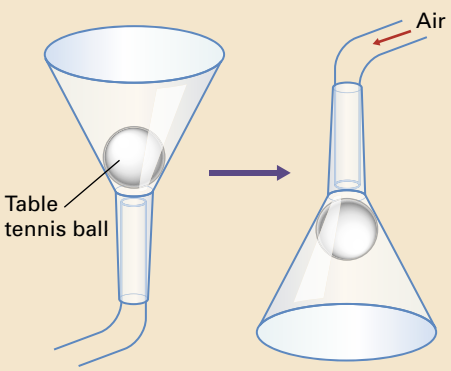


Figure 9.21
Using a table tennis ball and a funnel to demonstrate the effect of the Magnus force

3 Record what happens.
4 Tape lengths of thread to two table tennis balls and attach the threads to a piece of dowelling.

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5 Place a straw about 2.5 cm away from the balls and blow as hard as you can through the straw, directing the airflow between the balls (see figure 9.22).

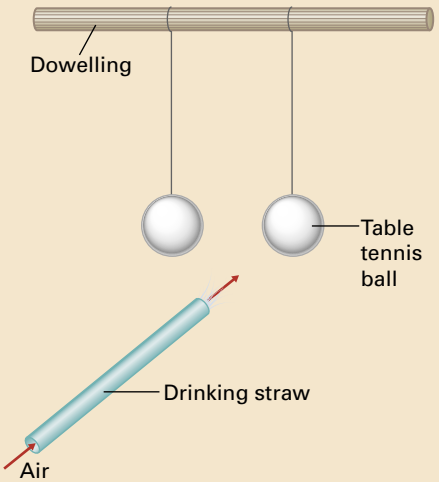


Figure 9.22
Using suspended table tennis balls and a drinking straw to demonstrate the effect of the Magnus force

6 Record what happens.

7 Place an A4 piece of paper on top of two books, and through a straw blow as hard as you can under the paper and between the books (see figure 9.23).

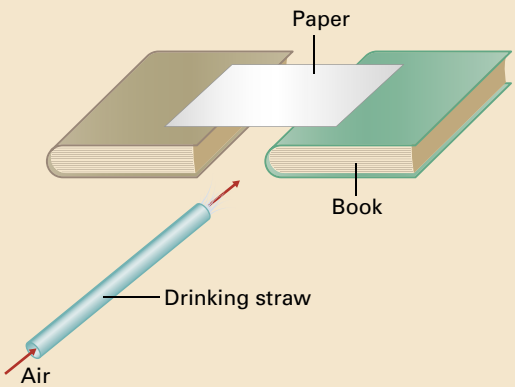


Figure 9.23
Using two books, a sheet of paper and a drinking straw to demonstrate the effect of the Magnus force

8 Record what happens.

Results

1 What were the results of each activity?

2 **a** Identify where the air was travelling fastest and slowest in each activity. This will tell you where the air pressure was lowest and highest.

b What direction was the force coming from in each activity to cause the observed result?

Conclusions

Describe why the ball spins in a given direction in each activity.

Movement in water

In aquatic activities (such as swimming, rowing and canoeing) forces must be dealt with that are normally not encountered when moving on land. An appreciation of these forces helps to develop a feel for the water, and an understanding of the dynamics of flotation and the movement of a body in and through the water.

Buoyancy

The **buoyant force** is an upward force against the underside of an object in water.

The **buoyant force** is an upward force exerted against the underside of a floating or submerged body, in this case a swimmer. This upward force or pressure enables the swimmer to counter the gravity or weight force which is trying to push the swimmer to the bottom (see figure 9.24). It is the buoyant force, therefore, that tries to push the swimmer towards the surface and into a potential floating position.

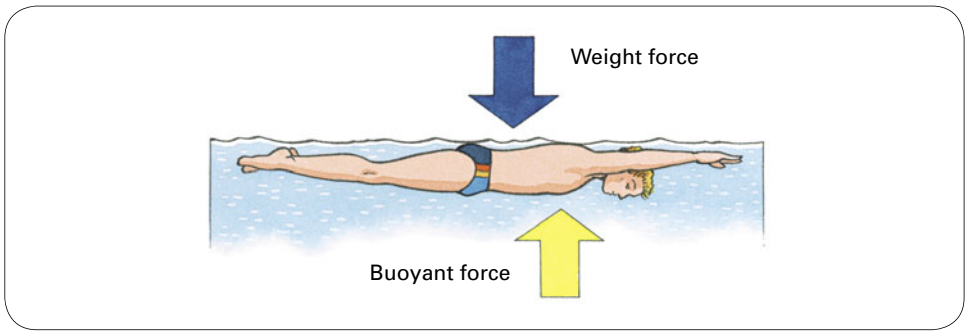


Figure 9.24 Counteracting forces—weight force and buoyant force

Let's try to understand this concept by imagining that the water in a swimming pool is divided into a series of vertical blocks (see figure 9.25). The top block does not have any other block to support and therefore has no weight pressing down on it. However, the block underneath has to support the pressure of the top block, and the third block has to support the pressure of the top two blocks and so on. The pressure on any given block of water must therefore increase with depth.

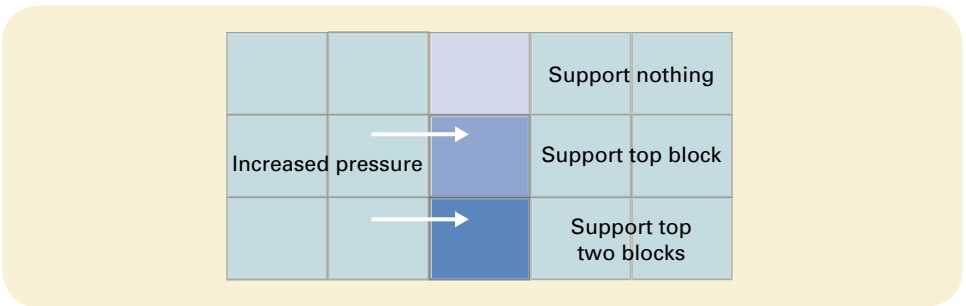


Figure 9.25 A diagrammatic representation of how water pressure increases with depth

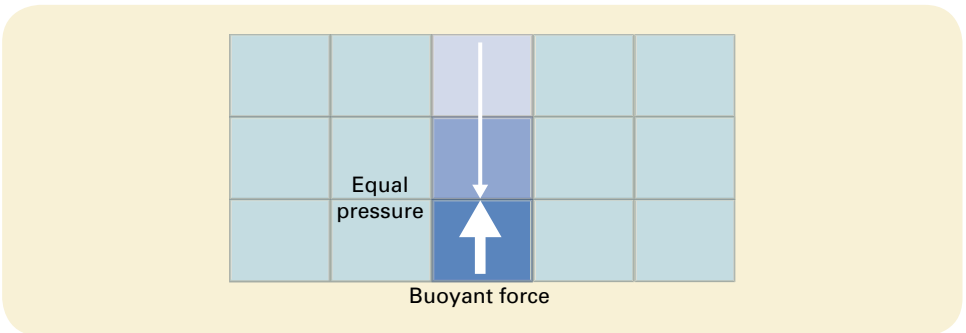


Figure 9.26 The upwards pressure of the bottom block on the blocks above it is known as the buoyant force.

One would think that the pressure of the top blocks of water would squeeze out or compress the supporting blocks. This cannot happen, however, because water is practically incompressible, and because the water is contained within the bounds of the pool and has nowhere to move. The supporting blocks therefore accept the pressure of the top blocks by exerting an upward pressure equal to the downward pressure of the top blocks. This upward pressure is known as the buoyant force (see figure 9.26).

Archimedes principle

The effect of the buoyant force depends on the physical characteristics of the body. This principle was first discovered by Archimedes. The **Archimedes principle** states that a body wholly or partly submerged in a fluid is buoyed up by a force equal to the weight of the displaced fluid.

Archimedes principle states that the buoyant force acting on a body is equal to the weight of the fluid displaced by the body.

Another way of describing this effect is to compare the weight densities of the human body with water. (Weight density is the weight per unit volume of a body.) As it turns out, the weight of the human body is approximately the same as an equal volume of water, and when this ratio is 1:1 the body will float perfectly. However, the human body has tissues with many different weight densities (e.g. fat has a weight density of 0.8, muscle 1.0 and bone 1.8). The human body therefore has a weight density that varies slightly above and below 1.

Figure 9.27
A man floats in Lake Retba in Senegal. The lake has a very high salt content and a pink colour due to the bacteria that thrive on the salt. Note the high position of flotation where, in accordance with Archimedes' principle, the increased weight of the water displaced provides a greater upward force on the underside of the body.

When the weight density of the body is exactly 1 (i.e. the weight of the body is exactly that of an equal volume of water), then the body will float perfectly, just lipping the surface of the water (see figure 9.28). Ideally, perfect floaters would be adults with large legs and underdeveloped muscles and quite a bit of fat tissue, or children who have a light frame and light musculature.

A body with higher proportions of fat could have a weight density of 0.9, making the body only nine-tenths the weight of an equal volume of water. Because the water is therefore exerting an upwards buoyant force that is greater than the downwards weight force of the body, the body will be pushed up and out of the water. The body will stop its upwards movement and find its position of flotation when the weight of the body exactly matches the weight of an equal volume of water. So if the body is nine-tenths the weight of an equal volume of water, then nine-tenths of the body will locate itself in the water and one-tenth will be out of the water.

On the other hand, a body with a heavy frame and heavy musculature could have a weight density of 1.1, making the body heavier than an equal volume of water and causing it to sink. In general, lean adults with heavy frames and light musculature will sink, as will massively built adults with heavy frames and heavy musculature.

In competitive swimming, positive buoyancy (i.e. the body being partly out of the water) reduces drag because less cross-sectional area of the body is exposed to the direction of movement through the water. It has been found that buoyancy lift may account for up to 10% of the variance in a 400 m swim.

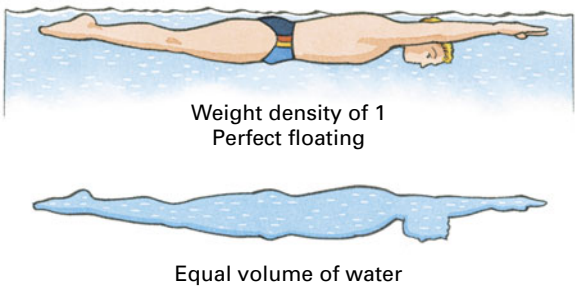


Figure 9.28
When the body weight of a swimmer is the same as the weight of an equal volume of water, then the body will float perfectly, just lipping the surface.

Centre of weight and centre of buoyancy

The weight density of the body will basically determine whether or not it floats. However, its position and angle of flotation will be determined by the relative location of the centre of weight (gravity) and the centre of buoyancy (see figure 9.29).

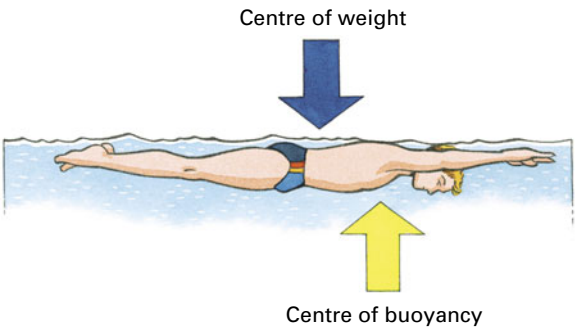


Figure 9.29
The centre of buoyancy is located around the sternum in a higher position than the centre of weight.

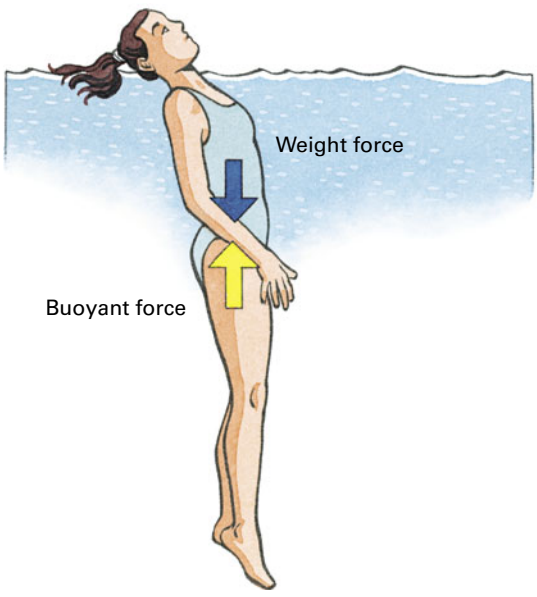


Figure 9.30
When the buoyant force and the weight force come into vertical alignment, the body will float in that position.

The human body

In a symmetrical object of uniform density, both the centre of buoyancy and the centre of weight would be located at the same point. However, the human body is an irregular object of varying weight density and, because of this, the centre of buoyancy is generally located in the bigger-volume chest cavity area around the sternum, and the centre of weight is located around the navel. The location of the centre of buoyancy will vary according to the individual's body type and can only be altered with a change in body shape and/or volume. However, the location of the centre of weight can be altered both by changes in body type and, at any given time, by a change in the distribution of body parts around the centre of weight.

When the buoyant force and the weight force are in vertical alignment, the body will maintain a stable floating position in the water (see figure 9.30). However, when the centre of weight is lower in the body than the centre of buoyancy, the downward weight force will rotate the lower body around the axis point—the centre of buoyancy—until both come into vertical alignment, and the body will then stabilise and float in that position.

When an individual finds it difficult to float in any given position, the centre of weight must be brought closer to the centre of buoyancy. This reduces the size of the moment arm (see 'moment of force', page 111) between the line of the weight force and the line of the buoyant force, and consequently lessens the potential of the legs to rotate. This is achieved by the redistribution of body parts, e.g. bending the legs under the body and/or stretching the arms overhead (see figure 9.31).

The most extreme redistribution of body parts is demonstrated in the tuck float in which the centre of weight can easily be brought into vertical alignment with the centre of buoyancy (see figure 9.32). The body will have no rotational tendency and will float, usually with the back just lipping the surface. Most people can float in this position. However, it is only a last-resort float, as it leaves the swimmer in a life-threatening face-down position in the water.

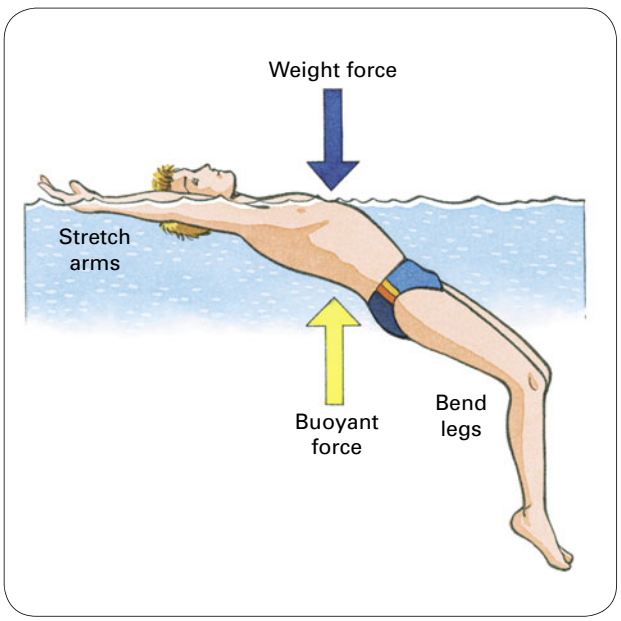


Figure 9.31 Redistribution of body parts to bring the centre of buoyancy and centre of weight closer together

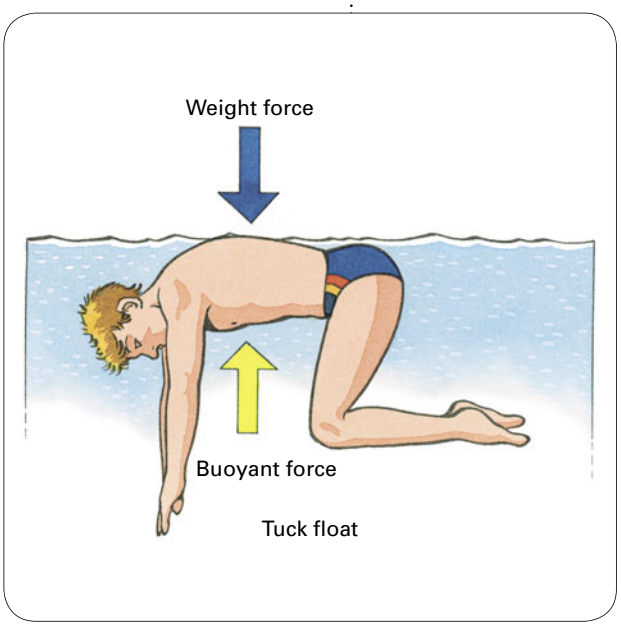


Figure 9.32 Extreme redistribution to enable flotation in the tuck position

Rowing boats and canoes

The principle of buoyancy can be applied in the same way to rowing boats and canoes when the weight force due to gravity is exactly matched by the buoyant force. When the hull of a boat is upright, the centre of buoyancy lies along the same vertical line as the centre of weight, but if the hull is rolled anticlockwise, the lines no longer coincide. The intersection of the weight and buoyancy lines is called the **metacentre**.

The **metacentre** is the intersection of the weight and buoyancy lines in aquatic craft.

Whether a boat floats in a stable or unstable position in the water depends on the relative positions of the metacentre and the centre of weight. The diagram on the left in figure 9.33 illustrates the case of an unstable rowing shell. The submerged hull is nearly semicircular; hence, the metacentre lies close to the waterline. However, to achieve an efficient rowing stroke, the crew has to be seated centimetres above the waterline. The centre of weight (due mostly to the crew) lies above the metacentre. If the boat rolls anticlockwise, the buoyancy continues to act upwards through the metacentre, but gravity acts downwards through the centre of weight, which has now moved to the left, so an anticlockwise turning

moment is generated, which reinforces the roll. The whole system is intrinsically unstable.

A canoe will be stable when the canoeist sits low in a wide-hulled boat (see the diagram on the right in figure 9.33). The centre of weight is below the metacentre, so any anticlockwise roll results in the centre of weight moving right relative to the metacentre to generate a clockwise restoring movement, so that the boat remains stable.

Note that stability is only determined by the relative positions of the centre of weight and the metacentre. It is quite possible to achieve stability for a rower sitting above the waterline by using a hull with a shallower curvature (raising the metacentre to the centre of a larger-diameter circle). This is why training boats are more stable than racing boats. The disadvantage is the increase in surface area for the same displacement, and hence increased drag. However, optimum balance in water is also due to the fin acting as a more efficient roll-damper and the shape of the bows creating a stabilising force.

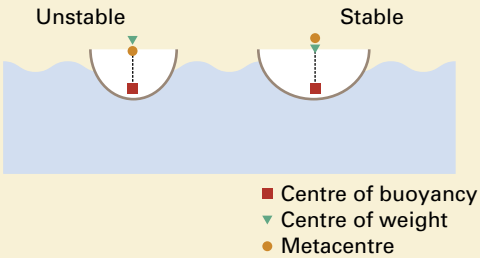


Figure 9.33
An unstable rowing shell (left) and a stable canoe (right)

Resistive forces

When a body moves through the water it is subject to resistive or **hydrodynamic drag** forces that serve to slow its progress.

Hydrodynamic drag is the sum of the resistive forces in water.

Total drag (**resistance**) is the sum of the three types of hydrodynamic drag:

Total drag = skin friction + profile drag + wave drag

Resistance in water is the sum total of skin friction, profile drag and wave drag.

This section discusses ways in which skin friction, profile drag and wave drag can be decreased to improve efficiency in water.

Skin friction

Skin friction drag is the resistive force in water caused by water flowing along the surface of the body.

Skin friction, or surface drag, is the resistive force (resistance) caused by the water flowing backwards along the surface of a body that is moving forwards through the water. The magnitude of the friction drag depends on the velocity of the flow relative to that of the body, the surface area of the body and the characteristics of the surface. Compared with the other types of drag in swimming, it is the least significant.

In swimming it has been a common practice to reduce skin friction by shaving the body, arms, legs and head if the amount of hair is excessive. Swimmers who shave their bodies often report that kinaesthesis and tactile sensitivity to the water are enhanced. However, it is also said that the swimmer's tactile sensitivity is reduced rather than enhanced by the removal of hairs that, when moved, serve to stimulate receptors beneath the skin. In

either case, the sensation is different with and without hair, and the latter may result in a psychological benefit for some swimmers.

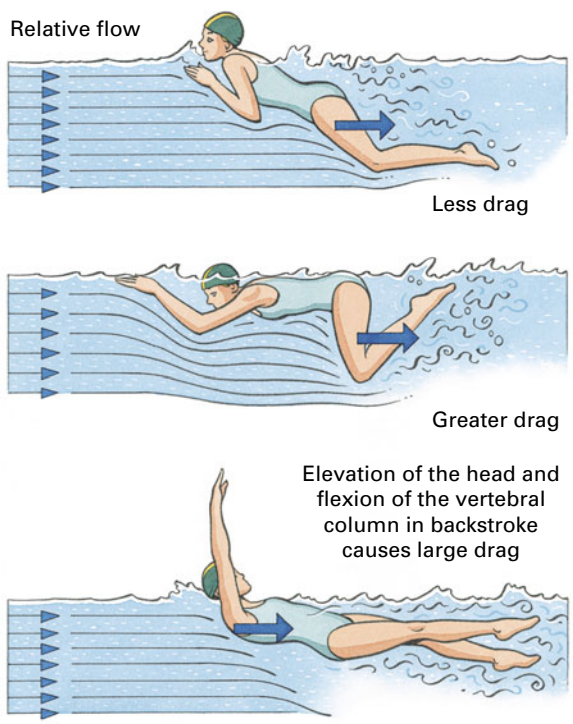
The smoother the skin and swimsuit, and the smaller the surface area of the body oriented parallel to the flow, the less water in the boundary layer carried along with the body or body part, and the smaller the skin friction resistance. A series of suits were developed for the 2000 Olympics, one aim being to minimise skin friction. These 'hydrodynamically' designed swimsuits were seamless, contained muscle and skin surface ripples and aided core stability. So successful were they, with so many world records being broken, that FINA decided to outlaw such suits from 2010.

Profile drag

The most significant type of resistance in swimming at most speeds is that created by the swimmer's body 'spreading the water apart' as it moves through the water. The amount of this **profile drag** depends on the size, shape and speed of the swimmer, as well as the orientation of the body relative to the flow. It should be noted that by doubling the swimming speed, the profile drag is quadrupled, and the power required by the swimmer is increased by a factor of eight.

Profile drag is the resistive force in air or water caused by the size and shape of the body.

The greater the area of the body and its parts that face the flow, the greater the drag (see figure 9.34). High-pressure zones are created on the leading surfaces of the body, and low-pressure zones are formed at the trailing surfaces where the water is moving faster and is turbulent, or full of eddies, thus creating a suction effect, as discussed earlier for air resistance. The pressure difference results in a net force acting backwards against the body and slowing swim speed.



Source: adapted from Kreighbaum, E & Barthels, KM, 1996, *Biomechanics—A Qualitative Approach for Studying Human Movement*, 4th edn, Allyn and Bacon, Sydney

Figure 9.34
Profile drag is increased when recovering the arms and legs in breaststroke (see diagrams A and B) and when using faulty mechanics in backstroke (see diagram C) with excessive elevation of the head and shoulders.

Figure 9.35
Federico Colbertaldo's head is held in a neutral position (in alignment with the body) in order to streamline the upper body and head, and reduce profile drag.

Profile drag is affected by the anthropometric characteristics of swimmers and relates directly to the body shape in the water. Maximum cross-sectional area of the body is a significant feature contributing to drag. The long, slender shape of the swimmer, with the body tapering from shoulders to hips to feet, promotes efficient water flow and reduces profile drag. However, as shoulder power is the mainstay of the freestyle and backstroke swimmer, large shoulders have to be tolerated in spite of their high profile drag. A streamlined shape means that the water is allowed to flow smoothly around and past the body without much turbulence.

Another way to reduce profile drag during swimming is to minimise the drag-producing aspects of limb recovery movements. How the limbs are brought forwards under water during recovery is important (in particular, the action of the breaststroker's arms and legs) for two reasons. These movements expose more area to the backwards flow, which increases resistance; and moving the limbs forwards through the water faster than the body (trunk) is moving increases the resistances even more.

In addition, some swimmers have a flaw in technique that may cause excessive hip sway back and forth in freestyle and backstroke, or rise and fall in butterfly. Excessive hip movements usually result from faulty stroke entries. One advantage of the use of bodysuits, at least from neck to knee, was that they restricted the amount of excessive hip sway. This reduction in movement range reduces both profile and wave drag.

Wave drag is caused by moving along, through or near the water surface.

Wave drag

Wave drag is the resistive force caused by a body moving along, through or near the surface of the water and forming waves. The force applied by the body, or its segments, to the water to form these bow waves generates an opposite reaction force applied by the waves against the body. The force of these swimmer-created waves increases with the speed of the swimmer. Even if a moving object or body is completely submerged but is still close to the surface, wave drag is not entirely eliminated as a source of resistance.

Although at low speeds wave drag is not significant, it may be the most important source of resistance at the faster swimming speeds seen in competition. Wave drag, and the power to overcome it, increases proportionately in the same way as profile drag. As the speed of the swimmer increases, the size of the bow wave increases and the 'wall' of water presses backwards against the swimmer.

The formation of bow waves also increases greatly with the vertical movements of the shoulders or head found in many strokes. For example, the breaststroker creates a large bow wave in front of the face and chest during the pulling action and as the breath is taken. Generally speaking, good streamlining of the body will produce lower waves with less wave drag.

Wave drag and profile drag as sources of resistance in swimming are so much larger than skin friction drag that skin friction drag may usually be considered negligible until an important competition.

SNAPSHOT

Leisel Jones has overcome many disappointments and even depression to fight her way back to the forefront of women's breaststroke. She is one of the world's best breaststrokers, but had never won a gold medal at the Olympic Games until the 2008 Games in Beijing, where she won gold In the 100 m breaststroke. The 24-year-old is now returning to international racing, with her focus on the 2012 London Olympics.

Figure 9.36 Leisel Jones on her way to winning and setting a new world record in the women's 200 m breaststroke at the FINA Swimming World Championships in Berlin 2009.

Resistance in boats

In rowing and canoeing, the craft are also subject to major sources of resistance. As the hull moves through the water, it will experience a retarding force caused by three factors. The first is the friction on the hull; the second is the moving wave pattern that is created by the hull and requires energy to sustain it; and the third is the turbulent wake that the hull creates behind itself.

These resistive forces mainly depend on the size and shape of the hull, the surface of the hull, and the water depth. The frictional resistance applied by the water onto the shell is also affected by the water temperature. As the temperature of the water rises, the viscosity of the water decreases, causing the frictional drag to decrease.

Propulsive forces

There are three theories that help to explain propulsive forces produced by the swimmer's body and/or limbs as they move through water:

- drag force
- lift force
- pump force.

Drag force

Drag force was explained previously in terms of how it acts to resist the forwards motion of the swimmer's body. However, drag force can also be used to propel the body in water.

As the hand is pulled back in the water, the water flows past the hand and becomes turbulent at the back of the hand (see figure 9.37). This fast-moving turbulent water results in a low-pressure zone at the back of the hand and a high-pressure zone at the front of the hand, in accordance with the Bernoulli principle. The hand will therefore want to move into the low-pressure zone. As this is in the opposite direction to the hand pull, the swimmer can apply a greater action–reaction hand force against the water, and the larger the hand paddle, the greater the effect.

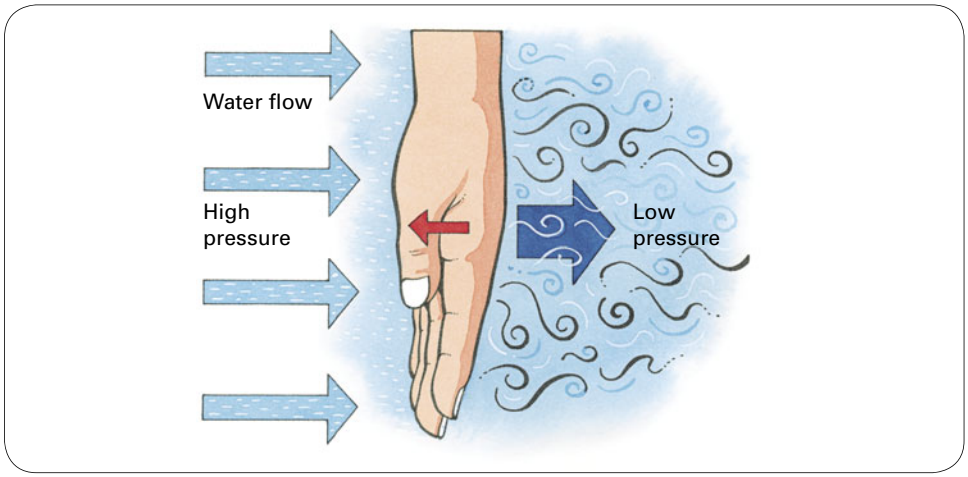


Figure 9.37
Drag force due to pressure differences

The angle of attack of the hand is also very important in optimising drag force, as the hand's orientation in the water controls the water flow over the hand. It is currently thought that such drag propulsion can be used more effectively in freestyle by straightening the deep 'S'-shaped pull pathway of the hand and promoting a shallower pull.

Figure 9.38
Germany's Paul Biedermann on his way to winning the men's 200 m freestyle at the FINA World Cup 2009, held in Berlin. The left arm flexed to just over 90° provides strong leverage, and the hand is angled so that it provides high propulsive forces.

Lift force

In swimming, water flow past the hand can also cause a **lift force**. In this case the hand must be shaped like an airfoil or aeroplane wing as shown in figure 9.39. When the water travels over the back of the hand, which has a longer surface area, the water is forced to travel at a higher velocity than it

Lift force is due to the development of high pressure under the hand and low pressure above it when the hand is pitched to the water at around 40°.

would when travelling under the hand. According to the Bernoulli principle, this will result in a higher pressure under the hand and force the hand from the high-pressure zone to the low-pressure zone. However, the competitive swimmer does not want purely vertical lift and therefore changes the orientation of the hand so that the so-called lift force now operates in a more horizontal direction. As the lift force is in the opposite direction to the hand pull, this gives the swimmer greater traction against the water.

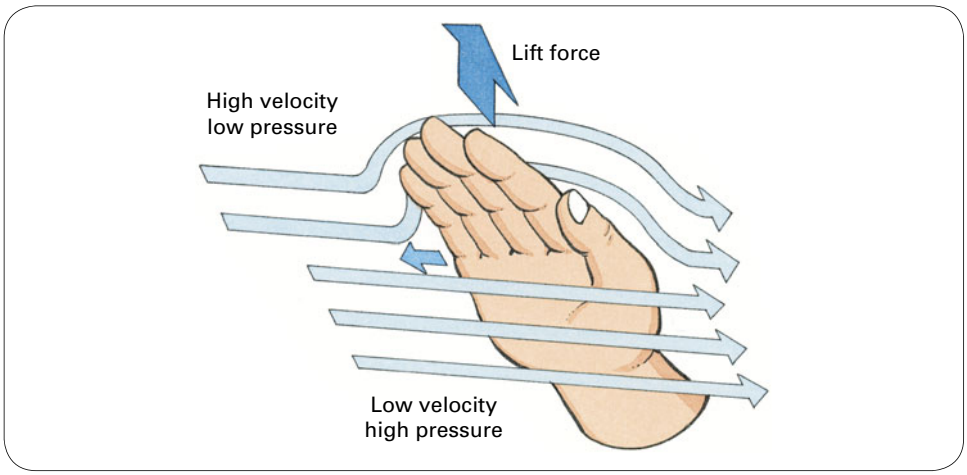


Figure 9.39
Hand shaped like an airfoil

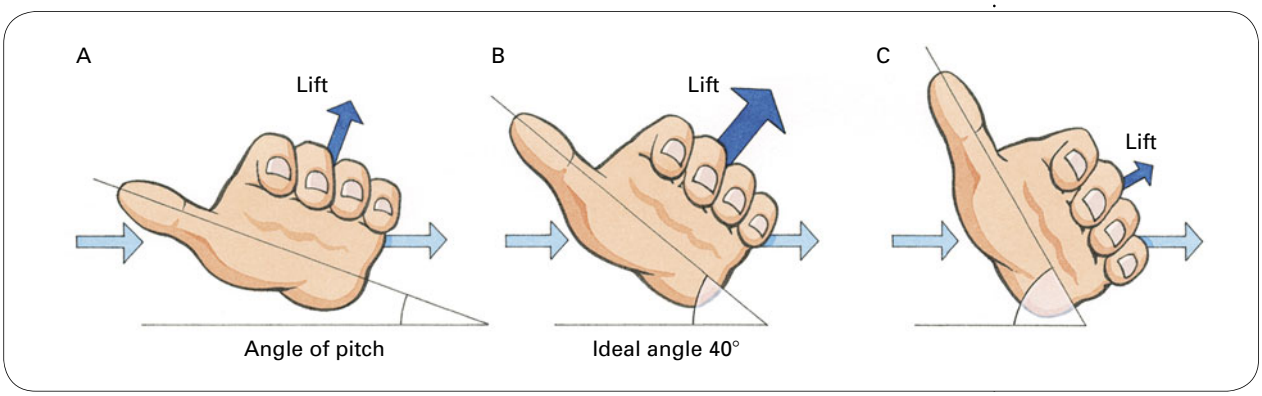


Figure 9.40
Lift effect for three hand positions. The length of the arrow indicates magnitude of lift.

Three pitches of the hand are shown in figure 9.40. To achieve the optimum lift force, the hand should be angled at approximately 40° to the horizontal, as shown in position B. In position A, there is not a great enough difference in the velocity of the water flow above and below the hand, and therefore there is little difference in pressure. The lift force will therefore be small. In position C, the hand has such a high pitch that the water cannot flow smoothly over the top of the hand, and the water breaks up, resulting in an almost complete loss of pressure. A belief in the importance of lift forces has also encouraged coaches to emphasise the curved nature of the hand path in all swim strokes, and the use of longer pathways to develop greater lift force application over a longer time.

Pump propulsion

Pump propulsion is the newest propulsion theory. To understand this, let's consider the simple model of a rotating stiff arm. As the arm rotates around the shoulder joint, the parts of the arm further from the shoulder will be travelling at a higher velocity, with the hand travelling at the highest velocity (see 'Inertial velocity and leverage', page 148).

Pump propulsion is due to a pressure gradient, pumping water down the arm and forming a low pressure area behind the hand.

According to the Bernoulli principle, the area where the hand and water are travelling at the highest velocity (i.e. around the hand) will have the lowest pressure, and the area around the shoulder will have the highest pressure (see figure 9.41). This will lead to a velocity gradient from high to low pressure along the arm, inducing an axial fluid flow along the arm and hand towards the fingertips. Thus the limb rotation leads to a pressure gradient pumping fluid along the arm towards the hand and boosting the low-pressure area on the back of the hand, as described for drag propulsion. The hand is now acting as a more efficient paddle.

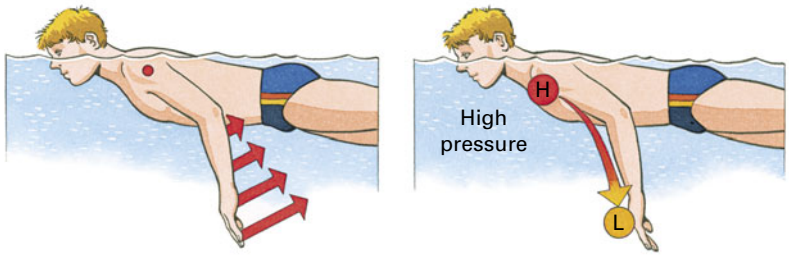


Figure 9.41
The high-velocity movement of the arm during the outsweep (left) creates a velocity gradient along the arm from high pressure to low pressure (right) that, according to the Bernoulli principle, leads to an axial water flow down the arm and towards the hand.

Before 1970, coaches believed that the best way to propel the body through the water was to drag the hand directly backwards. In the 1970s, following observations that the hands of elite swimmers followed curved paths and that the hand was pitched in the water, the theory of lift force in combination with some lesser drag force became popular. Pump propulsion is the latest theory in a bid to understand how the body forces itself through the water. Currently, however, it is believed that drag force is the major propelling force in the water.

Learning experience

LABORATORY RESPONSE: ARCHIMEDES PRINCIPLE

Aim

To investigate the relationship between weight and volume.

Equipment

- balloons
- swimming pool
- water container.

Procedure

Task 1

1 Completely fill a round balloon with water and tie off at the neck. Place the balloon in a swimming pool or large container and observe its position of flotation.
2 In which position did the balloon float in relation to the water surface?
3 In the diagram below, D, E and F represent three bodies of water, each equal in volume to the balloon that you placed in the water. Would A have the same weight as each of D, E and F? (Do not consider the weight of the balloon's skin.)
4 Is A in perfect equilibrium with the body of water immediately surrounding it?

>>

Conclusion
Under which conditions does an object float just under the surface?

Task 2

1 Now consider a balloon half-filled with water, and half-filled with air.
2 Does this balloon have the same volume as each of D, E and F?
3 Does this balloon have the same weight as each of D, E and F?
4 Which position of flotation does this balloon assume in the water?

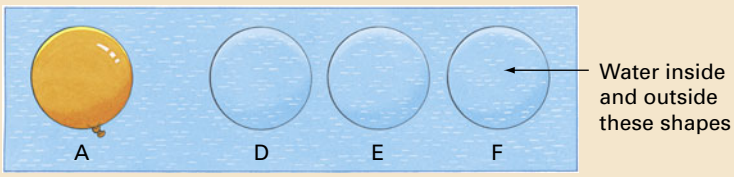


Figure 9.42 A round balloon filled with water and three imaginary bodies of water with the same volume as the balloon

Conclusion
Under which conditions does an object float half in and half out of the water?

Task 3

1 Now consider a balloon filled with air only.
2 Does this balloon have the same volume as each of D, E and F?
3 Does this balloon have the same weight as each of D, E and F?
4 Which position of flotation does this balloon assume in the water?

Conclusion
Under which conditions does an object float almost totally out of the water?

Task 4

1 Take a round balloon filled completely with water and drop it from a height of 1 m into a swimming pool or push it under the surface of a container filled with water.
2 Which force is acting on the balloon before it hits the water and while it descends through the water?
3 As the balloon descends through the water, it slows down and then stops before ascending to the surface again. Which force is acting on the balloon to slow it down and eventually stop it, and then cause it to ascend again?
4 What is this force called?

Learning experience

LABORATORY RESPONSE: WEIGHT AND FLOTATION

Aim
To understand how the weight of various body tissues affects flotation.

Equipment

- bone
- piece of meat
- piece of fat.

>>

Procedure

Place the bone, the piece of meat and the piece of fat in water and observe whether they float or sink.

Results

Complete the following statements using the terms 'float' and 'sink':

a Bone tissue will

b Muscle tissue will

c Fat tissue will

Note: For any of the tissues that sank, or were heavier than the weight of the displaced water, you can assess which one was heavier by observing the *speed* of sinking.

Conclusions

1 Which additional factors could a swimmer manipulate to lighten the body?

2 Which of the following body types would have the best flotation capability?

- **a** endomorph (fat)
- **b** ectomorph (lean)
- **c** mesomorph (muscular).

3 Is it likely that an individual with good flotation capabilities will learn to swim more easily than someone without such capabilities?

4 Do you think that a competitive swimmer with good flotation qualities is more suited to a sprint or an endurance event?

Task 1

1 In the swimming pool lie along the edge of the pool and move your hand and forearm through the water. Make different shapes with your hands and feel the different resistances of the water. Now repeat each hand position but bring the hand through the water at varying velocities. Document your results.

2 Select a swimming stroke you can perform reasonably well. Swim a given distance with the head held in an out-of-alignment position, i.e. higher than the trunk. Count how many strokes you take to complete one length of the pool.

3 Now drop the head into alignment with the trunk and repeat. Compare your results.

Conclusions

1 Which resistive force in swimming is the most significant? Briefly state why this is so.

2 Explain whether the hydrodynamically designed seamless swimsuit assists a swimmer in the water compared to a wetsuit used by divers.

Task 2

In the swimming pool, and working with a partner or in a small group, perform the following experiments. Discuss the results.

1 Tread water (without using the legs) by using broad horizontal sweeps of the hands. Keep the hands in a cupped position, as for an airfoil, and experiment with the hands at various angles to the water. Sweep in a sculling figure-of-eight motion. Which hand position was most successful in keeping you afloat?

2 Lie on your back and perform sculling actions with the hands to move backwards or forwards through the water. Now take up a prone position and repeat.

>>

3 Perform a freestyle action with the arms, and isolate the legs by keeping them together or using a tie around the ankles. Using no kick for propulsion, experiment with various arm actions. First, stroke under the body using a very expansive curved pathway such as a deep 'S'-shaped pull. (This will be helped with a sound rolling action of the body.) Second, try bringing the hand under the body in a narrow curved path. Check which felt better and seemed to give you the better propulsion?

4 Perform a breaststroke action and compare the propulsive effect of the whip kick if the ankles are:

- **a** kept in dorsiflexion throughout
- **b** kept in plantarflexion throughout
- **c** moved from dorsiflexion to plantarflexion as the legs near the end of their drive phase.

Can you deduce from the orientation of the feet whether the most effective action was due to a drag effect or a lift effect?

Chapter review

Air and water forces

Know	1	State the Bernoulli principle of differential pressures.
Comprehend	2	Describe the essential link between the Bernoulli principle and the Magnus effect.
Apply	3	In a wind tunnel, a ball *without* spin will form a turbulent wake behind the ball. This wake will, in turn, affect the air pressure behind the ball. Explain the effect of the change in air pressure on the flight of the ball.
	4	In the same wind tunnel, a ball *with* topspin will cause the air flowing over the top surface of the ball to cling to this surface over a greater distance than on the under surface of the ball. Explain the result of this phenomenon in terms of pressure effects and the resultant pathway of the ball.
Analyse Evaluate Synthesise	5	The arm and hand in freestyle swimming are used as a unit to generate propulsion through the water. Three theories related to the Bernoulli effect attempt to explain how such forces are generated. Compare and contrast these theories, to highlight the role of the Bernoulli effect in providing propulsive forces. Which theory would be the most logical to support?

chapter 10

Application of biomechanical knowledge

Sport biomechanics

Analysing performance

The athlete and coach need a thorough knowledge of biomechanics and its application in general skill analysis so that sound techniques can be verified and errors in performance identified. Skill in visual observation must be practised, at first without analytical equipment, so that the eye and mind become attuned to the performance and learn to identify critical movement patterns.

To begin with, try observing basic movement patterns that are not very forceful or ballistic, e.g. a lawn bowling action or walking on the Olympic beam. See if you can apply the suggested analysis steps that follow and identify some basic biomechanical principles underlying the skill.

When trying to assess the merit of an athletic performance, we are often deluged with detail. We do not know which details are significant and hence how to assess the merit of particular movements.

As athletes or sportspeople, we may copy what we see as the ideal performance of another athlete. This strategy can be useful, but not if the performer we are copying has succeeded in spite of using faulty technique. It is important, therefore, to have a sound knowledge of biomechanics so that we can:

- provide valid reasons for observed effects
- diagnose problems with technique
- justify changes in technique.

Consider, for example, one instance of bowling technique in cricket. When a bowler flexes the non-bowling arm to the chest in the delivery stage, this shortening effect will increase the acceleration of the shoulders and result in a higher velocity of the bowling arm.

This explanation is based on the principle of rotational inertia, which states that when any lever rotating around an axis is shortened, it will increase its acceleration. Such principles may appear daunting at first, but they can help you understand the biomechanics of the skill.

The objective of the skill

The first step in a biomechanical analysis of a skill is to state the objective of the skill, e.g. the objective of a javelin throw is to make the javelin travel

over the greatest distance possible while obeying the rules of the sport. If an objective is not identified correctly, an incorrect analysis may result (e.g. the objective of hurdling might be stated as jumping over a hurdle) whereas it is in fact to clear the hurdle, using a specialised running technique. If the jumping action is taken as the basis of the biomechanical analysis, the analysis will be incorrect.

Observation

When observing a skill for the first time, it should be observed at normal speed. This will demonstrate the skill as it is naturally performed in real time: its timing, coordination, sequencing and spatial characteristics. Slow-motion performance distorts these elements but has great value in providing discrete information regarding the relative position and placement of body segments at various points in the skill sequence and the displacement of the body's centre of gravity. For example, an experienced baseball coach will develop an eye for detail when the skill is performed in real time and observe the fluidity of the skill, whereas, to determine the exact release point of the ball in a pitching action, slow motion or still frame will be preferred.

Every skill should be observed many times, depending on its complexity. A typical gymnastics vault is at the top end of the complexity scale, having many different phases, and must be observed many more times than, for example, a lawn bowl. For the vault, therefore, it is wise to observe a different phase in each repetition.

Movement patterns

The next step in a biomechanical analysis is to place the skill within a pattern of movement, such as standing, walking, running, sitting, pushing, throwing, striking, pulling, jumping and lifting. This allows us to identify the specific skills that fit within a given pattern. For example, a one-foot jumping pattern is used in a basketball lay-up, and in the hurdle step in diving. In the same way, a cross-country runner and a cross-country skier will exhibit similar locomotor patterns. A taekwondo roundhouse kick would be classified as a kicking pattern, and a golf swing or an ice hockey slap shot would be classified as a striking pattern. See figure 10.1 for identification of other movement patterns.

Figure 10.1 Patterns of movement associated with different sporting skills

Standing	Walking	Running and stopping	Jumping, leaping, hopping, etc.	Landing and falling
All activities except: Canoeing Cycling Sailing Swimming	All activities except: Archery Canoeing Cycling Shuffleboard Weightlifting Note the use of walking coordination in the freestyle kick in swimming.	Badminton Baseball Basketball Dance Football Handball Hockey Lacrosse Racquetball Softball Tennis Track and field	Basketball Dance Diving Gymnastics Skiing Track and field Volleyball	Baseball Basketball Dance Football Gymnastics Skiing Softball Track and field Tumbling Volleyball Wrestling

(continued)

Sitting	Pushing and pulling	Holding, lifting and carrying	Throwing* and catching	Striking*
Canoeing Contemporary dance Cycling Sailing	Archery Canoeing Cycling Dance Fencing Sailing Shotput Shuffleboard Swimming Wrestling	Canoeing Dance Tumbling Weightlifting Wrestling Note that many activities also involve carrying equipment, e.g. golf, skiing.	Baseball Basketball Bowling (throwing) Deck tennis Football Gymnastics (spotting, catching) Lacrosse Softball Track and field Note that there is some use of throwing in soccer (for goalkeeper).	Badminton Baseball Basketball Billiards Bowling Boxing Football Golf Handball Hockey Pool Racquetball Squash Soccer Softball Table tennis Tennis Volleyball

* Note that throwing and striking use the same basic movement patterns.

All throwing patterns, such as the baseball pitch, the cricket throw, the gridiron pass and the European handball pass, have similar characteristics. For example, in a baseball pitch, some of the common characteristics would include:

- the whip at the elbow, which gives the arm most of its speed
- the rotation of the body parts, which gives momentum and velocity to the pitching arm
- the large base of support (at least three times shoulder width), which gives good balance and allows forward movement of the trunk
- the high position of the elbow, which allows for the greatest force and the correct delivery position.

The striking pattern is differentiated from the throwing pattern only by the characteristics of the lever (i.e. the striking implement, such as a racquet) and the impact between the striking implement and the ball. The same biomechanical principles underlie all examples of a particular pattern. For example, the same biomechanical principles apply to all striking skills, because they all have common phases, such as the impact phase.

Skill phases

The next step of the biomechanical analysis is to break down the skill into meaningful phases, each of which may be quite different in terms of technique and the underlying biomechanical principles. A basic breakdown of the golf drive (see figure 10.2) includes the following phases: preparation, backswing, downswing, impact and followthrough.

The downswing is the power or action phase and is characterised by:

- keeping the club and arm lever as short as possible at the beginning of the downswing to increase the speed of the whole lever

- unhinging the wrists to make a longer lever and increase speed at the end of the lever just before impact
- allowing body parts such as the trunk and hips to rotate to the front before impact.

These characteristics are the same for the downswing in all other striking skills.

Some skills, such as the tsukahara vault, are more complex than the golf drive and have more phases. The tsukahara vault, for example, consists of the following phases: run-up, take-off, pre-flight, arm compression, arm push-off, post-flight, and landing. (See figure 10.3 for several of these phases.) The take-off phase is common to many gymnastics skills and jumping activities, such as long jumping and high jumping. The same biomechanical concepts therefore apply to the take-off phase in all jumping activities.

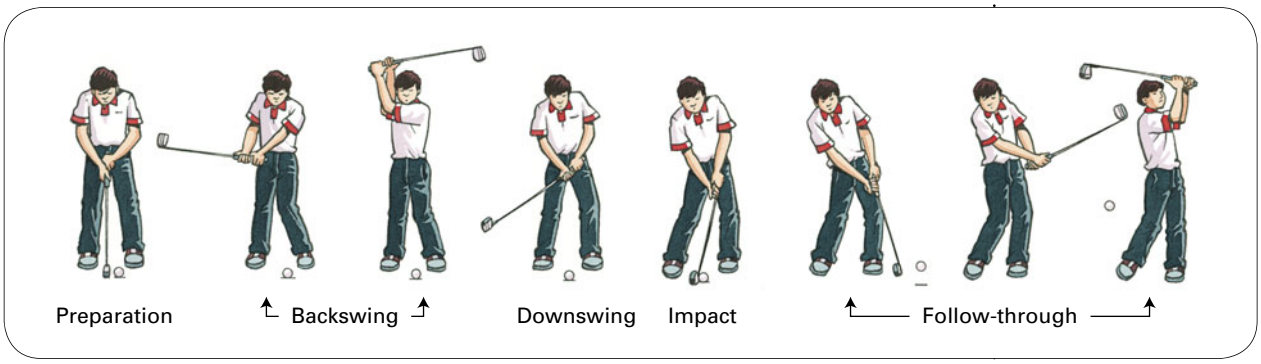


Figure 10.2 Phases of the golf drive

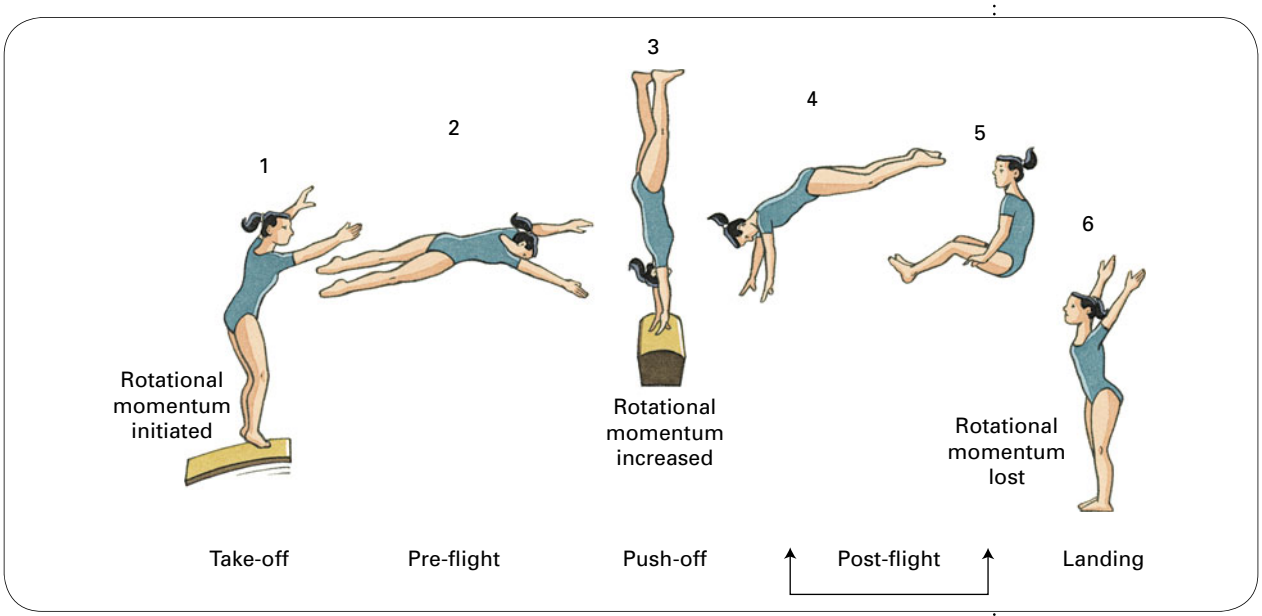


Figure 10.3 Phases of the tsukahara vault

Detecting errors

When a performer is making consistent errors in performance, it can sometimes be difficult to pick the cause. The effect of the error may be observed in some other phase or technique of the skill and mislead the coach into believing that the remedy is somehow directly linked with the symptom.

For example, a hockey player, when running with the ball, was occasionally seen to lose control of the ball. The symptom of the error was at the head of the stick, whereas the cause of the error was the player running with the body weight too far back on the foot instead of on the balls of the feet, resulting in a jerky running action.

In many instances the cause of the error will be found in the large-mass body parts and in the base of support. For example, if golfer Adam Scott was having trouble with the golf swing arc, he could first look to his base of support, i.e. his stance, and hip and leg action for the cause of the problem.

It is important for the athlete or coach to be able to identify critical elements in a skill. These may be points of technique, particular body positions, or phases, and are essential to the efficient performance of the total skill. For example, take-off in a gymnastic vault is absolutely critical to the execution of the skill, because the flight pattern is predetermined at take-off, with no changes possible. Most skills performed in the air will therefore be influenced by the take-off, with only minor adjustments possible after take-off.

SNAPSHOT

Figure 10.4 The football kick

Source: GT Hosford and D Meikle, *The Science of Kicking: Kicking for Distance and Accuracy in Australian Football*, BIPE Publications, Melbourne, 2008

As shown in figure 10.4, in a football kick, a high-speed leg swing is necessary to explosively drive the thigh into its correct position opposite the support leg. This is achieved by progressively flexing the leg at the knee and decreasing the rotational inertia of the leg. The result is a dramatic increase in thigh speed. With the thigh in position, the lower leg now drives through to impact with the ball. The player should be aware that although a kicking action is a natural event, a full flexion of the leg as described requires a regular exercise program to increase and maintain leg flexibility.

Starter mechanisms

Certain movements may be used in a skill that would appear to have little relevance to the efficient performance of the skill. Such mannerisms may include the small forward movement of the hands just before initiating the swing in golf, or the high-jumper's bouncing movements before beginning the run-in. While many mannerisms have little bearing on the skill, some (including the examples just given) act as starter mechanisms to initiate an early rhythm before entering the important phases of the skill.

Occupational biomechanics

Occupational biomechanics is not only a subdivision of biomechanics, but also one component of the study of the interaction between the worker and the work environment. Work productivity, health and safety are the most important goals of the occupational biomechanist. The emphasis is on enhancing performance without compromising health or safety.

Occupational biomechanical analyses must include analysis of the workspace, as the workspace often determines the manner in which a task will be performed. There are three types of workspaces to consider:

- sitting spaces
- standing spaces
- locomotor spaces.

Sedentary occupations

In our 'information society', sitting is by far the most common work position, i.e. most people have sedentary occupations. Developments in technology, including computers, have resulted in less reliance on physical strength to perform occupational tasks.

For instance, ultra-efficient transportation devices bring objects to the worker's table, bench or chair. In other cases, the worker is sitting at a display terminal, manipulating information on-screen. Dentists are another example of how working positions have changed. Few dentists now stand and twist their bodies as they work. Instead, they sit on an adjustable swivel chair, and so reduce the possibility of injuries due to twisting.

In sedentary occupations it is very important to sit correctly, so that the body is correctly aligned, and no undue strain is imposed on any part of the body. Figure 10.5 shows the correct posture and seating for a sedentary worker.

Dance

Let's look in some detail at one occupation in which health and safety play a major role. Dance is an art form that uses the body as its instrument of expression. It differs from sport in that it is not concerned with movement purely as a means of performing some feat (e.g. for the purpose of scoring points) but rather with the artistic intent and expressive quality of the movement.

Dance is an arrangement of patterns of the body in space and time, which require varying degrees of force to perform. The properties of movement that a dancer must consider include:

- moving through space using locomotor patterns, e.g. walking, running, jumping and hopping
- moving within a personal space using non-locomotor movements, e.g. performing turns and moving the arms expressively.

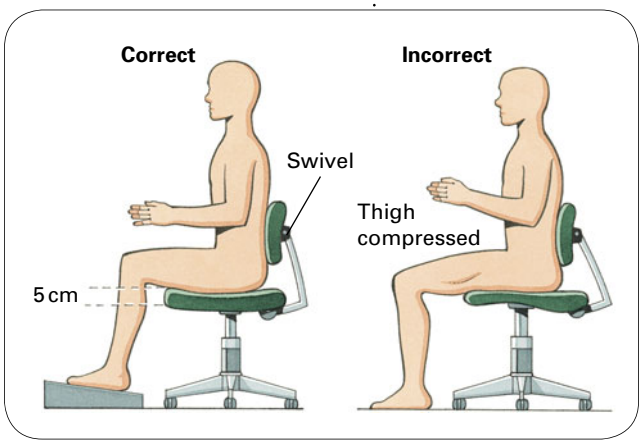


Figure 10.5
Correct and incorrect seating positions for a sedentary worker

While performing, the dancer is concerned with a complex combination of skills, including:

Figure 10.6
Correct biomechanical performance of dance technique will help dancers avoid injury. In this photograph, the dancers show great stability and control, as well as strength and flexibility.

- initiating and terminating actions
- executing moves in the air
- holding balances
- executing single and multiple turns
- extending the limbs
- achieving particular spatial relationships
- creating rhythmic patterns
- moving with force and energy, or smoothly and lyrically.

In addition, the movements must all be performed with efficiency, fluidity and artistic expression.

Biomechanics and injury prevention

In recent years, an increasing amount of attention has been directed towards dance injuries. To excel, the dancer today is forced to train longer and harder, and begins training early in life. Injuries can result from the demands placed on the body, from incorrect performance of dance skills and from accidents.

The most common sites of dance injuries are in the lower extremities: feet, ankles, knees, shins, hips and lower back. Many dancers strive to continue despite injuries, but early detection and proper care are very important for successful rehabilitation.

The effective and efficient use of the body is crucial in preventing injury. Incorrect biomechanical performance of dance technique may cause injury. Compliance with sound biomechanical principles is important as the following examples demonstrate:

- **Leverage:** Longer levers are easier to control. When moving a long lever or body segment, apply the force as far as possible from the centre of rotation to give greater muscular control of that segment. For example, in the performance of a pirouette (a turn) on one leg, the displacement of an extended leg away from the body will give more control over the turn.
- **Force development:** To maximise force, apply that force directly in line with the centre of gravity and in the direction of desired movement. When possible, use large muscles to initiate actions and follow sequentially with segments of decreasing mass. For example, in a vertical jump, the hips extend first, followed by the knees and ankles (all within an extremely short time).
- **Stability:** The body is stable when the centre of gravity is over the base of support. It is most stable when the line of gravity intersects the middle of the base of support. Increasing the size of the base or decreasing the height of the centre of gravity will increase stability. For example, when you are lifting, the feet should be approximately hip width apart, and the centre of gravity low.

Forensic biomechanics

Forensics refers to investigative procedures that enable questions relating to accident and injury to be answered. Forensic biomechanics can be applied to many fields of expertise, including engineering, medicine and, in this case, human movement analysis. There are several forensic movement analysis companies in Australia, the principals of which have been trained in physical education and human movement science courses.

Forensic movement analysts are concerned with injuries that are sustained following a slip, trip or fall, and use principles in biomechanics and applied anatomy to paint a picture of the events that have occurred as a result of the accident in order to explain how the injury was caused.

Investigative procedures

For example, in the case of an industrial accident, an injured party sustained a catastrophic back injury to the vertebrae L5/S1 (lower spine) (see figure 10.7). This occurred when the worker pulled on the handle of a piece of equipment, the handle broke away from its moorings and their back experienced a severe and impulsive twisting motion.

Procedures would be as follows:

1 The solicitor representing the client would forward all documentation to the movement analyst, including medical reports, interrogatories (questions asked of the plaintiff and defendant) and any other relevant material.
2 A site visit would be organised to take measurements from the accident scene, including photographs and film. The injured worker would also be anthropometrically measured to record limb length and to enable the centre of gravity of the body to be located precisely.
3 The accident would be reconstructed in the laboratory. Test subjects with the same body build as the injured worker would perform a pulling action similar to that experienced in the accident. A force plate would record forces in three planes of motion (vertical, sideways and forwards/backwards). Data can also be extracted from the force plate to work out friction forces and offer clues as to the state of imbalance of the injured person. Kin Kom equipment (an isokinetic dynamometer designed to test muscle strength) could also be used to approximate the arm-pulling forces at the moment the handle broke. All events would be filmed for future analysis.
4 The mechanism of the relevant equipment in the factory would be replicated and built to precise specification so that the injured party's movements during the break-and-release can be observed and recorded.
5 A computer bioanimation would be made based on all investigations and findings. The bioanimation is reproduced against the background of the real accident scene, and shows a humanoid figure performing a pulling action. It includes graphics of the injuries sustained. It can be shown in court to demonstrate to the judge and/or jury the probable events that took place on the day of the accident.
6 A detailed report is prepared on all the information gathered, to provide an explanation as to probable cause.
7 The movement analysts appear in court to give expert testimony and to be cross examined.

Figure 10.7 (a) The reconstruction of a catastrophic L5/S1 back injury using a test subject, (b) a multiple image sequence of the twisting movements in the bioanimation, and (c) the impingement of the nucleus (yellow) and nerve (purple) at L5/S1

CASE STUDY

Description

A footballer contesting a rucking duel slipped on an artificial surface, hyperextending the knee and rupturing the anterior cruciate ligament. It was accepted initially that the artificial take-off surface introduced by the sport's governing body was solely responsible for the injury. However, the forensic analysts were of the opinion that the rucking action was atypical of that stipulated in official coaching literature, and recommended an analysis of the player's technique, together with comparative testing of the take-off surfaces, both artificial and natural turf.

Procedures

Investigation was undertaken at several levels:

1 Digital film was taken of the test subjects to determine whether the action was atypical of that recommended in official coaching literature. This was compared with actual film of the incident.

2 Microphotographs were taken of the boot to determine wear patterns and cleat penetration at demonstrated angles of dorsiflexion (toe up) and inversion (toe in).

3 Force plate testing was carried out on test subjects of comparable height and weight using the same atypical action. This would determine the typical forces generated in three planes of motion at heel strike and foot plant of the take-off leg.

4 Slip testing of the player's boot on both artificial and natural turf was used to determine the degree of cleat penetration at the instant of heel strike. A slip-resistance cart was attached to a prosthesis (artificial leg), which was inserted into the player's boot, and a coefficient of friction determined.

Conclusions

The two surfaces, artificial and natural turf, were tested and the slip-resistance factor with the foot in the heel-strike position for the two surfaces was found to be almost identical. The surface was therefore eliminated as a causal factor. Digital film analysis of the actual incident revealed that the take-off action used was contrary to that recommended in the coaching literature. At the instant of heel strike it was found that the take-off leg was already in a position of hyperextension with the anterior cruciate ligament already stressed. This position, with the player's weight now superimposed, was impossible to reverse and was contraindicated in terms of sound anatomical and biomechanical theory. The atypical action set in motion a series of events that resulted in the rupture of the anterior cruciate ligament.

Video analysis

Train the eyes to see

When biomechanists and coaches observe a skill in real time, they can often have many different opinions and versions of what they actually see. The truth is that it is impossible for any coach to observe the fine details of a high-velocity hockey strike or football kick. Everything is happening so quickly that we tend to be selective in what we see. In fact, most often it is the slow-moving parts of the skill, such as the trunk in a kicking action, that will be most easily observed. In a golf drive performed at high velocity, the perplexed professional may simply make an observation about the player's grip or head movement because the swing was just too difficult to observe.

The eye is capable of seeing up to 10 frames per second, allowing us to observe gross body movements, the sequence of movement and slower-moving body parts. However, digital video gives us the facility to record from 25 to 50 frames per second in which we can now observe the fine details of the skill either through slow motion or captured still frames.

In addition, digital movie cameras, even at the bottom end of the price range, will have high shutter speed settings that enable every frame in playback to be seen with absolute clarity. A very basic digital movie camera will show all analysis features needed to analyse even the most complex and dynamic of skills.

Procedures

There are some basic rules to follow in setting up your subject for analysis:

1 The subject should be moderately skilled. A poorly skilled subject who cannot demonstrate the skill in its most basic form makes any definitive analysis a waste of time. A highly skilled subject, while preferred over the poorly skilled subject, may demonstrate such a near-perfect performance that it is difficult for you to make critical comment.
2 Film the subject from the front and the side. If you have only one camera, the skill will therefore have to be repeated; with two cameras, both views can be filmed simultaneously.
3 Make sure your image fills the screen of your camera so that when you come to analyse it you have the biggest and clearest image.
4 If possible, film on an overcast day to eliminate shadows. There is generally enough light outside to accommodate any shutter speed. If filming inside and you have selected a high shutter speed of 1/500 s or greater, then a basic set of lights will have to be used. (The higher the shutter speed the less light that gets into the camera and so the image will be darker.)
5 Set the shutter speed to accommodate the speed of the skill. For striking or throwing skills, use a shutter speed of at least 1/1000 s; for pushing and running skills use at least 1/500 s, and for accuracy or placement skills 1/250 s. However, make sure you experiment first to find the correct shutter speed.

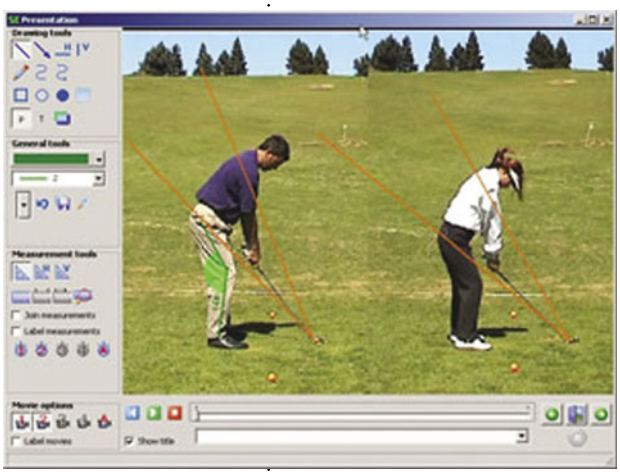


Figure 10.8
The Silicon Coach analysis screen

Screenshot of Siliconcoach Pro 7 Software, refer http://www.siliconcoach.com/

6 Wear minimum and tight clothing so that body parts and markers can be easily identified. Preferred colours are pastel shades, especially blues and greens.
7 Use markers on the joints so that a consistent spot can be identified when analysing many sequential images. Small polystyrene balls (15 mm diameter) cut in half and stuck to the skin with a 'grip it' fastener can be bought in haberdashery stores.

Skill analysis—golf drive

We will use the golf drive as our example analysis. After having filmed the golf drive, the analysis and investigation will require computer software such as Silicon Coach or Dartfish. These programs will enable you to perform a two-dimensional analysis and will provide many investigative features.

We will look at some of the most critical questions that could be asked about the efficient performance of the golf drive and how software may be used for an analysis. This is not an exhaustive list; there are many more techniques and elements that can be measured.

Biomechanical questions

1 Where is the centre of gravity of the body? This is the 'hub' of the skill. It is the slowest moving part except for the base of support and easy to locate. It is critically important to identify and track because it tells you where the body weight is distributed in relation to the base of support, i.e. the front and back foot. Weight should be moved so that it is positioned closer to the front foot. Unskilled players will tend to have the weight centred over the back foot at contact.

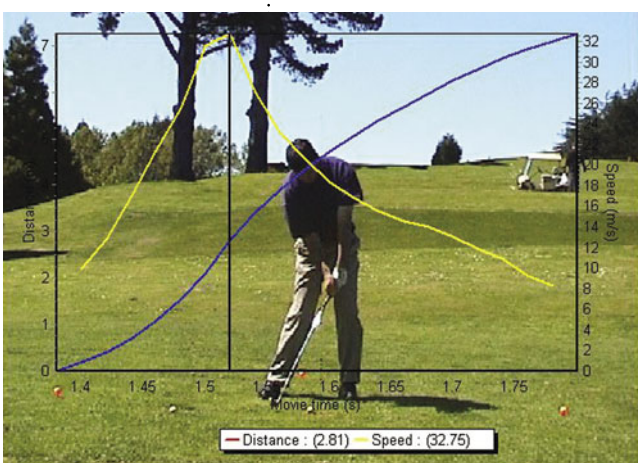


Figure 10.9
An analysis screen in which the data has been extrapolated to a graph of the clubhead velocity from address through impact and into the followthrough

Screenshot of Siliconcoach Pro 7 Software, refer http://www.siliconcoach.com/

Software: Identify the centre of gravity for all positions in the sequence and draw a vertical line to intersect with the base of support. This will give you the location of each weight shift.

2 How high is the centre of gravity above the base of support? In the golf swing it should be at a height at which the player can comfortably flex at the hips and knees. Does the height vary during the movement? It should stay at roughly the same height throughout the skill; if not, check for changes in knee and hip flexion.

Software: Join each of the centre of gravity points so that you have a curvilinear trace.

3 Hip movements must ensure that the movement forwards across the base of support locates the weight closer to the front foot. In addition there should not be excessive hip rotation; rather, it is the shoulders

that should rotate around the centre of gravity, permitting a strong hip/shoulder twist.

Software: With a marker on each side of the hips, determine the amount of hip turn and repeat for the shoulders. Note that this will not be perfect, as both hips and shoulders rotate through several planes of movement. However, it will be a strong indicator.

4 In the backswing the club should be brought back at a moderate velocity. However, in the downswing the club must generate a high velocity and accelerate positively all the way to and through the impact with the ball.

Software: For the clubhead mark all points on the backswing and downswing. On the downswing find a point for every frame. After having scaled your measurements, the software will give you a displacement, velocity and acceleration of the clubhead for every position.

5 How much head movement should be tolerated? In a golf swing the head must stay at the same height but may have some small movement forward. Any significant movement will affect the mechanics of the swing, as the head gives your body a reference point for accuracy and control.

Software: Identify a point on the head and trace its movement throughout the swing.

6 How wide is the effective base of support? Too wide a base and movement is restricted, too narrow and the player may be unstable. A stance approximately a little more than shoulder width apart is desirable. Feet should be in a naturally comfortable position.

Software: Draw a horizontal line between the feet and compare this displacement with that of a horizontal line from shoulder to shoulder.

7 Observe the followthrough from in front or behind. Note that the plane of the swing should tend towards being more vertical. Many players swing the club too horizontally, thereby missing out on the generation of shoulder rotation in the correct plane and on sideways accuracy. Note also the difference between the plane of the backswing and downswing.

Software: Track each position on the backswing and downswing and join the points.

8 What is the range, direction and pattern of the followthrough of all body parts? This will give you an indication as to whether the downswing and impact were executed in the correct plane and whether the body movements were efficiently performed.

9 What is the position of the hands in relation to the ball at impact? The hands should be above or slightly in advance of the ball so that the club successfully swings through the ball.

Software: Drop a vertical line from the hands to the base of support and measure the horizontal distance to the ball.

10 What is the angle of the ball to the ground as it leaves the clubhead? Given that the ball leaves the clubhead at about 70 m/s, then the angle is very low at approximately 6° to 9°.

Software: Use the angle icon to give you an exact angle from the horizontal.

Learning experience

WRITTEN RESPONSE: VIDEO ANALYSIS

Choose a skill to analyse. If it is a moderately complex skill with many phases, it will provide more material and information for your analysis.

1. Phasic breakdown: Identify and name the essential phases of the skill. The naming process must describe in the most precise way (one word if possible) the action being performed.
2. Critical elements: State and describe the three most critical elements in coaching the skill. An element normally consists of a number of grouped techniques and usually refers to a body action phase or technique that is seen to be absolutely critical to the efficient performance of the skill. State the order of importance for the critical elements.
3. Biomechanical analysis: Select the three principles most relevant to your skill. It is better to state each principle in turn, explaining the concept and then applying it to your skill. You may prefer to see how each principle can be applied within a phase. This is a more meaningful approach, but is also more difficult.
4. Performance diagnosis and remediation strategies: Describe the techniques that were performed inefficiently and how the corrections to technique would be made. This section should include critical analysis of both a positive and negative nature, and state practices or advice you would give the performer to correct inefficient technique.

Chapter review

Application of biomechanical knowledge

Know	1	List 10 important biomechanical principles, which we shall call 'the big 10', that can be used to analyse human movement.
Comprehend	2	Biomechanics may be used as an analysis tool in, for example, sport biomechanics, occupational biomechanics and forensic biomechanics.
Apply	3	In sport biomechanics it is essential to analyse a skill in terms of sequential phases before any biomechanical analysis is attempted. Why is this so? List six phases for a forehand drive in tennis.
	4	In occupational biomechanics correct lifting technique is required in order to lift a heavy object (e.g. from the floor to a table). Describe the techniques that could be used to achieve such a 'safe' lift.
	5	In forensic biomechanics various investigative procedures must be followed before a biomechanical analysis can be attempted. For an individual who has fallen over the handrail of a staircase, list the relevant procedures to follow and contribute some that you consider could be of value to a biomechanist.
Analyse Evaluate Synthesise	6	On the internet, log in to <www.accidentanalysis.biz>, a forensic analysis website. Click on the link for 'Case studies'. Compare two of the case studies and describe the essential differences in the procedures and equipment used to analyse an accident scene.

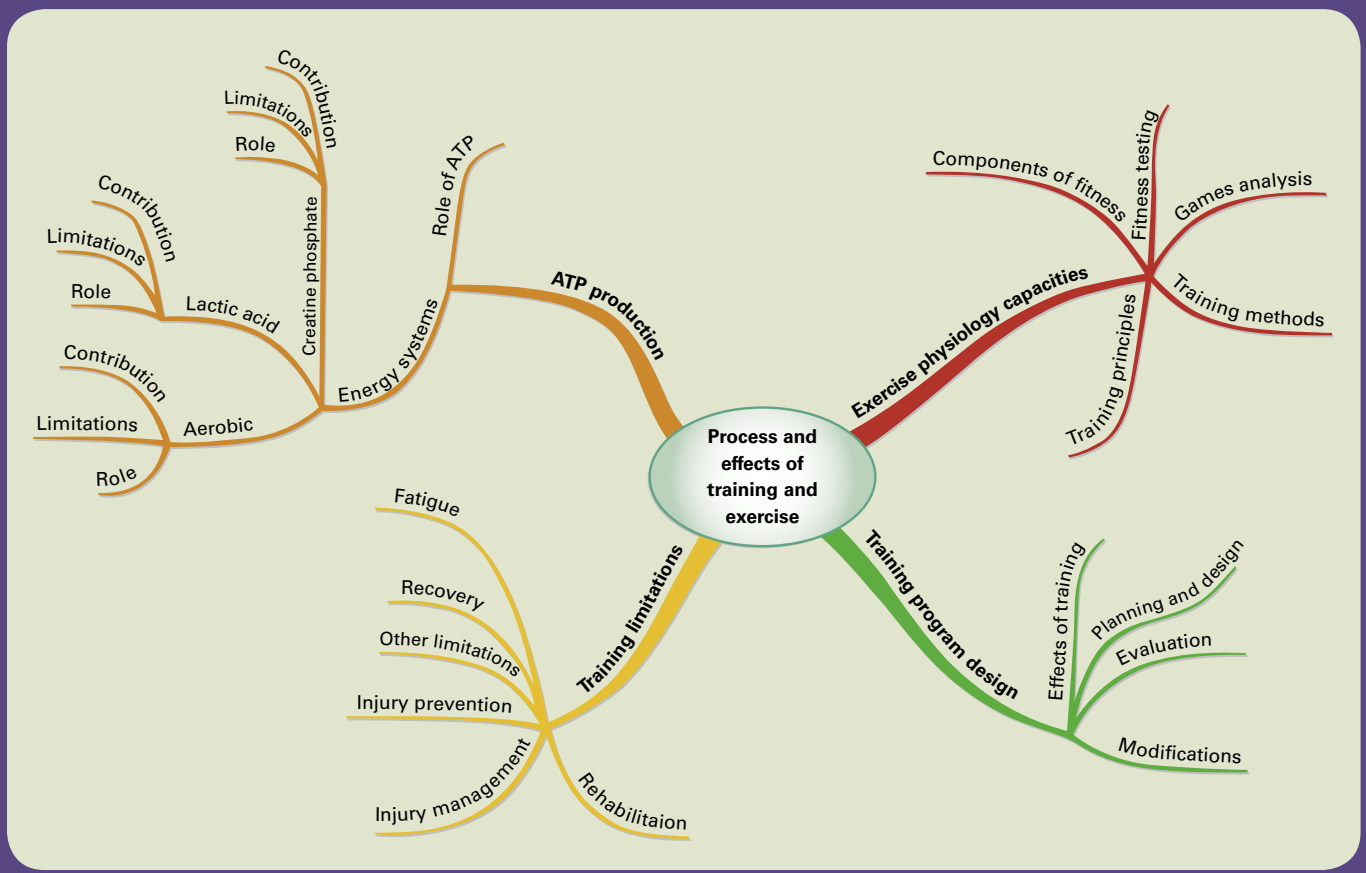
Focus Area B

Process and effects of training and exercise

HOW CAN AN UNDERSTANDING OF PHYSIOLOGY OF EXERCISE, TRAINING AND PROGRAM DEVELOPMENT IMPROVE TEAM AND INDIVIDUAL PERFORMANCE?

This area examines the physiological responses of the body that enable it to perform physically. This includes an examination of the physiological response of the body to exercise and training and the application of principles to aid, support and promote physiological adaptations. Students need to have an understanding of these principles in order to develop and implement personal and team training regimes. Students need to be able to adapt these regimes to suit varying circumstances and differing physical performance environments.

Source: *Physical Education 2010 Senior Syllabus*, published by Queensland Studies Authority


Process and effects of training and exercise
ATP production
Role of ATP
Energy systems
Creatine phosphate
Contribution
Limitations
Role
Lactic acid
Contribution
Limitations
Role
Aerobic
Contribution
Limitations
Role
Exercise physiology capacities
Components of fitness
Fitness testing
Games analysis
Training methods
Training principles
Training program design
Effects of training
Planning and design
Evaluation
Modifications
Training limitations
Fatigue
Recovery
Other limitations
Injury prevention
Injury management
Rehabilitaion

Energy systems

HOW DOES AN UNDERSTANDING OF ENERGY SYSTEMS HELP TO IMPROVE TEAM AND INDIVIDUAL PERFORMANCE IN PHYSICAL ACTIVITIES?

chapter 11

Energy systems

The body has a choice of three systems to provide **energy** for muscular work and exercise including two anaerobic systems and one aerobic. Understanding how these energy systems contribute to energy production and their limitations is an important aspect of improving physical performance. Which of the energy systems is used depends on the **intensity** and **duration** of the activity. It is important that athletes, coaches, trainers and people interested in maintaining health and fitness understand the relevant components of fitness, the percentage each energy system contributes to the activity and what methods of training can be utilised to ensure that training is effective.

Energy systems and the role of ATP

Energy is the capacity or ability to do work.

Intensity in relation to exercise is the degree of difficulty or the amount of strength and/or energy required.

The length of time that something takes is its **duration**.

Adenosine triphosphate (ATP) is the chemical that serves as the immediate source of chemical energy for most of the energy-consuming reactions of the body, especially for muscle contraction. ATP is split into adenosine diphosphate and phosphate to produce energy.

Mitochondria are the structures located within cells that contain the enzymes responsible for the generation of ATP by aerobic mechanisms.

Muscles require energy to contract or perform muscular work, such as picking up a pen, doing a push-up or going for a jog. This energy is produced by the breakdown of a very special molecule known as **adenosine triphosphate (ATP)**. There are three mechanisms or energy systems that the human body uses to provide the energy for the production of ATP. These have a variety of names, but for studies in Physical Education they will be referred to as the creatine phosphate system, the lactic acid system and the aerobic system. This section will help you to understand the role of the energy systems in synthesising ATP, the importance of ATP, the limitations of these systems and the percentage contribution of each energy system in physical activities.

ATP

ATP is an energy-rich molecule found in all cells. It is needed to perform just about every function in the human body, including cell respiration, growth and repair. ATP is synthesised in the **mitochondria** of our cells and is often referred to as the energy currency of life, where energy can be defined as the capacity to do work. ATP is comprised of adenosine and three phosphate groups, and contains a lot of potential energy due to its structure. When energy is required for muscular work (as in Physical Education studies), a chemical reaction takes places in which ATP is split at the third phosphate molecule and energy is released (see figure 11.1). This chemical energy is converted into mechanical energy by stimulating the protein filaments in

the muscle fibres, **actin** and **myosin**, to connect via the cross-bridges, thus making the muscle contract. However, there is only a short supply of ATP in the mitochondria of a muscle cell, therefore our bodies need to continually remake or resynthesise ATP, to sustain the exercise or muscular work needed for daily activities. Once the ATP molecule is split and energy is released, the ATP must be reformed or resynthesised using another source of energy if the muscular work or muscular contraction is to continue. The energy to resynthesise ATP from **adenosine diphosphate (ADP)** and phosphate, so it is again available to do more work or provide energy, is obtained from one of the three energy systems mentioned in the introduction and explained in detail later in this chapter.

Actin is a protein filament in the muscle fibre.

Myosin is the contractile protein making up the thick filament in the muscle fibre.

Adenosine diphosphate (ADP) is one of the chemical products of the breakdown of ATP for energy production during muscle contraction.

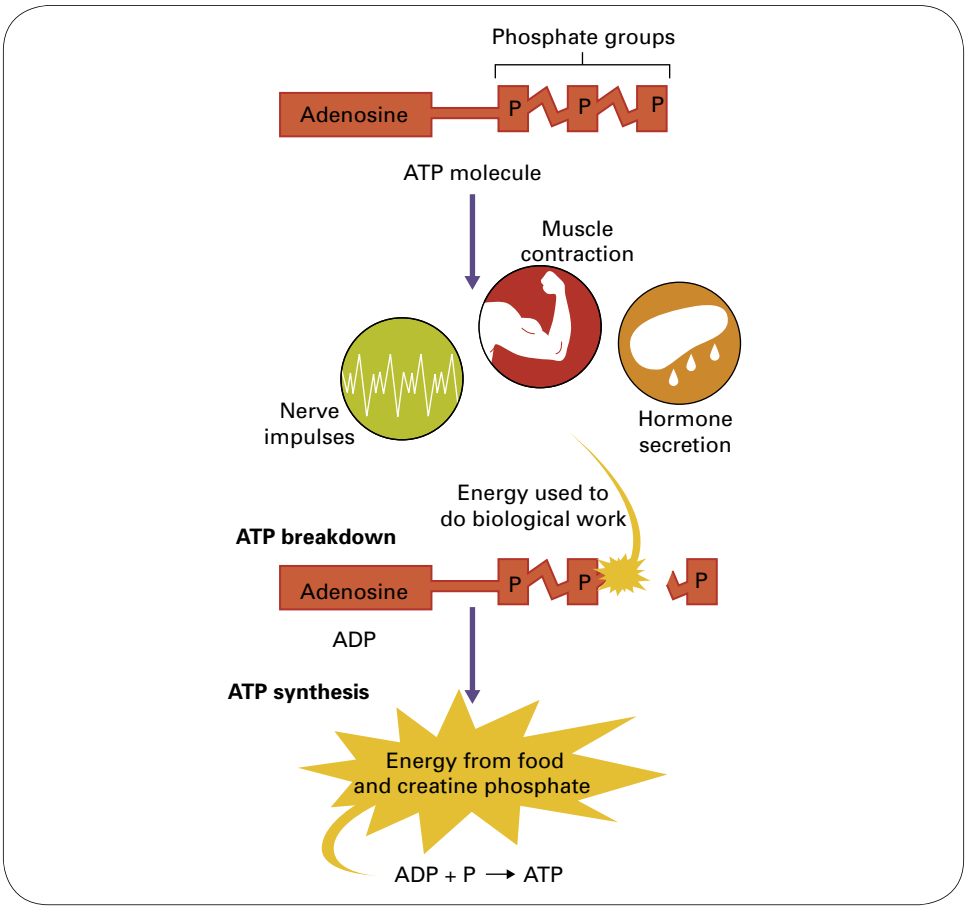


Figure 11.1
The breakdown and resynthesis of ATP. ATP is made up of adenosine diphosphate (ADP) plus a phosphate. Breakdown of ATP into these components releases energy. Combining ADP and phosphate to form ATP uses up energy.

Learning experience

UNDERSTANDING MUSCLE CONTRACTION AND THE SLIDING FILAMENT THEORY

Use a search engine on the internet to research muscle contraction, which is often referred to as the 'sliding filament theory'. View several of the sites devoted to explaining how muscles contract and relax to produce muscular work. (Pay particular attention to the terms actin and myosin cross-bridges.)

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Task

1 Create a PowerPoint™, pamphlet or handout that could be used in a junior PE class explaining how muscles contract through the sliding filament theory.
Information to include:
- references to any websites used (Harvard system of referencing is appropriate)
- diagrams to demonstrate how the process works
- written explanations to accompany the diagrams
- terminology that is accurate and suitable to a student in a junior PE class.

2 Share your PowerPoint, pamphlet or handout with a classmate for feedback on accuracy, clarity and effectiveness.

SNAPSHOT

How much ATP does the human body produce each day?

It is estimated that there is only 100 g of ATP in our entire muscle system but more than 50 kg of ATP will be used to provide the energy for muscular work during a marathon. In general, approximately 160 kg of ATP is formed in the human body each day.

Figure 11.2
A marathon finish

Creatine phosphate (CP) is a chemical stored in muscle fibres that can donate its phosphate to ADP to rapidly replenish tissue stores of ATP. It is also called phosphocreatine.

Carbohydrates are chemical compounds that consist of carbon, hydrogen and oxygen atoms in specified arrangements. They are major components of foods such as bread, potatoes and rice.

Glycogen is the form in which digested carbohydrates are stored in muscles and liver.

Energy sources to replenish ATP

The energy sources the human body uses to power the reproduction or resynthesis of ATP comes from three different series of chemical reactions that take place in the body. Two of these three systems depend on the food we eat (carbohydrates, fats or proteins), the other depends on another high-energy compound found in the cells called **creatine phosphate (CP)**. Put simply, we have three ways to recharge the high-energy stores so they can continue muscular work or be ready to work again at a later stage.

Creatine phosphate

Creatine phosphate is readily available in muscle cells and rapidly produces ATP. Like ATP, CP is only available in short supply in the muscles; therefore, it can only provide limited amounts of ATP to the muscle so that it will keep contracting or working. Fortunately, the body can also use the energy from food sources such as carbohydrates, fats and, in extreme cases, protein to provide the energy to resynthesise ATP.

Carbohydrates

Carbohydrates are the primary source of ATP production. They are obtained from foods such as bread, grains, pasta, fruits and vegetables, and are known as complex carbohydrates (see figure 11.3). Carbohydrates are digested by the body and converted into glucose, which is transported to the muscles via the bloodstream from the intestine. The body can also store a limited amount of glucose in the form of **glycogen** in the muscles or liver. These sources can

become depleted quickly during prolonged, intense exercise (see figure 11.4) and so carbohydrates must be replenished daily through a balanced diet. It is recommended that complex carbohydrates form the bulk of our **kilojoule (kJ)** intake per day. For example, approximately 55 per cent of our daily kilojoule intake should be in the form of carbohydrates.

The **kilojoule (kJ)** is a unit of energy used to refer to the energy content of food or drink (1 kilojoule ≈ 24 calories).

Many endurance athletes utilise **carbohydrate loading** to increase muscle glycogen stores and therefore delay the onset of fatigue prior to exercise lasting more than 1 hour. It is also essential to consume carbohydrates immediately after high-intensity, long-duration exercise due to the depletion of these carbohydrate stores. The Australian Institute of Sport (AIS) recommends that athletes who train heavily, particularly in endurance events for longer than one hour, should increase carbohydrate intake to approximately 70 per cent of total kilojoule intake. This can be difficult to measure, so the athlete may find it easier to use a guideline of 7–10 g/kg of body mass. For example, a 70 kg individual should consume between 490 and 700 g of carbohydrates per day. However, if we eat too many carbohydrates and do not balance energy input (kilojoules in) with energy expenditure (kilojoules out), excess glucose is converted to fat and stored as adipose tissue, and weight is gained. For interest you may wish to refer to the AIS website, which contains handy facts sheets on a range of nutrition subjects including the quantities athletes who exercise at various intensities and durations should consume.

Carbohydrate loading is a nutritional strategy to maximise muscle glycogen (carbohydrate) stores prior to endurance competition.

Figure 11.3 Carbohydrates must be obtained from a balanced diet.

Fats

Fats are incredibly energy-dense, containing approximately 37 kJ/g, and can produce large amounts of ATP. They are obtained from foods such as dairy products, nuts, fatty meats and oils. Fats are broken down to fatty acids, which circulate in the blood, and triglycerides, which are found in the muscles or liver and stored in adipose tissue throughout the body (see figure 11.4). For example, an 80 kg male has approximately 108 000 kilocalories of energy stored in the fat molecules of the adipose tissue, which would provide enough energy to exercise for 120 hours. Although fats are energy dense, the process to convert the stored forms of triglycerides to a more useable form, such as free fatty acids and glycerol, is too slow for high-intensity activity. However, fats are the body's preferred energy source when at rest or performing low-intensity activities, such as walking. Aerobic training increases fatty acid oxidation (breakdown) during exercise of mild to moderate intensity, which, in turn, spares glycogen stores and allows the trained individual to exercise at a higher absolute level of **submaximal exercise** before experiencing the fatiguing effects of glycogen depletion. That is, they can do more, for longer, before tiring. Recent research has reported that many Australians have far too much fat in their diet, and this is contributing to increasing rates of obesity. It is interesting to note that the National Health and Medical Research Council recommends only 160 mg/day for males and 90 mg/day for females.

Submaximal exercise usually refers to exercise at less than maximal intensity, but may also refer to exercise of less than maximal duration.

Proteins

Proteins contain **amino acids**, which are the building blocks of our body and are essential for growth and repair. They are obtained from foods such as meat, fish, eggs and dairy products. In extreme cases, such as starvation or prolonged physical activities (e.g. ultra-marathons), amino acids can be used

Amino acids are compounds that are the building blocks of proteins. They contain nitrogen, hydrogen and carbon.

to provide the energy to resynthesise ATP (see figure 11.4). The recommended daily intake (RDI) for proteins is based on an individual's body weight and the National Health and Medical Research Council recommends 0.75 g/kg for adult females and 0.84 g/kg for adult males per day. For example, a 65 kg female should have approximately 49 g of protein per day. Research also suggests that this amount should increase to 1–1.2 g/kg or 75–78 g/day if the individual is involved in regular high-intensity training.

Proper nutrition should be a part of every athlete's training, as the incorrect balance of carbohydrates, fats and proteins can severely affect body composition, strength, speed, power, endurance, recovery and general health. In fact, the Australian Bureau of Statistics in 2007–08 reported that 25 per cent of Australian children aged 5–17 years and 61 per cent of adults were overweight or obese. Therefore, proper nutrition should be a concern for all, not just athletes.

Figure 11.4 Forms of food fuel and storage sites in the body

Food fuel	Stored as	Site
Protein	Muscle amino acids Excess as fat	Muscles Adipose tissue
Carbohydrate	Glucose Glycogen Excess as fat	Blood Muscles and liver Adipose tissue
Fat	Fatty acids Triglycerides Fat	Blood Muscles and liver Adipose tissue

Learning experience

WHAT DID YOU EAT AND DO TODAY?

Keep a food and activity diary for one day. You may wish to organise this information into a table for ease of analysis. There are a variety of food and activity diaries online that you could use as models. (*Note:* The diaries may be completed as part of a 'blog' using your school's online network.)

1. Food diary: From waking up to going to bed, record the quantities of what you ate and drank, e.g. Breakfast—1/3 cup rolled oats, 1/2 cup full-cream milk, regular cappuccino full-cream milk.
2. Activity diary: For the same period record all of the physical activities you participated in. Ensure you include time and approximate intensity, e.g. walked to the shop, 20 minutes, low intensity.
3. Analyse your food and activity diaries.
   - **a** Based on your activity levels, were you eating the correct amount of proteins, carbohydrates and fats to provide a balanced diet?
   - **b** Were there any surprises in your food and activity diaries, e.g. you noticed that you did not do any physical activity during the day apart from walk from class to class.

>>

c On the basis of your analysis and research, do you need to make any changes to your diet or activity levels? What will help you make those changes? What will prevent you from making those changes?

d Did you enjoy the process of keep a diary?

e Were there any barriers that prevented you from working out if you were having the correct amount of proteins, carbohydrates and fats in relation to your activity levels?

4 Your teacher may select a sample diary to upload onto the school's network for you to critique and comment on as part of a 'wiki'.

Note: There are various online calculators you may be interested in using to work out kilojoule intake and output.

Learning experience

FOOD FUEL AND STORAGE

Refer to figure 11.4 and answer the following questions:

1 Why does adipose tissue appear in the site column for all three food fuels?

2 Is this a concern? Why?

Learning experience

NUTRITION FOR THE ATHLETE

1 Refer to the 'Sports and nutrition' fact sheets on the AIS website, at <www.ausport.gov.au/ais/nutrition/factsheets>.

2 Read the facts sheets on 'Competition and Training' and select a protocol that is most relevant to your type of training, physical activity/competition or sport. For example, if you are a 100 m sprinter you may wish to investigate the meal recommendations for 'Tournaments and multiple heat competitions'.

3 Prepare a daily meal planner (this can be for one meal or the whole day) based on the recommendations. You may wish to conduct further research using the Australian Healthy Eating Guidelines or other fact sheets on the AIS website, to assist and inform your plan and understanding of the food fuels (carbohydrates, fats and proteins).

4 Compare your daily meal plan with a classmate who has similar requirements, and consider any modifications you would make or recommend any modifications to their plan, based on your understanding and research. (Your teacher may organise to upload one of the daily meal plans onto the school's network so that your comparison and critique can be completed as part of a wiki.)

5 On the basis of your research, judge how easy it is for an athlete to eat a well-balanced diet that supports their training and competition needs. Use a report structure to discuss your food choices and any enablers or barriers that you may encounter when implementing your food choices. Ensure you list personal examples and research to justify your judgment.

Production of ATP

The three energy systems

There are three chemical methods of producing ATP inside our muscles (see figure 11.5):

- from the energy released by the breakdown of creatine phosphate (this method is known as the creatine phosphate system)
- from the energy released when glucose (formed from the conversion of stored glycogen) is converted to lactic acid (this method is known as the lactic acid system or anaerobic glycolysis)
- from the breakdown of carbohydrates and fats, using oxygen (this method is known as the **aerobic system** or oxygen system).

The **aerobic system** is a method of resynthesising ATP using carbohydrates and fats as fuels in the presence of oxygen.

The major distinguishing features of each energy system are the speed at which they function and the total amount of ATP resynthesised by each series of chemical reactions. All three energy systems can operate at the same time within the muscle cell. Which method is used depends on whether our muscles are resting or active and on the intensity and duration of the activity. If the resynthesis of ATP occurs in the presence of oxygen it is labelled aerobic, and if it occurs without oxygen it is labelled anaerobic (see figure 11.6).

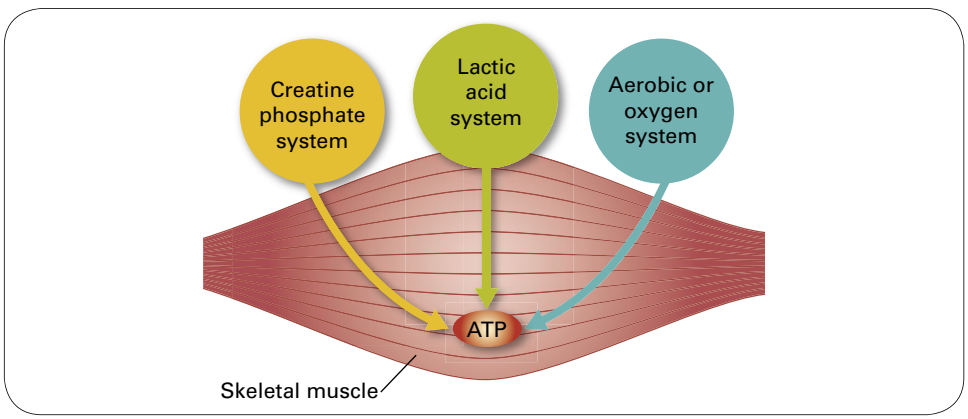


Figure 11.5
The three chemical methods of producing ATP inside our muscles: the creatine phosphate system, the lactic acid system (anaerobic glycolysis) and the aerobic (or oxygen) system.

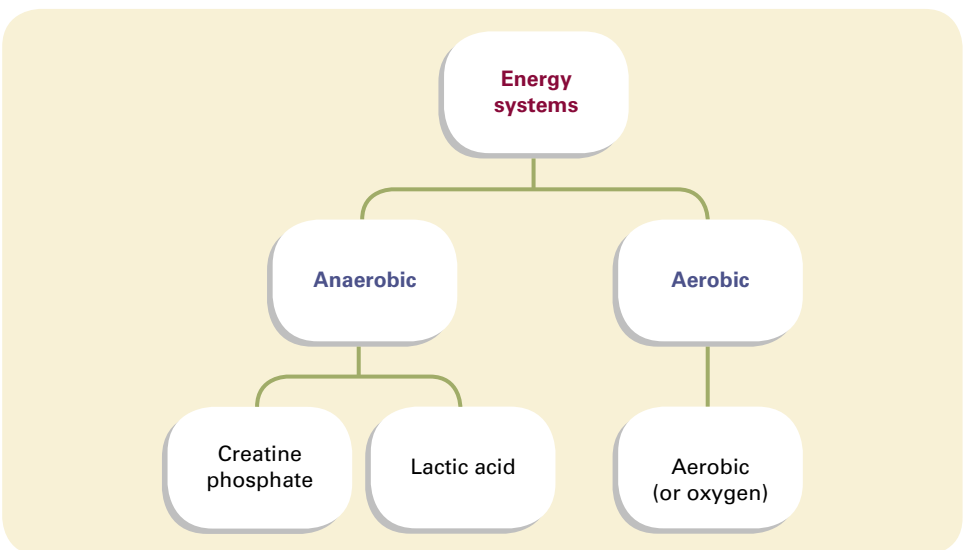


Figure 11.6
The three energy systems—creatine phosphate and lactic acid are anaerobic methods of resynthesising ATP, whereas the oxygen system uses food fuels in the presence of oxygen to resynthesise ATP and is said to be aerobic.

Learning experience

QUALITY ONLINE INFORMATION ABOUT THE THREE ENERGY SYSTEMS

Conduct an online search for sites that contain quality information about the three energy systems. (*Note:* Your teacher may organise for this learning experience to be completed on the school's network as part of a class forum.)

Tasks

1. Before you conduct your search, decide what makes a good online resource, e.g. correct information.
2. Compile a list of the resources that you have analysed. Use the correct referencing format for online sources, e.g. Harvard system.
3. Select your top five online resources and justify your decisions.
4. Summarise in your notebooks any new information you may have learned about each of the energy systems.
5. Write an essay of 300–400 words, based on your research and in your own words, about how each of the energy systems contributes to energy production.
6. Swap your explanation with a classmate and mark it according to the PE Syllabus criteria. (You can find this online at <www.qsa.qld.edu.au/10-12/1714.html> or your teacher may give you a copy.) Give feedback for improvement and to justify the allocation of your grade for the three dimensions—Acquiring, Applying and Evaluating.

ATP production during resting conditions

When the body is at rest, the demand for ATP is low and any ATP that is required is produced aerobically (see figure 11.7). The chemical reactions producing this aerobic ATP occur in the bean-shaped mitochondria, which are found in the muscle fibres. The ATP produced in the mitochondria is later transported to the myosin cross-bridges.

At rest, the two fuels for aerobic energy production are fats (two-thirds) and carbohydrates (one-third) (see figure 11.8). Fats and glucose (from the carbohydrates) combine in chemical reactions with oxygen to release energy and produce:

- the waste product carbon dioxide, which we breathe out
- water that is removed in sweat, urine, or water vapour in the breath
- heat.

The energy released is used to combine ADP molecules with free phosphates to produce large quantities of ATP. Aerobic energy production is very efficient, producing 32 molecules of ATP for each glucose or fat molecule, without producing fatiguing by-products.

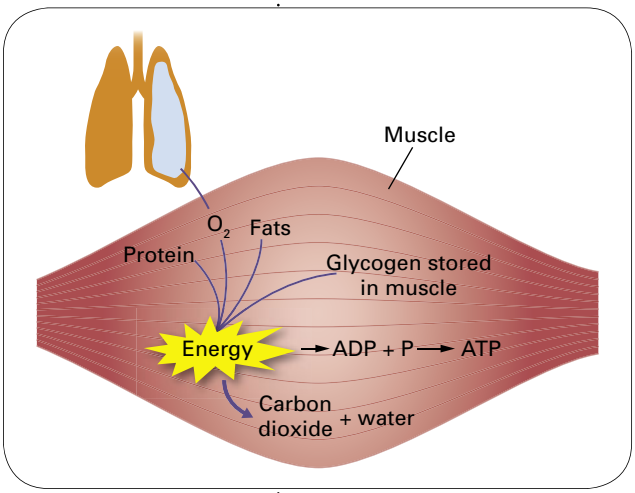


Figure 11.7
The oxygen, or aerobic, system. The aerobic breakdown of carbohydrates and fats (and proteins, under some conditions) provides energy for ATP resynthesis. Because abundant ATP can be manufactured without producing fatiguing by-products, the aerobic system is most suited to endurance activities.

Fuel		Oxygen		Carbon dioxide		Water		Heat		Energy
$\frac{1}{3}$ glucose from muscle and liver $\frac{2}{3}$ fats (triglycerides and fatty acids) from blood	+	Breathed in	With enzyme assistance →	Breathed out	+	As water vapour and in sweat and urine	+		+	Used to combine ADP and phosphate ADP + P → ATP

Figure 11.8 Aerobic energy production when muscles are at rest

Figure 11.9
When the body is at rest fat is the preferred form of fuel for energy production.

ATP production during exercise

During exercise the energy system used to produce ATP will depend on:

- how long the exercise continues (time)
- how vigorous the exercise is (intensity)
- how well developed the person's cardiorespiratory system is (aerobic fitness).

Our body is always trying to produce the energy we need aerobically. To do this, the muscles need a constant, and sometimes large, supply of oxygen. When we begin to exercise, the demand for ATP increases quickly, particularly if the exercise is intense, and therefore the body is in **oxygen deficit**. Once the exercise stops, the athlete has to recover and repay the deficit. As a result, breathing and heart rate remain high for some time after exercise ceases. This is because we work aerobically to deliver oxygen to the muscles to resynthesise the ATP and remove any accumulated lactic acid. At this point we are said to be in **oxygen debt**. (See chapter 15 for further details about oxygen deficit and debt.)

To produce all the ATP aerobically, we would need an instantaneous rise in oxygen supply. However, it takes time to get oxygen from the atmosphere into our lungs, absorbed into our blood and transported via the heart to our muscles, so muscles have two stopgap methods of producing energy that do not rely on oxygen.

These two methods, or energy systems, are called 'anaerobic systems'. They are used only when there is not enough oxygen to produce all the ATP required.

Oxygen deficit is the period during exercise when the oxygen consumption is below that necessary to aerobically supply all the ATP required for the exercise.

Oxygen debt is the oxygen uptake during recovery from exercise that is in excess of the normal oxygen uptake during a rest period of similar duration.

Figure 11.10
When exercising, the body can utilise fats, carbohydrates and creatine phosphate stores as fuel for energy production.

The anaerobic energy systems

There are two anaerobic methods used by the body for resynthesising ATP to create and supply energy. One uses a chemical called creatine phosphate and the other uses the food fuel carbohydrates.

The creatine phosphate system

The simplest of the energy systems is the **creatine phosphate system**. This system provides energy through a chemical reaction to resynthesise ATP using creatine phosphate, which like ATP is a high-energy phosphagen available in the muscle cells. The **enzyme** creatine kinase speeds up a chemical reaction that results in the separation of the creatine and phosphate and the release of energy. This energy is then used to recombine ADP and phosphate to re-form ATP. One molecule of CP resynthesises one molecule of ATP (see figure 11.11).

The creatine phosphate system is an anaerobic method of resynthesising ATP using creatine phosphate as the fuel.

Enzymes are proteins that function as catalysts, which act to increase the speed at which chemical reactions occur.

The use of this system to provide energy for muscular work is limited by the small supply of CP in the muscle cell, and so it is used to supply ATP for muscular contraction during high-intensity, short-duration activities of up to 10 seconds, such as shotput, long jump, weightlifting or running up a flight of stairs. Because this reaction happens very quickly, it occurs in the absence of oxygen and therefore it is known as anaerobic.

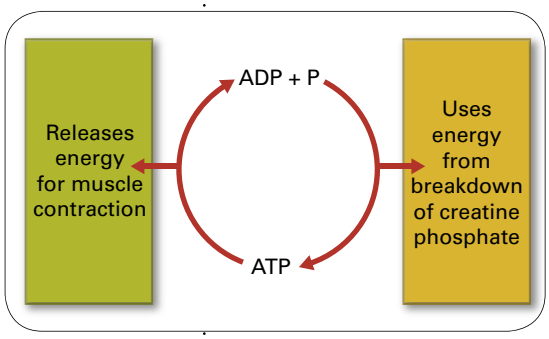


Figure 11.11
The creatine phosphate system

Once the athlete has depleted the muscles stores of CP, the body utilises one of the other two energy systems as the dominant energy source and method of ATP production. The CP stores in the muscle can be resynthesised during low-intensity exercise or at rest. It takes several minutes to fully restore muscle CP stores, which is why athletes training for speed must ensure adequate recovery times between each effort when working out. Sprint and power athletes and team sports athletes requiring short intervals of high-intensity activity rely heavily on their CP stores to provide energy. As a result there is enormous scientific and

commercial interest in creatine supplementation and the impact of this on improving power and speed-based athletic performance. This system is also commonly referred to as the phosphocreatine, ATP–CP or ATP–PCr system.

Figure 11.12
Sprint start. The frenzied start of a race is high-intensity activity that takes place in a few seconds. Energy for such activities is provided by the creatine phosphate system.

SNAPSHOT

Creatine supplementation

A substance used to enhance performance is known as an **ergogenic aid**.

The use of creatine as an **ergogenic aid** is widespread and its usefulness in improving performance well documented. However, the most effective way to take creatine is not as well known. Of course for any athlete there is no substitute for good training methods and proper nutrition. Creatine is naturally found in skeletal muscles and is used to resynthesise ATP. When supplies are depleted, the intensity of the exercise must decrease so CP stores can be restored. Loading the skeletal muscle with creatine monohydrate (the most common form of creatine supplementation) would seem to be an aid by increasing:

1. muscle creatine phosphate stores
2. exercise performance in short periods of intense, high power output activities, particularly with repeated bouts
3. maximal strength when combined with resistance training
4. glycogen stores and carbohydrate loading in trained muscles
5. initial weight gain of 600–1000 g (this can be a disadvantage for some athletes).

The AIS only provides creatine to their athletes under supervision, as part of an overall training plan and by following well-researched dosages for a limited period of time, such as a 5-week cycle (see figure 11.13).

Figure 11.13 Creatine supplementation methods

Rapid-loading protocol	Slow-loading protocol
4 doses of 20 g daily for 5 days Doses should be taken with a meal or snack containing at least 50–100 g of carbohydrates **Maintenance dose 3 g/day**	3 g/day with a carbohydrate meal or snack **Maintenance dose 3 g/day**

The lactic acid system

The second anaerobic system, the **lactic acid system**, takes over when CP stores become exhausted. It supplies the ATP our muscles need to keep exercising, particularly when exercising at a high intensity. This is a slightly more complex method of ATP production. It uses glycogen, the stored form of carbohydrates, as the energy source and involves 10 to 12 chemical reactions. The use of glycogen as the energy source in the absence of oxygen is known as **anaerobic glycolysis**. It involves the conversion of glycogen to glucose, which is then converted into **pyruvic acid**. The energy released at this point produces approximately 1–3 ATP molecules for each glucose molecule. In the absence of oxygen the pyruvic acid is converted to **lactic acid** (see figure 11.14).

Lactic acid system is an anaerobic method of resynthesising ATP using glycogen or glucose as the fuel.

Anaerobic glycolysis is the conversion of glucose to lactic acid in the absence of oxygen.

Pyruvic acid is a three-carbon molecule produced by the breakdown of glucose.

Lactic acid is the by-product of the anaerobic metabolism of glucose in muscle. The salts of lactic acid are called lactates.

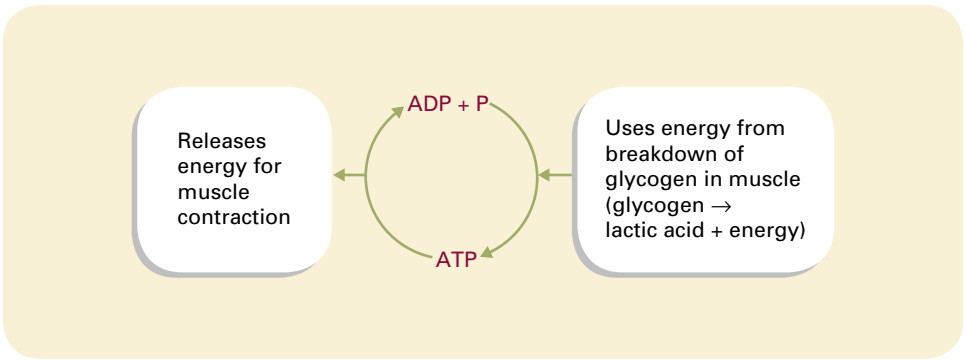


Figure 11.14 The lactic acid system (anaerobic glycolysis). Carbohydrate (glycogen) is broken down anaerobically (without oxygen) to lactic acid. The energy released during this breakdown is used to resynthesise ATP. Exercises performed at maximum rates for between 30 seconds and 2 minutes depend heavily on the lactic acid system for ATP energy.

Lactic acid levels in the muscles increase when high-intensity exercise continues beyond 10 seconds. If the lactic acid is not cleared from the muscle and accumulates due to an insufficient amount of oxygen, it dissociates (breaks apart) into hydrogen ions (H^+) and lactate. An increase in H^+ lowers the pH levels in the muscles thus increasing acidity. This is

Figure 11.15 Running repeats of stairs taxes the lactic acid system.

called acidosis. Acidosis affects the cellular processes within the muscle, thus impairing energy production and muscle contraction. It is not necessarily the presence of lactic acid but the inability to clear the lactic acid from the muscles that is the limiting factor in this system. The best way to describe lactic acid build up is the heaviness felt in the legs after a burst of speed or at the end of race. At this point activity must decrease in intensity or stop so that the lactic acid can be removed aerobically. The lactic acid system provides the energy for the resynthesis of ATP during high-intensity, moderate-duration activities lasting 30 seconds to 2 minutes, such as the 400 m sprint, repetitive bursts of high intensity during a game or a gymnastics routine. It also supplies ATP as a stopgap in the early minutes of longer submaximal activity until the oxygen supply increases and the oxygen system takes over.

The aerobic system

The aerobic system is the most complex of the three energy systems, with many more reactions occurring to provide the energy to resynthesise ATP. This system uses carbohydrates and fats as the primary fuels in the presence of oxygen, which is why it is also known as the aerobic system. The food fuels (carbohydrates, fats and in extreme cases protein) are broken down in the mitochondria or 'powerhouses' of the cell in the presence of oxygen to produce energy to resynthesise ATP aerobically (see figure 11.7).

Although this energy system is slow to start, due to the time it takes to provide the increased amount of oxygen, it produces an abundant supply of ATP and no fatiguing by-products as long as the fuel and oxygen supplies remain adequate. The limiting factors of this energy system are the stores of food fuels and the ability of the cardiorespiratory system to supply the required amounts of oxygen.

The demand on the cardiorespiratory system to deliver oxygen is considerable, and once we begin to exercise there are several responses to ensure oxygen supply increases. For example, our respiratory rate, tidal volume (depth of each breath), **heart rate**, stroke volume, cardiac output and **arteriovenous oxygen difference (a–vO_2 diff.)** all increase in an attempt to rapidly increase oxygen delivery to the working muscles. Put simply, when we begin to exercise we breathe more often and more deeply, and the heart beats faster in order to provide more oxygen to the working muscles. Also the muscles extract more oxygen from the arteries. (See chapter 15 for more details.)

Heart rate is the number of beats of the heart in 1 minute.

The oxygen concentration difference between arterioles and venules is known as the **arteriovenous oxygen difference (a–vO_2 diff.)**. It shows how much oxygen is taken up by the tissues of a muscle.

During exercise, the fuels for the aerobic system are:

- glucose, either from muscle tissue or from the liver, released into the bloodstream
- fats, triglycerides from muscle or fatty acids from adipose tissue and released into the bloodstream.

The fuel used depends on the duration and intensity of the exercise. During rest and in submaximal activities of very low intensity where the energy demands are low, such as lawn bowls or slow walking, fats are the primary fuel. But during exercise such as running, swimming and intense team sports, carbohydrates (glucose) are the primary fuel.

During prolonged endurance events, such as marathons or long-course triathlons, it is possible to use up all the body's carbohydrate (glucose) stores. At this stage, fats become the only fuel available to allow the athlete to continue. The metabolism of fats requires far more oxygen than does the metabolism of carbohydrates to produce the same amount of ATP; therefore, for the athlete to continue running at the same pace, the cardiorespiratory system will have to work much harder. This puts a huge strain on the athlete and is called 'hitting the wall'. At this point, most athletes must slow down and fight hard mentally to keep going.

Three to five minutes after you begin exercising submaximally, the oxygen supply increases sufficiently to enable all the ATP to be produced aerobically. Thus, the aerobic system is the major contributor of energy in continuous activities such as marathons, fun runs, lap swimming, road cycling or spin classes.

Figure 11.16 The characteristics of the three energy systems

Energy system	Creatine phosphate system	Lactic acid system	Aerobic (oxygen) system
Method of energy production	Anaerobic	Anaerobic	Aerobic
Speed of ATP production	Very rapid	Rapid	Slow
Fuel source	Chemical fuel: creatine phosphate	Fuel from food: glucose	Fuel from food: glucose, fats (and protein in extreme circumstances)
Quantity of ATP	Very limited ATP production	Limited ATP production	Unlimited ATP production
Limitations	Muscle stores limited	By-product is lactic acid, which causes muscle fatigue	By-products are water, carbon dioxide, heat; by-products do not cause fatigue
Duration and intensity	Used in sprints or any high-intensity activity (95–100% of maximal effort) of short duration (up to 10 seconds)	Used in high-intensity activities (85–95% of maximal effort) lasting 1–2 minutes	Used in endurance or long-duration activities lasting over 5 minutes and of submaximal intensity (less than 85% of maximal effort)

Learning experience

PERFORMANCE TIME, ENERGY SYSTEMS AND ACTIVITY

For each of the performance times listed in the table below, identify:

a the major energy system/s contributing to energy production

b two to three examples of physical activities/sports that are relevant to this time period and energy system.

Performance time	Major energy system/s	Examples of activities/sports
<10 s		
10–30 s		
30–90 s		
90 s to 3 min		
>3 min		

Contributions of the energy systems during physical activity

Each energy system contributes in varying amounts during physical activity, depending on the intensity and duration of the activity and the fitness level of the individual. The three energy systems do not operate independently of each other but are a part of linked process that allows physical work to occur efficiently and allows recovery from that effort so that energy is available soon after exercise or activity stops.

For example, during a game of touch football the individual may tap the ball to start the game, run 5–10 m before getting touched, play the ball and then be involved in several rucks to advance the ball up the field. They may then have to back pedal quickly to get on side and defend for a set of six touches. They may have to do this for several minutes before substituting off the field to recover. Without realising it, the athlete has utilised all three energy systems to provide the energy so muscular contractions of the working muscles (mainly legs) can continue and play can be effective.

Learning experience

ENERGY SOURCE FOR AN ACTIVITY

In a 1500 m race, the athlete uses the CP system during the first 10 seconds of the race. When CP stores are depleted the lactic acid system takes over to provide the energy for the athlete to continue at high intensity during the first 2 minutes of the race. Once the heart and lungs have increased oxygen delivery to the working muscles, the athlete can work aerobically to use the carbohydrate stores to continue into the latter half of the race. For that final lap the anaerobic systems are needed again, as intensity increases for the final surge to the line. The athlete then uses the aerobic energy system in the recovery phase to resynthesise ATP and clear blood lactate.

Use a similar format as the example above to analyse the energy sources and contributions for the physical activity you are currently studying.

Learning experience

WHICH ENERGY SYSTEM IS THAT?

For each of the photos in figure 11.17 (below and on the next page) answer the following:

1. Which energy system is dominant (i.e. produces most of the energy for the activity to occur)?
2. Which fuel would supply the energy to resynthesise ATP?
3. Approximately how long would the activity last (i.e. the duration)?
4. What intensity would the activity require (very high, high, high–medium, medium, low)?
5. Draw a graph that includes all the activities and demonstrates the relationship between intensity (*x*-axis) and duration (*y*-axis). Hint: There should be a line on your graph for each physical activity.

>>

Figure 11.17 A variety of physical activities that have different energy demands due to their intensity and duration

Percentage use of energy systems in physical activities

Figure 11.18 How the different energy systems contribute to different activities (The figures give the percentage contribution from each system.)

Sports or events	Creatine phosphate system	Lactic acid system	Aerobic (oxygen) system
Archery	0	0	100
Athletics			
100 m	50	50	1
200 m	38	57	5
400 m	27	55	18
800 m	18	31	51
1500 m	20	55	25
3000 m	20	40	40
5000 m	10	20	70
10 000 m	5	15	80
Marathon	0	5	95
Jumps	100	0	0
Throws	100	0	0
Baseball	95	5	0
Basketball	80	20	0
Biathlon	0	5	95
Canoeing			
c1 1000 m	25	35	40
c2 1000 m	20	55	25
c1, c2 10 000 m	5	10	85
Cycling			
200 m track	98	2	0
4000 m pursuit	20	50	30
Road racing	0	5	95
Diving	100	0	0
Driving (motor sports, luge, etc.)	0	0–15	85–100
Equestrian	20–30	20–50	20–50
Fencing	90	10	0
Figure skating	60–80	10–30	20
Gymnastics (except floor)	90	10	0

(continued)

Sports or events	Creatine phosphate system	Lactic acid system	Aerobic (oxygen) system
Handball	80	10	10
Ice hockey	80–90	10–20	0
Judo	90	10	0
Kayaking			
K1 500 m	25	60	15
K2 4500 m	30	60	10
K1 1000 m	20	50	30
K2, 4 1000 m	20	55	25
K1, 2, 4 10 000 m	5	10	85
Rowing	2	15	83
Rugby	30–40	10–20	30–50
Sailing	0	15	85–100
Shooting	0	0	100
Skiing, alpine			
Slalom	40	50	10
Giant slalom	30	50	20
Super giant	15	45	40
Downhill	10	45	45
Skiing, Nordic	0	5	95
Soccer	60–80	20	0–10
Speed skating			
500 m	95	5	0
1500 m	30	60	10
5000 m	10	40	50
10000 m	5	15	80
Swimming			
100 m	24	51	25
200 m	11	19	70
400 m	20	40	40
800 m	10	30	60
1500 m	10	20	70
Tennis	70	20	10
Touch football*	80	8	10–12
Volleyball	40	10	50
Water polo	30	40	30
Wrestling	90	10	0

*Sporting Pulse homepage for Victoria Touch Football (online)

Learning experience

PHYSICAL ACTIVITY AND ENERGY CONTRIBUTION

Refer to figure 11.18, which lists the percentage contribution for a range of activities and each energy system.

1. Conduct some research (library or internet) on the energy contributions of each of the three energy systems for a variety of activities (including those in the table).
2. List the energy contributions for new activities not included in figure 11.18 (e.g. surfing is a popular activity in Australia but is not included).
3. Were there any discrepancies between the information you found during your research and the energy percentage contributions for the physical activities listed in figure 11.18?
4. What were the discrepancies? Which resource would you say is more reliable and why?
5. What might be the reasons for the discrepancies between sources of information (e.g. text or internet)?

Note: Your teacher may set this activity up as a forum on the school's network.

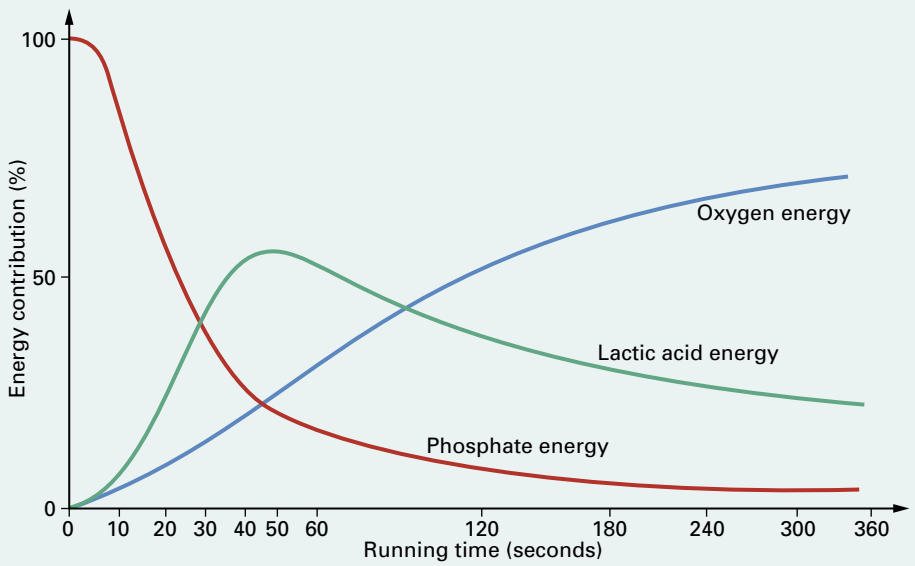


Figure 11.19 The relationship between the length of time an athlete has been running for and the contribution of different energy systems

Learning experience

ENERGY SYSTEMS AND DURATION OF EXERCISE

Refer to figure 11.19 and in your own words explain the relationship between energy contribution and duration of exercise in relation to each of the three energy systems.

Learning experience

ENERGY CONTRIBUTIONS

1 Use the following physical activity opportunities to judge the contributions of each of the three energy systems to the activity by considering the intensity and duration of the activity.

2 Select 2–3 that you have easy access to and if possible video the physical activity for 5–10 minutes:
- physical activity you are currently participating in
- club training session
- junior PE class at your school
- club/team game on the weekend
- club/team warm up
- lunch time play (boys or girls).

3 Show the relevant aspects of the video footage to the class or a small group and highlight where the three energy systems are contributing to the activity. Ensure you discuss the intensity and duration of the activity to justify your decisions.

Learning experience

MAGNITUDE OF ENERGY SYSTEM CONTRIBUTIONS

Refer to figure 11.20. Draw a similar diagram of how different energy systems contribute to different aspects of the physical activity you are currently studying by selecting a range of skills or scenarios that will reflect how each energy system contributes.

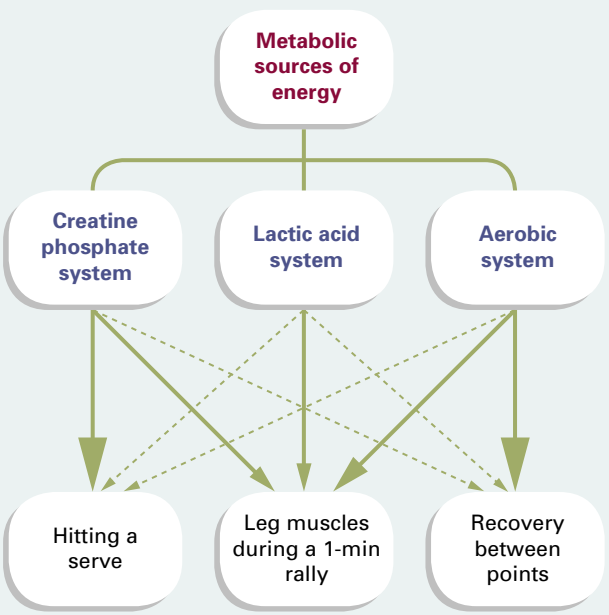


Figure 11.20 Examples of how the different energy systems contribute to different aspects of tennis. Each energy system contributes in different amounts. The magnitude of the energy contribution is estimated by the size of the arrow. Remember, magnitude of contribution for each energy system depends on the time and power output demands placed on the muscle

Diagram based on 'How the different energy systems contribute to different aspects of tennis' from *Strength Training for Sport*, edited by William J Kramer & Keiko Hakkien, Blackwell Science 2000, Periodized Training Programs, p. 123, John Wiley & Sons Ltd, UK

Chapter review

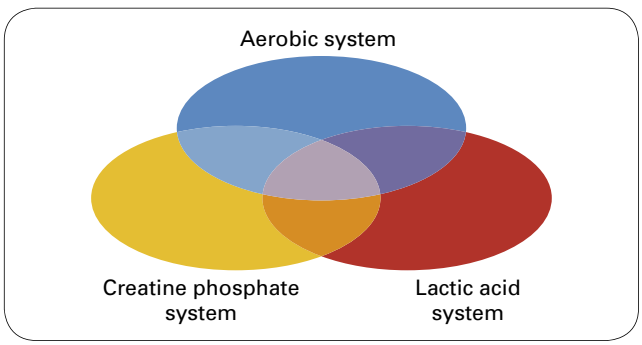
Energy systems

Know

1. List the characteristics of each of the food fuels that supply the body with energy to perform muscular work and how they relate to each of the energy systems.
2. Collect 10–15 images of people participating in sport, physical activity, leisure activities, exercise or fitness activities and identify the dominant energy system.

Comprehend

3. Explain why the Venn diagram below might be an accurate representation of the relationship between the energy contributions of the CP, lactic acid and aerobic systems.



Apply

4. Interview an elite athlete at your school or club to ascertain how much understanding they have of the energy systems involved in their sport or physical activity.
5. Produce a graph or figure to demonstrate to the athlete the contribution of each energy system in their sport or physical activity (see figure 11.19).

Analyse
Evaluate
Synthesise

6. Watch 5–10 minutes of video footage of the physical activity you are currently participating in.
7. Take note of the movement patterns (sprint, jog, walk, stand), skills (pass, catch, dodge, sidestep, kick) and the intensity, duration and frequency of these. Observe the movements of others with whom you interact, such as teammates.
8. Using your knowledge of the energy systems in the human body discuss how each of the three energy systems may be used in this physical activity.
9. Justify your decisions with practical examples from the game play, remembering that movement intensity and duration are key elements affecting energy system usage.
10. Based on your knowledge of movement patterns, skills, intensity and duration, create a warm-up for a small group (4–6) that incorporates the dominant energy systems, movement patterns and skills of the physical activity you are currently studying. Implement the warm-up and evaluate how effective it was in preparing you for the physical activity you are currently involved in. Justify your decision with examples from the warm-up, practical examples from game play, research you may have conducted and opinions from your group.

Exercise physiology principles

HOW DOES AN UNDERSTANDING OF EXERCISE PHYSIOLOGY PRINCIPLES HELP TO IMPROVE TEAM AND INDIVIDUAL PERFORMANCE IN PHYSICAL ACTIVITIES?

chapter 12

Fitness

Fitness can be defined as the ability to carry out everyday activities without becoming excessively fatigued, and to still have enough energy left to deal with emergencies and to participate in active leisure.

However, the words 'fit' and 'fitness' are repeatedly used in conversation and the media with a wide variety of meanings, e.g.:

- 'Helen goes to body pump class three times a week, so she must be fit.'
- 'Damien rides to work every day to get fit.'
- 'Greg runs for fitness.'
- 'Sue surfs, and all surfers are fit.'
- 'Helen plays netball to stay fit.'
- 'Emma is so fit because she does ballet.'
- 'Luke pumps weights to keep himself fit.'

In each case, 'fit' or 'fitness' means something completely different. The fitness that Damien gets from riding is very different from the fitness that Luke gets from weight training. Similarly, the fitness that Helen gets from body pump class is different from Sue's surfing fitness. As the words 'fit' and 'fitness' can be used in so many ways, they must be replaced by more specific terms that describe the different components (or parts) of fitness.

Fitness is the ability to carry out everyday activities without fatiguing and having enough energy left over to deal with emergencies or participate in leisure activities.

Learning experience

THE MEANING OF THE TERM 'FIT'

1. Search the internet, newspapers or magazines and find 10 different sentences, words or images that represent the terms 'fit', 'fitness' or 'fitter' to you.
2. Organise these sentences, words or images into a collage that represents what fitness means to you.
3. Present your collage to a classmate and explain your choices and understanding of the terms.
4. Discuss the similarities and differences in your collages and why there might be differences based on individual interests, sporting or family backgrounds, gender or other factors. Share your collages with another pair in the class.

The benefits of being fit

As long ago as the Golden Age of Ancient Greece, people were aware of the benefits of physical activity, giving rise to the adage 'a healthy mind in a healthy body'. However, the message needs to be repeated. An essential part of improving the attitudes of Australians to fitness and their activity levels is to convince them of the benefits of health-related fitness. The decisions that we make daily can have significant impact on our quality of life now and in the future.

Figure 12.1
Consider the decisions about your lifestyle that you make every day and the impact these have on your health now and in the future.

Hypokinetic diseases

Unfortunately, in our modern high-technology world of industrialisation, automation, computers and labour-saving devices, most people fail to spend some of their increased leisure time in regular physical activity. As a result, diseases and conditions caused by low levels of fitness and physical activity are in epidemic proportions in our society. The latest update on Australian Social Trends, 2009, from the Australian Bureau of Statistics (ABS), revealed that approximately one-quarter of all Australian children aged 5–17 years and 61% of Australian adults are overweight or obese. The total annual cost of obesity to the nation was estimated to be around $58 billion. The World Health Organization attributed the alarming increase in childhood obesity to a lifestyle of eating more foods high in fat and sugars and spending less time on physical activity. These hypokinetic (lack of movement) diseases and other conditions range from heart disease, hypertension, obesity and lower back pain to emotional stress, depression, loss of self-esteem and insomnia.

The role that exercise plays in reducing the incidence of many problems caused by the sedentary nature of today's society has been well documented. Researchers in every major country in the world have studied the effects of exercise on the major ills of contemporary societies. Results have been duplicated time and again, so that now there is an enormous bank of evidence showing that physical activity which improves personal fitness will reduce or eliminate many physical and psychological conditions.

Consider that there are 1440 minutes in a day and current government and medical research recommends only 30–60 minutes of that should be spent in moderate to vigorous physical activity, such as walking, jogging, playing sport, doing a yoga class or riding a bike. Unfortunately, despite government and private-sector attempts to encourage activity and educate society, the ABS survey results (2004/05) revealed that 70% of Australians aged 15 years and over were classed as sedentary or having low exercise levels, and this percentage has not changed in the last three National Health Surveys. If we recall that health authorities are recommending between 30 and 60 minutes of daily physical activity, then, alarmingly, we are not doing enough exercise to ward off hypokinetic conditions that create an enormous economic burden for modern societies, and untold human pain and discomfort. Yet if people heeded the warnings of researchers and took up regular, active leisure programs, the savings in medical, pharmaceutical, workers compensation, physiotherapy, drug and food bills would be enormous.

Research findings on the benefits of improving fitness

Figure 12.2 summarises the benefits of improved fitness that have been found in hundreds of research studies conducted worldwide. These studies have investigated all major groups within society (including males, females, older people, children, disabled people, the fit, the unfit, workers and the unemployed). They have given consistent results that show the psychological, physical, social and societal benefits of improved fitness as a result of following a regular training routine or program.

Figure 12.2 A summary of the general health benefits of frequent physical activity

Psychological benefits
Feelings of being in better health
Reduced stress levels
Reduced tension, anxiety and depression
Increased ability to relax
Reduced feelings of aggression
Improved self-concept, body image and self-esteem
Improved sleep
Improved mental performance and memory in older people
Positive mood alteration because of increased oxygen supply to the brain
Improved feelings of controlling your destiny rather than feeling like a victim of fate
More positive work attitude

(continued)

Physical benefits
Improved work capacity
Increased energy available for daily tasks
Increased ability to meet emergencies, e.g. ability to save yourself or someone else from drowning
Improved coordination
Improved skin tone because of improved circulation
Reduced body fat because of increased energy use
Improved body contours due to increased muscle tone
Increased basal metabolic rate (BMR), thus increasing fat loss
Decreased amount of food eaten and desired
Improved posture and personal appearance
Delay of the ageing process
Decreased chance of heart attack
Increased chance of surviving heart attack
Improved fat metabolism
Decreased blood levels of LDL cholesterol and triglycerides
Decreased blood pressure
Improved digestion and decreased constipation
Decreased menstrual discomfort and premenstrual tension symptoms, e.g. decreased breast tenderness, anger, depression and fluid retention
Decreased discomfort during pregnancy and birth, and faster postnatal recovery
Decreased age-onset diabetes and insulin requirements
Improved immune system because of stress relief, giving decreased susceptibility to illness and faster recovery from illness
Decreased arthritis because of improved blood supply
Increased musculature of the heart
Decreased resting heart rate
Increased heart stroke volume, therefore increased blood supply to muscles and organs
Faster recovery after strenuous work
Ability to perform more strenuous work
Decreased stress placed on the heart at rest and during submaximal work
Increased lung capacity
Improved oxygen extraction

(continued)

Physical benefits
Relief from respiratory diseases (e.g. asthma) because of improved lung efficiency
Decreased chance of muscle or joint injury because of increased strength of bone, ligament, muscle and tendon
Increased muscle tone and size
Improved flexibility, therefore better posture control
Decreased incidence of lower back pain
Social and societal benefits
Reduced hospital admissions
Reduced medical consultations, especially for older people
Greater physical independence for older people
Reduced absenteeism and workers compensation claims
Reduced number of industrial accidents
Reduced health service expenditure
More successful adjustment to retiring and ageing
New social contacts and sources of friendship
Development of a group identity

Learning experience

THE HEALTH BENEFITS OF IMPROVING FITNESS

Review the general health benefits of improving fitness (figure 12.2).

1 Select your top three benefits for each category (psychological, physical, social).

Psychological	Physical	Social
1	1	1
2	2	2
3	3	3

2 Narrow your choices by highlighting the top three overall benefits of improving fitness.

3 Share your selection with a classmate and discuss the similarities and differences in your choices (e.g. were the overall top 3 from one category or evenly spread across all categories?).

4 Show your parent or caregiver the list and ask them to complete steps 1 and 2.

5 Share your selection with your parent or caregiver and discuss the similarities and differences. For example, do you think age, time, financial constraints or gender affected your choices?

6 Write a paragraph on why you chose the top three overall health benefits for improving fitness, using specific personal examples to justify your decisions.

The fitness feedback loop

One of the greatest benefits of fitness, which carries with it an intrinsic value, is the boost provided to self-esteem through the fitness feedback loop (see figure 12.3).

Working goals

First, set working goals. Working goals are not long-term goals, such as 'I want to lose 5 kg and improve my aerobic fitness' or 'I want to be able to run 10 km in 50 minutes'.

Working goals state:

- what activity will be done in each workout
- how much activity will be done, e.g. distance, time, laps, weight, sets
- when the workout will take place, i.e. date and time
- how often activity will take place each week.

Figure 12.3
The fitness feedback loop

The reinforcement circle

At the end of each exercise session, you will have completed your working goals, giving you a sense of achievement. This motivates the achievement of the next set of working goals. Over time, your continued achievements boost your self-esteem.

You have set up a reinforcement circle of goal setting, achievement, boost to self-esteem and then further goal setting, achievement and boost to self-esteem, and so on. Eventually, you will reach your long-term goal, with the additional benefit of many booster injections to your self-esteem along the way.

Learning experience

WEEKLY WORKING GOALS TO IMPROVE FITNESS AND MEET ACTIVITY TARGETS

Local, state and federal governments are spending considerable amounts of money to encourage Australians to exercise and be proactive in reducing their risks to lifestyle diseases, such as diabetes, heart disease and stroke. Research has recommended between 30 and 60 minutes of moderate to vigorous physical activity daily as ideal.

Task

1 Record your daily physical activity for a minimum of three days. (Try to include one weekend day.) *Note:* Try to record your activity for the whole week.

Day	Activity*	Intensity	Duration (time)	Dominant energy system	Goal achieved? How did you feel?
Example day	Jog Touch training Ride to school	Moderate Hard Easy	20 min 60 min 30 min	Oxygen Anaerobic Oxygen	Yes 80 min Great
1					
2					
3					
4					
5					

*Remember you may participate in more than one activity during the day.

2 The ABS survey results also revealed that the biggest barriers people reported for not participating in physical activity were a lack of time and interest. Report on what were your biggest barriers if you did not meet the daily activity targets and what were the enablers or things that did help you meet your targets. Don't forget to use research as well as personal opinion to justify your decisions.

Learning experience

FITNESS GOES ONLINE: FITNESS BLOGGING

1 Conduct a search on the internet of 'fitness blogs'.
2 Find your top three fitness blogs and share them with a classmate.
3 In pairs, discuss whether:
- **a** the information is accurate/useful/motivational
- **b** you learnt anything from the blog
- **c** you would consider starting your own fitness blog, why or why not.

Components of fitness and fitness testing

As we have realised, fitness has many meanings and therefore should be broken into components or parts to describe the different types (see figure 12.4). As you may have observed through your experiences in sport and physical activity, some people are stronger, faster, can run for longer or are more flexible. These all relate to a specific component of fitness. Some are necessary for general health and fitness and these are the 'health-related' components of fitness. The others are those that are specifically related to 'sport- or skill-related' components of fitness. The sport-related fitness components are evident in athletes who excel at certain types of sports or physical activities. For example, a touch player needs speed and agility, whereas a sprinter needs speed and a great reaction time. Athletes involved in competitive sports and physical activities need to train to develop and improve *both* the health- and sport-related fitness components.

The following sections of this chapter discuss each fitness component in detail and outline fitness tests that can be implemented to ascertain your level of fitness for each component of fitness and therefore your suitability to particular sports or areas of fitness that you need to work on to improve your performance.

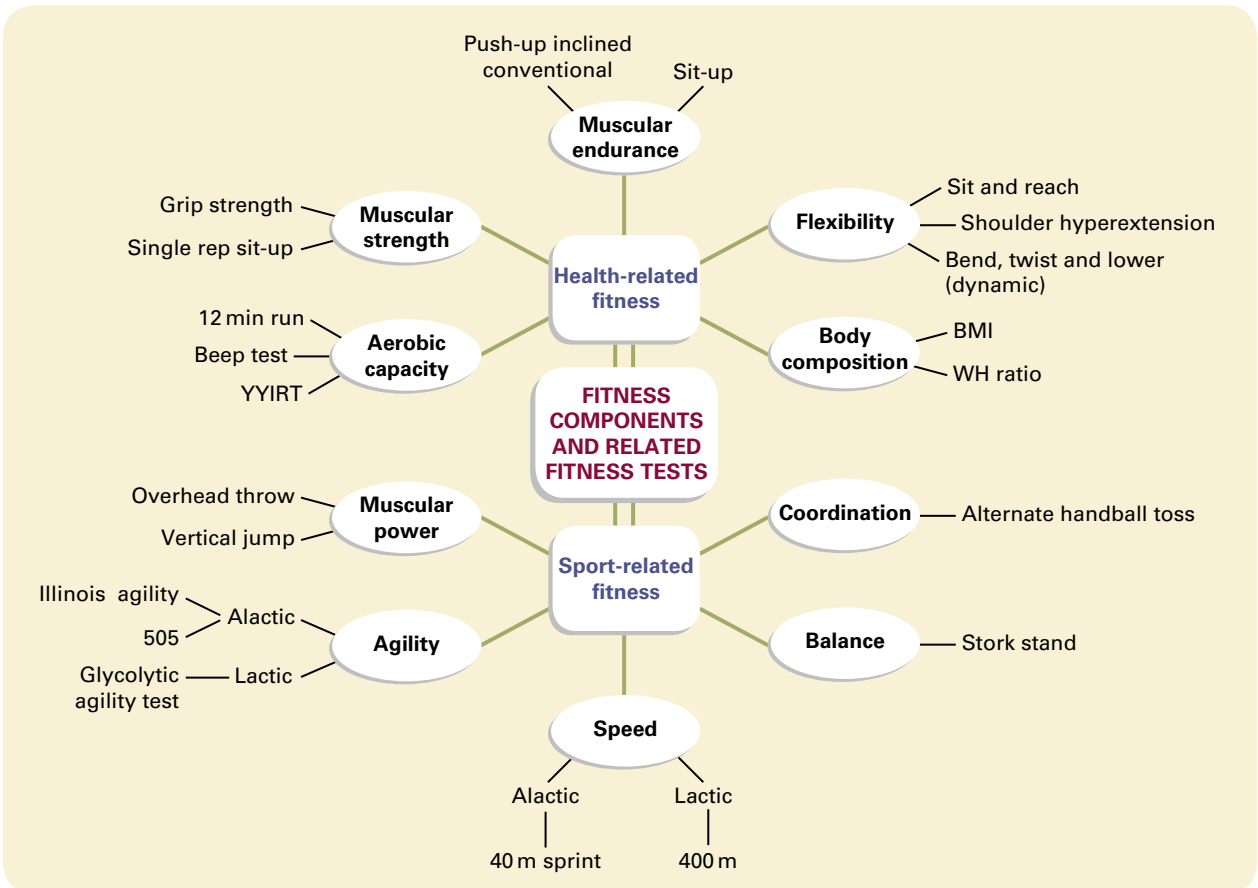


Figure 12.4 The relationship between fitness components and fitness testing

It is important to remember that the energy needed to make us move (i.e. to make the muscles contract) is produced through three energy systems. Two of these are anaerobic (without oxygen) and one is aerobic (with oxygen). The methods of energy production are linked with the various fitness components in figure 12.5, below, and explained in greater detail in chapter 14.

Figure 12.5 The relationship between components of fitness and energy systems

Fitness component	Energy system
Aerobic capacity	Aerobic
Strength	Anaerobic: phosphate
Local muscular endurance	Anaerobic: lactic acid Aerobic (for activities of longer duration)
Power	Anaerobic: phosphate
Agility	Anaerobic: phosphate
Speed	Anaerobic: phosphate, lactic acid (for activities of slightly longer duration)

Learning experience

IDENTIFYING THE COMPONENTS OF FITNESS IN DIFFERENT SPORTS

Use the following information fitness components to identify (✓) the two most important fitness components for each activity or sport in the table on the opposite page, then answer these questions.

1. Explain why you placed the ticks where you did.
2. Does the standard of competition or skill level make any difference to your choices? Explain your answer, using examples.
3. Do the different skills of each game or activity require different components of fitness? Explain your answer, using examples.
4. Do different playing positions in the same activity require different components of fitness? Explain your answer, using examples.

>>

Activity or sport	Muscle strength	Power	Local muscle endurance	Aerobic endurance	Agility	Anaerobic speed	Flexibility	Balance
Tennis								
Weights								
Jogging								
Cricket								
Rugby								
League								
Touch								
football								
Squash								
Cycling								
Netball								
Softball								
Water polo								
Basketball								
Volleyball								
Soccer								
Athletics								
Yoga								

Learning experience

FITNESS COMPONENTS NEEDED IN A DIRECT OR INDIRECT INTERCEPTIVE ACTIVITY

Aim

To analyse the fitness required for a direct or indirect interceptive activity.

Subjects

Each student does this task individually.

Procedure

1. Participate in an organised training session for a direct or indirect interceptive activity that concludes with a period of game play.
2. Based on your experiences and observations during the session, list all the specific skills or actions performed throughout the session. For each action, record whether it occurred with low, medium or high frequency.
3. For each action you have listed, suggest the fitness components it may require.
4. Compare your list with those of your classmates and then modify or justify your results as you think necessary.

Aerobic (cardiorespiratory) capacity

Aerobic (cardiorespiratory) capacity is the most important component of fitness. It is also called 'general endurance', 'stamina' and 'heart–lung fitness'. **Aerobic capacity** (also referred to as aerobic fitness or aerobic endurance) is the foundation block on which all other fitness components depend.

Aerobic capacity is the ability to keep producing energy aerobically and using it to perform tasks involving the whole body for extended periods of time. This requires heart–lung (cardiorespiratory) efficiency in delivering oxygen to the working muscles and removing wastes such as carbon dioxide. The ability to consume oxygen for energy production is called your **oxygen uptake**, or your ability to consume oxygen (VO_2). The highest possible oxygen intake is the 'VO_{2max}' or **maximal oxygen uptake**. Oxygen uptake is expressed as millilitres or litres per minute and it is related to body size. To account for individual body size variations it is expressed in millilitres of oxygen consumed per kilogram of body weight per minute (mL/kg/min). It is also affected by age, gender and genetics.

Aerobic capacity is the ability to persist in physical activities that rely heavily on oxygen for energy production.

Oxygen uptake is the ability to consume oxygen to produce energy.

The level of oxygen an individual can consume and utilise to produce energy in 1 minute is called the **maximum oxygen uptake** VO_{2max} (also called maximal oxygen consumption).

Generally athletes who excel at endurance sports have a greater capacity for aerobic transfer—that is, the ability to generate energy for the resynthesis of ATP aerobically. In other words, they have a greater capacity to take up, deliver and transfer oxygen to the working muscles and remove carbon dioxide and other wastes, and so it is a good measure of an individual's capacity to exercise. Most elite athletes record a VO_{2max} well over 60 mL/kg/min. One of the highest recorded was an alpine skier with 90 mL/kg/min, and cyclist Lance Armstrong had a VO_{2max} of 85 mL/kg/min.

Most team sports require aerobic fitness as a base of fitness so that players can recover rapidly between periods of high-intensity effort. However, aerobic fitness is needed most for activities such as distance running, swimming, surfing and cycling. Aerobic activities also require local muscular endurance.

Aerobic capacity tests

The following tests can provide an individual with approximate VO_{2max} based on the result they achieve in the test. They are the most useful way of testing aerobic fitness without using expensive laboratory equipment.

The multistage fitness test (beep test)

Procedure

1 This test requires you to run back and forth between two lines 20 m apart.
2 The pace is determined by beeps on a special CD. You must touch each line with your foot just before or as the CD beeps. Pivot as you touch the line and do not make large circles when turning.
3 The idea of the test is to keep up with the beeps as long as possible. Do not race the CD. When you cannot keep up with the CD and you miss two consecutive beeps, you are eliminated.
4 Record the last stage you completed successfully (e.g. 9.9) and check your predicted VO_{2max} on figure 12.6.

Figure 12.6 Predicted maximum oxygen uptake for the multistage fitness test

Level	Shuttle	Predicted VO_{2max}	Level	Shuttle	Predicted VO_{2max}
4	2	26.8	6	6	35.0
4	4	27.6	6	8	35.7
4	6	28.3	6	10	36.4
4	9	29.5	7	2	37.1
5	2	30.2	7	4	37.8
5	4	31.0	7	6	38.5
5	6	31.8	7	8	39.2
5	9	32.9	7	10	39.9
6	2	33.6	8	2	40.5
6	4	34.3	8	4	41.1

(continued)

Level	Shuttle	Predicted VO_{2max}	Level	Shuttle	Predicted VO_{2max}
8	6	41.8	14	6	62.6
8	8	42.4	14	8	62.7
8	11	43.3	14	10	63.2
9	2	43.9	14	13	64.0
9	4	44.5	15	2	64.6
9	6	45.2	15	4	65.1
9	11	46.8	15	6	65.6
10	2	47.4	15	8	66.2
10	4	48.0	15	10	66.7
10	6	48.7	15	13	67.5
10	8	49.3	16	2	68.0
10	11	50.2	16	4	68.5
11	2	50.8	16	6	69.0
11	4	51.4	16	8	69.5
11	6	51.9	16	10	69.9
11	8	52.5	16	12	70.5
11	10	53.1	16	14	70.9
11	12	53.7	17	2	71.4
12	2	54.3	17	4	71.9
12	4	54.8	17	6	72.4
12	6	55.4	17	8	72.9
12	8	56.0	17	10	73.4
12	10	56.5	17	12	73.9
12	12	57.1	18	2	74.8
13	2	57.6	18	4	75.3
13	4	58.2	18	6	75.8
13	6	58.7	18	8	76.2
13	8	59.3	18	10	76.7
13	10	59.8	18	12	77.2
13	13	60.6	18	15	77.9
14	2	61.1	19	2	78.3
14	4	61.7	19	4	78.8

(continued)

Level	Shuttle	Predicted VO_{2max}	Level	Shuttle	Predicted VO_{2max}
19	6	79.2	20	14	84.3
19	8	79.7	20	16	84.8
19	10	80.2	21	2	85.2
19	12	80.6	21	4	85.6
20	2	81.8	21	6	86.1
20	4	82.2	21	8	86.5
20	6	82.6	21	10	86.9
20	8	83.0	21	12	87.4
20	10	83.5	21	14	87.8
20	12	83.9	21	16	88.2

Aerobic run tests

The original run test was the 12-minute run developed by Kenneth Cooper. This test was based on laboratory treadmill data obtained from groups of varying fitness levels. The data showed a linear relationship between the distance run and the amount of oxygen consumed, therefore the distance run in 12 minutes could be used to predict VO_{2max}.

Procedure

1 Participate in a complete warm-up by jogging until sweating, followed by lower body stretches of the muscles that will be used in the run.
2 Establish a measured course, preferably a 400 m track marked with witch's hats every 50 m.
3 Record the distance run in 12, 15 or 5 minutes, depending on the test used. For the 1.6 km run, record the time taken to complete the distance.
4 Figures 12.7 and 12.8 give fitness ratings for the distance covered in 12 minutes, which can be converted into a predicted VO_{2max} in figure 12.9.

Figure 12.7 Twelve-minute test for men: distance in kilometres covered in 12 minutes

Fitness category	Age	
	17–20	21–30
Very poor	Less than 2.29	Less than 1.60
Poor	2.30–2.49	1.60–1.99
Fair	2.50–2.69	2.00–2.39
Good	2.70–2.99	2.40–2.79
Excellent	3.00+	2.80+

Figure 12.8 Twelve-minute test for women: distance in kilometres covered in 12 minutes

Fitness category	Age	
	17–20	21–30
Very poor	Less than 1.49	Less than 1.50
Poor	1.50–1.79	1.50–1.79
Fair	1.80–2.09	1.80–2.19
Good	2.10–2.29	2.20–2.59
Excellent	2.30+	2.60+

Figure 12.9 Prediction of VO_{2max} of people under 30 years of age, based on fitness categories used in the 12-minute run test

Fitness category	Oxygen consumption (mL/kg/min)
Very poor	Less than 25.0
Poor	25.0–33.7
Fair	33.8–42.5
Good	42.6–51.5
Excellent	51.6+

Figure 12.10 Classification of maximum oxygen uptake for Australians aged 20–29

Classification	Men	Women
Very poor	Less than 41.9	Less than 30.0
Poor	42.0–46.3	30.1–34.9
Fair	46.4–51.0	35.0–39.9
Good	51.1–55.0	40.0–45.0
Excellent	55.1+	45.1+

Yo-yo intermittent recovery test

This test was designed specifically for soccer and is similar to the beep test (multi-stage fitness test) but involves an active recovery of 10 seconds after each up-and-back shuttle (2 × 20 m). This test is now used by many team sports when testing their players, due to its ability to mirror the demands placed on athletes during games (i.e. the intermittent nature of many team sports that require periods of high intensity followed by periods of recovery) and as a result it may represent a better picture of the fitness of team sports athletes. (*Note:* There are a number of variations of the Yo-yo test.)

Procedure

1 The equipment needed to conduct the test includes a tape measure, markers, a Yo-yo CD, a CD player and recording sheets. (Figure 12.11 illustrates where you need to place the markers.)

It is suggested that you divide your group into pairs so one person can run and the other can monitor how far that person runs before they are eliminated from the test. The partners then swap over.

Figure 12.11
Line marking for Yo-yo test

2 Students run 20 metres forward, pivot at a line (or marker) in time with the beep from the CD and run 20 metres back to the start before the next audio beep.
3 During their 10 seconds of active recovery they continue jogging to (and around) the next marker and back to the start line.
4 On the next beep, they repeat another up-and-back shuttle.
5 The speed of the audio beeps corresponding to the shuttle run gradually increases throughout the test while the 10-second recovery interval remains consistent throughout the test.
6 The test continues until the student either has missed two consecutive beeps at the 'finish' marker or is unable to get to the 'start' marker in time for the next beep. At this stage, there is no normative data for school students using this test. However, to give you some indication of performance, figure 12.12 reports test values that have been recorded for athletes from different sporting groups.

Figure 12.12 Examples of elite athlete target results in the Yo-yo intermittent recovery test

Junior elite basketball players (male)	17–22.5
Junior elite basketball players (female)	15–18.7
Australian women's basketball squad	17–21
NRL players	20–24

Muscular strength

By definition, **muscular strength** is the force that a muscle or group of muscles can exert against a resistance in a single maximal contraction. In practice, strength is the ability to perform an action that requires large amounts of force and can only be completed a maximum of 10 consecutive times.

Muscular strength is the capacity to apply force against a particular resistance.

Physical activities that require strength include:

- gripping a hockey stick, tennis racquet or golf club when hitting the ball
- weightlifting
- jostling for position in basketball or soccer
- tackling in rugby or Australian Rules football
- field events involving throwing.

Strength is the foundation of muscular power and is vital in preventing damage to the muscle belly, tendons and ligaments. Strength activities rely on phosphate anaerobic energy production within the muscles.

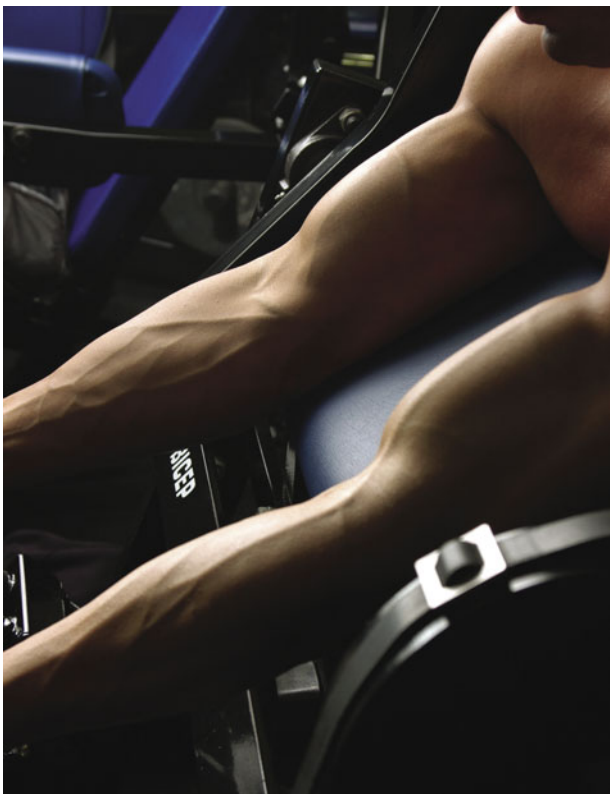


Figure 12.13 Weight training develops muscular strength

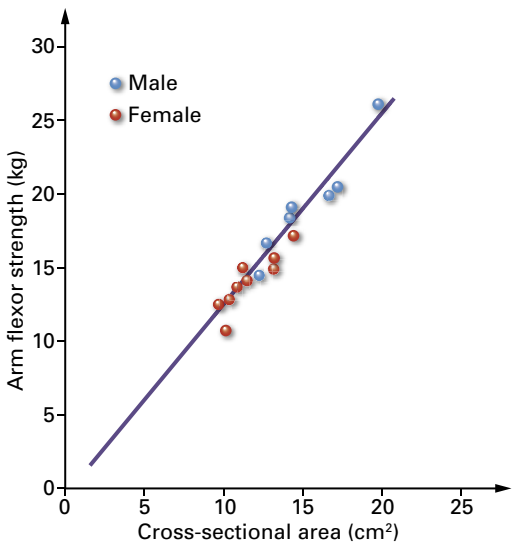


Figure 12.14 The relationship between the strength of the arm muscles and their cross-sectional area. Notice that the relationship is the same for both males and females.

There are two types of muscle fibres—slow and fast twitch—that affect the application of strength. Slow-twitch fibres are suited to aerobic endurance work, as they contract slowly and are slow to fatigue. Fast-twitch fibres are speed/strength fibres suited to anaerobic work, as they contract rapidly but are easily fatigued. Genetic inheritance of these fibre types affects your speed and endurance potential. (See figures 12.15 and 12.16 for further information on muscle fibre types.)

Factors affecting the application of strength

The six factors that affect the application of strength are:

- recruitment of muscle fibres
- cross-sectional area of a muscle
- pre-stretch
- muscle fibre types
- age
- gender.

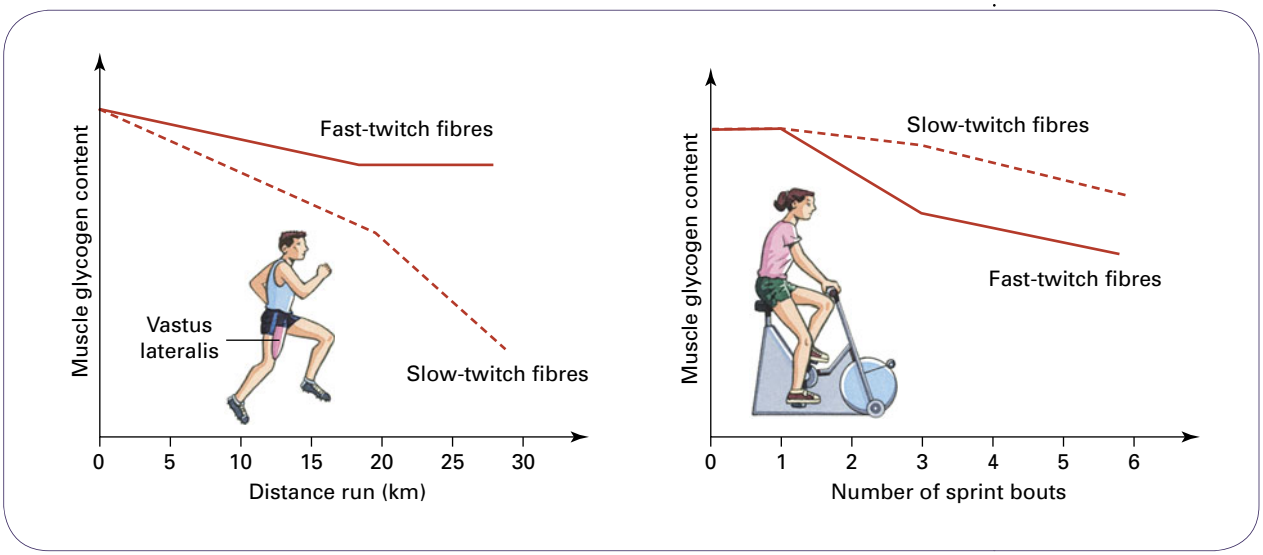


Figure 12.15 Muscle glycogen usage in fast-twitch and slow-twitch fibres during a 30 km race (left) and during repeated sprints (right). Glycogen depletion in the slow-twitch fibres was greatest during the 30 km race; glycogen depletion in the fast-twitch fibres was greatest during the sprint bouts. The results show that slow-twitch fibres are used more during prolonged work, and fast-twitch fibres are used more during sprint work.

Figure 12.16 A summary of the differences between fast-twitch and slow-twitch muscle fibres

Characteristic	Fast-twitch fibres	Slow-twitch fibres
Aerobic capacity	Low	High
Anaerobic capacity	High	Low
Capillary density	Low	High
Contraction time	Fast	Slow
Force of contraction	High	Low
Recruitment pattern	Sprint-type activities	Endurance-type activities
Distribution in athletes	High in non-endurance athletes	High in endurance athletes
Fatiguability	Rapid	Slow

Single-rep sit-ups test

Purpose

To measure abdominal strength.

Equipment

- 2.5 kg and 4.5 kg weight discs

Procedure

1 The subject lies supine on the floor. Adjust the knee angle to 90° and ask the subject to tilt the pelvis backwards to flatten the lower back onto the floor.
2 Explain variation 1 (figure 12.17) to the subject.
3 If the subject successfully performs variation 1, explain variation 2 (figure 12.18) and have the subject attempt it.

4 The subject attempts each of variations 1 to 7 (see figures 12.17–12.22) until unsuccessful (i.e. until unable to complete the nominated variation correctly).
5 Record the last successful variation. Compare the results with figure 12.23.

Improper procedure

1 Lifting either heel off the floor
2 'Throwing' the arms or the head forward
3 Moving the arms from the nominated position
4 Lifting the hips off the floor
5 Failing to maintain the 90° knee angle

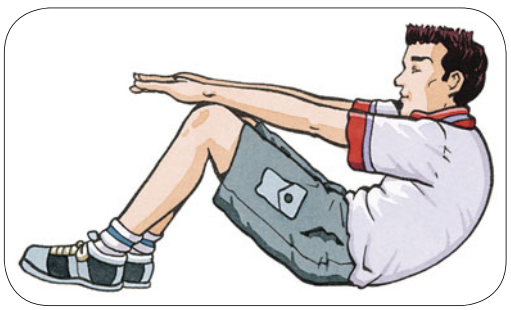


Figure 12.17
Variation 1
Start: Arms straight, hands on top of thighs Finish: Arms straight and fingertips touching patellas

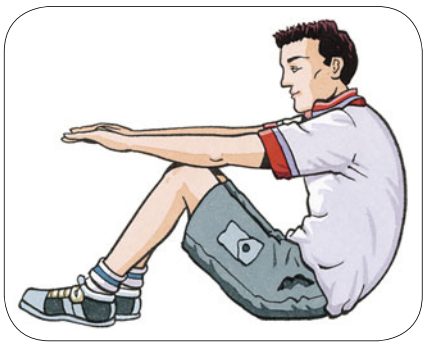


Figure 12.18
Variation 2
Start: Arms straight, hands on top of thighs
Finish: Arms straight, elbow tips touching patellas

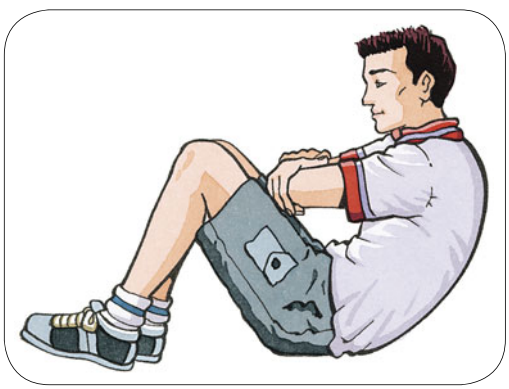


Figure 12.19
Variation 3
Start: Arms flexed across the abdomen, hands gripping the opposite elbows
Finish: Forearms touching thighs

Figure 12.20
Variation 4
Start: Arms flexed across the abdomen, hands gripping the opposite shoulders
Finish: Forearms touching thighs

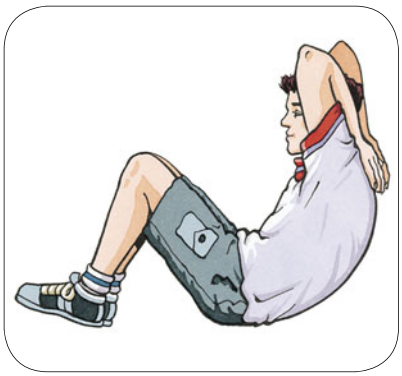


Figure 12.21 **Variation 5** Start: Arms flexed behind the head, hands gripping the opposite shoulders Finish: Chest touching thighs

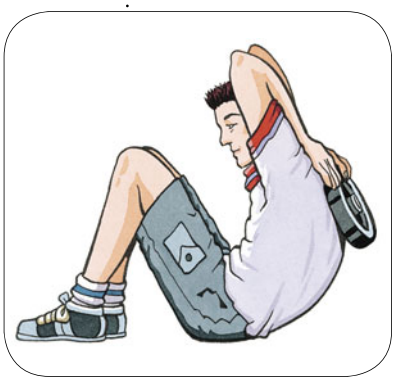


Figure 12.22 **Variations 6 and 7** As for variation 5, but with hands gripping the opposite sides of a 2.5 kg and a 4.5 kg weight disc, respectively, behind the shoulders

Figure 12.23 Ranking of the last successful variation in the single-rep sit-ups test

Variation	Description	Ranking
1	Fingertips	Very poor
2	Elbows	Poor
3	Abdomen	Fair
4	Chest	Good
5	Shoulders	Very good
6	2.5 kg	Excellent
7	4.5 kg	Excellent

Grip strength test (dominant hand)

Purpose

To test the strength of muscles of the fingers, hand and forearm, which is an example of an isometric strength test, using a handgrip dynamometer (see figure 12.24).

Procedure

1 The student holds the dynamometer in their hand (palm up) with their arm raised and parallel to the floor. Make sure the pointer has been reset to zero.
2 The student squeezes the grip as hard as possible for several seconds. A downwards thrust is allowed.
3 Record the best trial from three attempts for the dominant and non-dominant hands.
4 Compare your results with the norms shown in figure 12.25.

Improper procedure

If your hand, arm or elbow touches the body or any other object while performing the test, the test is invalid.

Figure 12.24
Testing grip strength

Figure 12.26
Rock climbing requires muscular endurance.

Muscular endurance
the ability of a muscle to perform repetitive work over a prolonged period of time.

Figure 12.25 Ratings for handgrip strength

Rating	Males		Females	
	Non-dominant	Dominant	Non-dominant	Dominant
Excellent	>57	>61	>36	>40
Good	51–56	55–60	31–36	35–40
Average	45–50	49–54	25–30	29–34
Fair	39–44	43–47	19–24	23–27
Poor	<39	<43	<19	<23

Muscular endurance

By definition, **muscular endurance** is the ability to work a muscle for long periods at less than maximum effort, where local fatigue rather than general exhaustion is the limiting factor. In practice, actions that can be repeated 30 or more times without rest are classed as requiring local or muscular endurance. Sporting examples include paddling a canoe (endurance in the arms), distance swimming (endurance in the arms and shoulders), jogging (endurance in the legs) and gripping a tennis racquet for a whole set (endurance in the forearm).

Muscular endurance activities tend to rely on a combination of aerobic muscle energy and lactic acid anaerobic energy production, depending on the intensity and frequency of muscle contractions.

Factors affecting muscular endurance

There are five main factors affecting muscular endurance:

- contraction intensity
- fibre types
- blood supply to the muscle
- ability to produce aerobic energy
- lactic acid tolerance.

Push-ups test

This is a test for muscular endurance of the chest, shoulders and triceps. (There are many alternative muscular endurance tests available, e.g. incline push-up test.)

The person being tested does as many push-ups as possible in 60 seconds (see figure 12.28 for ratings). Start the test in the push-up position with weight on the hands and toes, as shown in figure 12.27. The subject's hands should be just wider than shoulder width apart and their back and legs kept straight at all times. Lower the body to the floor until the elbows are at 90 degrees. Push back up to the start position. This is one repetition. Repeat as many times as possible. The push-up does not count if the chest does not come to just off the floor.

Figure 12.27
The push-up test

Source: Visualcoaching® Pro software, <www.visualcoaching.com>

Figure 12.28 Ratings for the push-up test

Rating	16–19-year-old males	16–19-year-old females
Excellent	>56	>35
Good	35–56	21–35
Average	19–34	11–20
Fair	11–18	6–10
Poor	<11	<6

Sit-ups (bent knee) test

Purpose

To determine the endurance of the abdominal muscles.
Note: This type of sit-up is not normally recommended and should only be performed to test abdominal endurance.

Procedure

1 Assume a supine position, with hands interlocked behind your neck. Draw back your feet towards the buttocks until they are flat on the floor (knees bent). The angle of your lower legs to your thighs should be about 90°.
2 Your partner should kneel on one knee, placing it between your feet while grasping both your ankles.
3 A full sit-up is counted when you have curled your back and raised your trunk until your lower back is at least perpendicular to the floor, and then returned to the starting position.
4 Repeat the procedure as many times as possible within the time limit (1 minute for women, 2 minutes for men). The holder counts out loud, emphasising every fifth sit-up. This helps the performer and lessens the risk of losing count. The score is the number of sit-ups completed within the specified time. Resting is permitted, but only on your back with hands in the proper position (see figure 12.29).
5 Compare your results with the norms shown in figure 12.30.

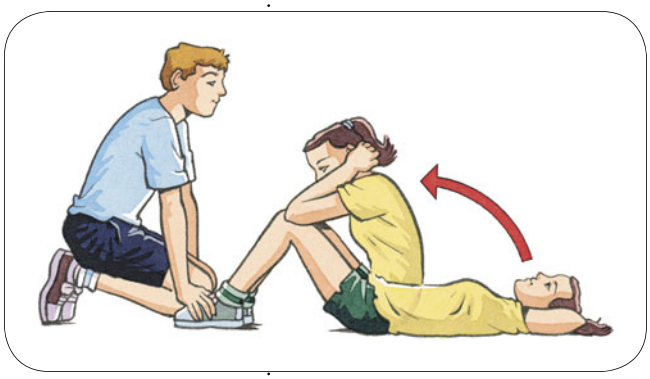


Figure 12.29
Sit-ups with bent knees

Improper procedure

1 Not coming all the way up to the vertical position. (Do not let your elbows touch your knees—they should pass your knees.)
2 Releasing your hands from behind your neck.

Figure 12.30 Norms for muscular strength and endurance

Rating	1 minute sit-up test (no.)	2 minute sit-up test (no.)
Super	38–45	79–91
Excellent	33–37	69–73
Good	28–31	62–67
Average	23–26	52–59
Fair	17–21	50–44
Poor	12–15	35–41
Very poor	3–10	21–32

Flexibility

Flexibility is the range of motion of the body's joints.

Flexibility is the ability of the muscles, ligaments and tendons to allow large movements of the joints. It is often called mobility or suppleness. Flexibility can be increased by stretching the muscles and, to a limited degree, the tendons and ligaments.

Sporting activities that require flexibility include gymnastics, hurdling, the high jump, and tackling in team sports. Most kinds of dance also require flexibility. Factors affecting flexibility include:

- the type of joint
- the resting length of the muscles
- the resting lengths of the ligaments and joint capsule
- body build
- muscle and joint temperature
- gender
- age
- injury.

Types of flexibility

There are two types of flexibility:

- dynamic or active (see figure 12.31)
- static or passive (see figure 12.32).

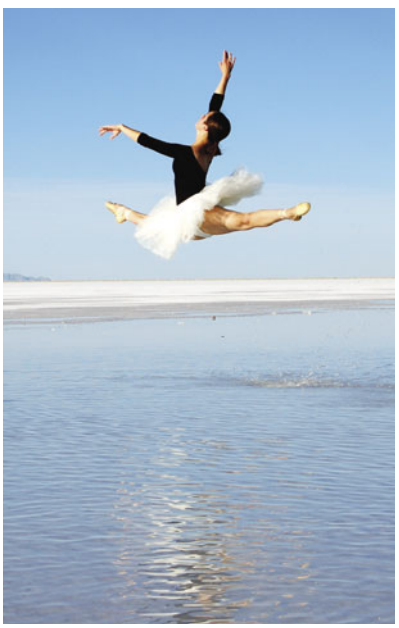


Figure 12.31 Ballet dancers are renowned for their excellent flexibility.

Figure 12.32 A good example of static flexibility combined with muscular strength

Problems linked with lack of flexibility

There are various problems associated with lack of flexibility. Tight, short muscles can:

- tear and strain much more readily during sports activities than flexible muscles, e.g. footballers who have short hamstrings or who do not stretch their hamstrings often pull these muscles when kicking
- produce bad body posture, e.g. tight pectorals can cause a cramped chest and round shoulders
- produce health problems, e.g. tight hip flexors can pull on the lumbar vertebrae, producing lower back pain

- prevent competitive players from fulfilling their potential, e.g. a hurdler with limited hip flexibility might have to jump 10 cm higher to clear the hurdle than someone with flexible hips, and will thus be slower; a swimmer with poor shoulder flexibility has a reduced distance over which to develop force in an arm stroke.

Static flexibility test

The sit and reach test

Purpose

To measure the amount of trunk flexion and the ability to stretch the lower back muscles and hamstring muscles.

Equipment

- bench
- metre rule or
- sit and reach box

Procedure

1 Begin this test only after a total body warm-up. It is best carried out following an aerobic submaximal test.
2 Sit on the floor with your feet on either side of the ruler and pressed against the front board (see figure 12.33).

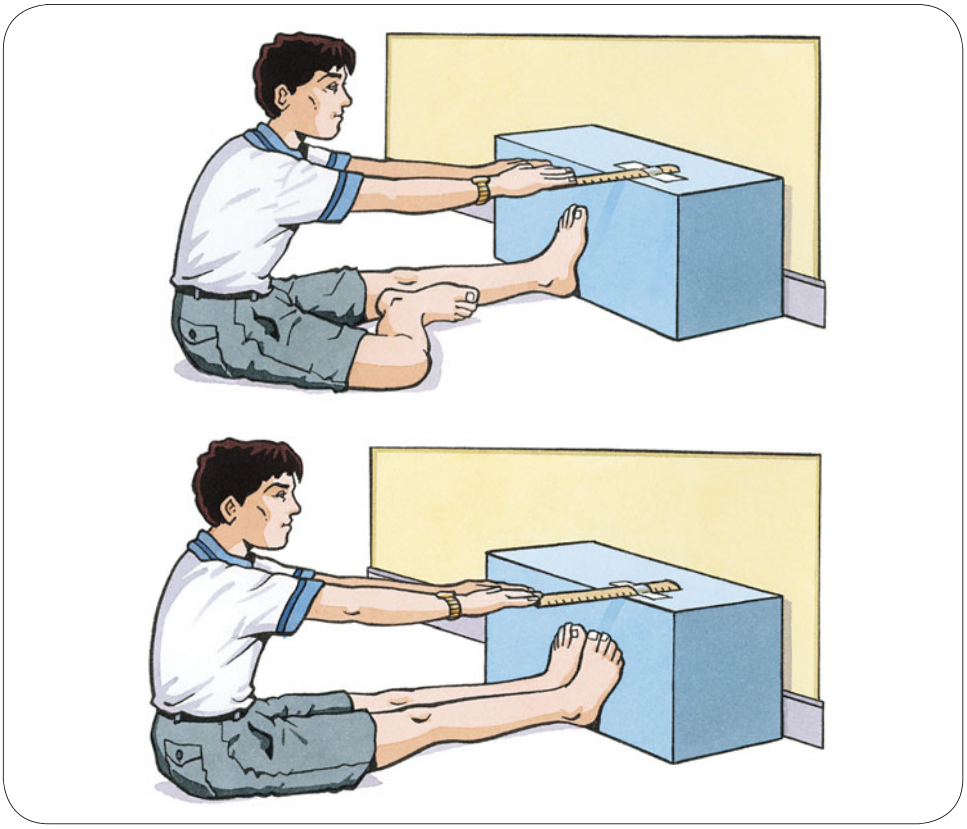


Figure 12.33
The sit and reach test can be done on a single leg or both legs together.

3 Keep your knees straight, bending at the trunk and reaching as far forward as possible. When you cannot stretch any further, hold the position for 3 seconds.

4 Take three readings and record the best measure. Distances before the edge (not able to touch your toes) are expressed as negative scores; those beyond the edge are expressed as positive scores.
5 Compare your result with the norms shown in figure 12.34.

Improper procedure

1 Not holding the flexed position for 3 seconds
2 Bending the knees.

Figure 12.34 Ratings for the sit and reach test (single leg and both legs), measurement in centimetres

Rating	16–19-year-old females			16–19-year-old males		
	Left	Right	Both	Left	Right	Both
Excellent	>24	>24	>23	>23	>23	>22
Good	22–23	22–23	22–23	21–22	21–22	20–21
Average	21–22	21–22	20–21	20–21	20–21	19–20
Fair	20–21	20–21	19	19–20	19–20	18
Poor	<19	<19	<18	<18	<18	<17

Dynamic flexibility test

The bend, twist and touch test

Purpose

To measure dynamic flexibility, i.e. the number of rotational movements that can be made in a set time period.

Note: This test must be preceded by a complete warm-up.

Procedure

1 Stand about 0.5 m from a wall, with your back to the wall and feet apart.
2 From a standing position, bend to touch the floor with both hands (see figure 12.35).

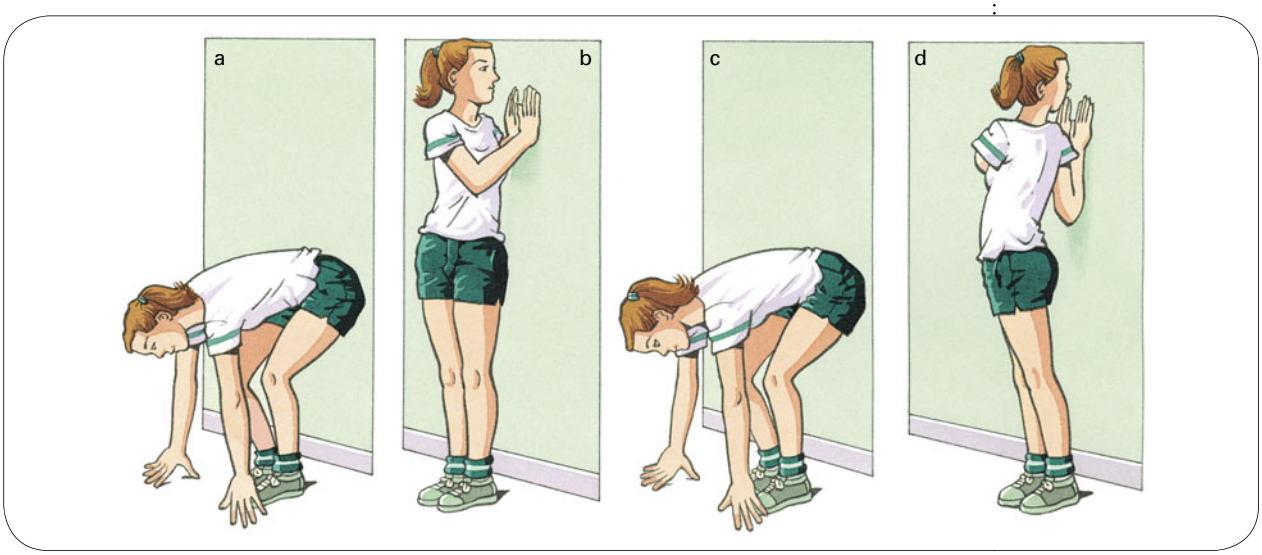


Figure 12.35 The bend, twist and touch test of dynamic flexibility

3 Return to the standing position, turning to the right to touch the wall directly behind.
4 Bend to touch the floor, stand, and touch the wall to the left.
5 Practise these movements in quick succession for a while before beginning the test.
6 To do the test, repeat the movements as many times as possible in 20 seconds and keep score.
7 Compare your score with the norms shown in figure 12.36.

Figure 12.36 Flexibility ratings for the sit and reach test, and the bend, twist and touch test

	Static flexibility (sit and reach test) (cm)		Dynamic flexibility (bend, twist and touch test)	
Rating	**20–39 years**	**40–59 years**	**20–39 years**	**40–59 years**
Poor	≤1.0	≤–6.0	≤14	≤11
Fair	1.1–6.0	–5.9–1.0	15–16	12–13
Average	6.1–10.0	1.1–7.0	17	14–15
Good	10.1–13.0	7.1–10.0	18	16
Excellent	13.1+	10.1+	19+	17+

Body composition

Body composition refers to the proportion of fat and lean (muscle and bone) constituents of the human body.

Body composition refers to the ratio of fat to non-fat components in your body.

Body fat consists of essential fat in and around organs, and storage fat found in fat cells all around the body. The amount of storage fat in your body can be altered, e.g. by overeating, which increases your fat stores.

The amount of body fat a person has can be measured by the thickness of skin folds. These measurements can be converted to an estimate of the percentage of fat on the body. Lean body weight consists of all the non-fat parts of your body, e.g. muscles, bones and organs. The amount of your body that is lean tissue can be altered, e.g. by weight training, which increases your muscle mass.

Your body composition is the ratio of body fat to lean tissue and so can be altered by diet and exercise. However, women on average carry more body fat than males of similar age who do similar amounts of exercise. Carrying this extra 'dead' weight partially explains the better performances of males in running and jumping activities.

There are some very simple tests for body composition that are less invasive than the skin fold test. Remember these are only a guide, as body mass is affected by many factors, including height, bone density and ethnicity.

Body composition tests

Body mass index (BMI)

Body mass index is an indirect measure of body composition. As it does not distinguish between excessive weight produced by muscle or body fat, this test is not suitable for athletes (as muscle weighs more than fat, it could skew the results). When scores fall above or below the standard range, further assessment is recommended.

BMI is calculated using the following formula:

$$\text{BMI} = \text{mass (kg)} \times \text{height}^2\ (\text{m}^2)$$

For example, if your height is 170 cm and your body mass is 60 kg:

$$\text{BMI} = 60\,(\text{kg}) \times 1.7 \times 1.7\ (\text{m}^2)$$
$$\text{BMI} = 60\,(\text{kg}) \times 2.89\,(\text{m}^2)$$
$$\text{BMI} = 20.8$$

Figure 12.37 BMI categories for adults

BMI categories	Score
Underweight	<18.5
Normal weight	18.5–24.9
Overweight	25–30
Obesity	>30

Waist-to-hip ratio

Calculating a person's waist-to-hip ratio (WHR) indicates how much body fat they are carrying around their abdomen compared to their hips. Increased body fat around the abdomen increases the risk of heart disease, stroke and type 2 diabetes. Instructions are as follows:

1 Take a waist measurement at the level of the narrowest point between the lowest rib and the hips (iliac crest).
2 If there is no obvious narrowing then the measurement is taken at mid-way between the two points.
3 Take the measurement at the end of a normal expiration, with the arms relaxed at the sides.
4 Then take the hip measurement at the level of the greatest protrusion of the buttocks. The person stands with feet together and gluteal muscles relaxed.

WHR is calculated using the formula waist girth (centimetres) divided by hip girth (centimetres).

Figure 12.38 WHR ratings in adults

Ratings	Males	Females
Low risk	<0.85	<0.72
Increased risk of cardiovascular disease	>0.9	>0.8

Sport-specific fitness components and related tests

Muscular power

Muscular power is the ability to utilise strength in rapid, explosive muscle contractions.

Muscular power is the ability to use strength quickly to produce an explosive effort. Power depends on a trade-off between strength and speed. Slow contractions produce maximum force, but during quick contractions there is not enough time to develop a large force. As a result, maximum power is produced when both the speed and force of contraction are about 35% of maximum. Sporting activities such as throwing events, jumping events, sprint starts, dunking and kicking a ball for distance require power (see figure 12.39).

Power activities rely on phosphate anaerobic energy production, and so power athletes require high proportions of white (fast-twitch) fibres in their muscles. For example, in elite weightlifters, an average of 83% of the muscle fibres in the legs are fast-twitch fibres.

Figure 12.39
The basketball slam dunk is a classic example of muscular power in sport.

Standing backward overhead throw

Start with your back facing the direction in which you will throw. Holding a 4 kg medicine ball above your head, swing your arms down so the ball goes between your legs and then swing up and throw the ball backwards over your head as far as possible. Your arms must remain straight throughout the throw. Measure from the start line to where the ball hits the ground. Your score will be the best of three trials (see figure 12.41).

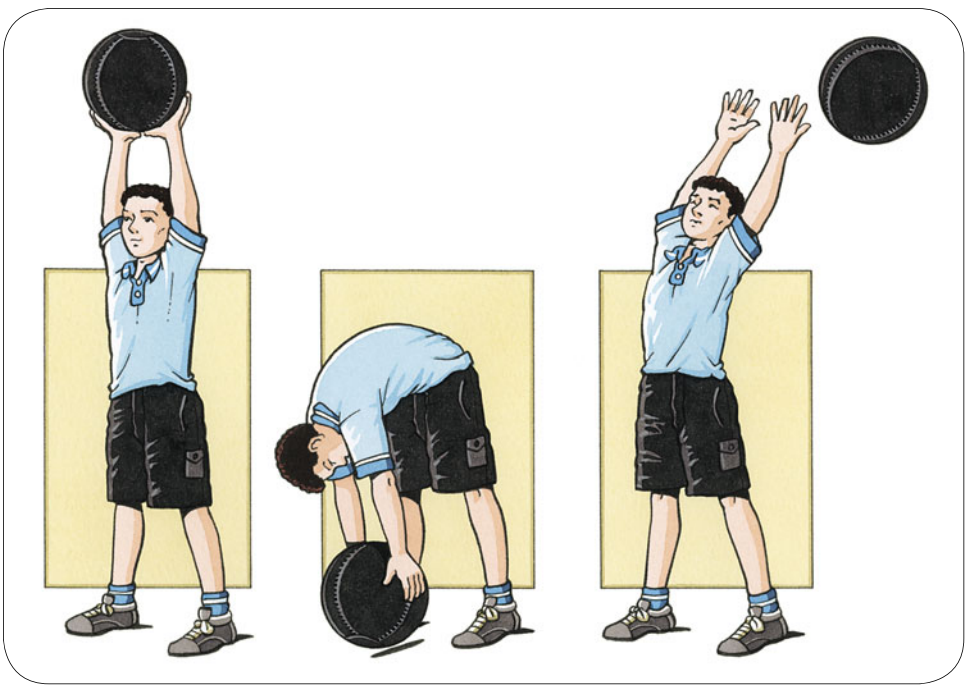


Figure 12.40
The backward overhead throw

Vertical jump test

Purpose

To test the power of the extensor muscles of the hips, knees and ankles.

Figure 12.41 Ratings for backward overhead throw

Rating	Males	Females
Fair	<11.4 m	<6.6 m
Average	11.4–12.6 m	6.6–9.0 m
Good	12.7–16.2 m	9.1–2.0 m
Excellent	>16.2 m	>12.0 m

Procedure

1 Face the jumping board and stand slightly in front of it, with your feet flat on the floor and both arms fully extended overhead (see figure 12.42). Note the point where the extended tips of the middle fingers touch the board.
2 Turn, so that you are side-on to the jump board. Without moving your feet (you are not allowed to step into the jump), take a deep squat and jump, touching the board as high as possible with the fingers nearest the board.
3 After a brief rest, try a second jump.
4 Record the greatest distance obtained between your standing reach and your jumping reach, to the nearest 10 mm. Compare your results with the norms shown in figures 12.45 and 12.46.

Improper procedure

1 Not getting a true standing reach
2 Moving the feet in preparation to jump.

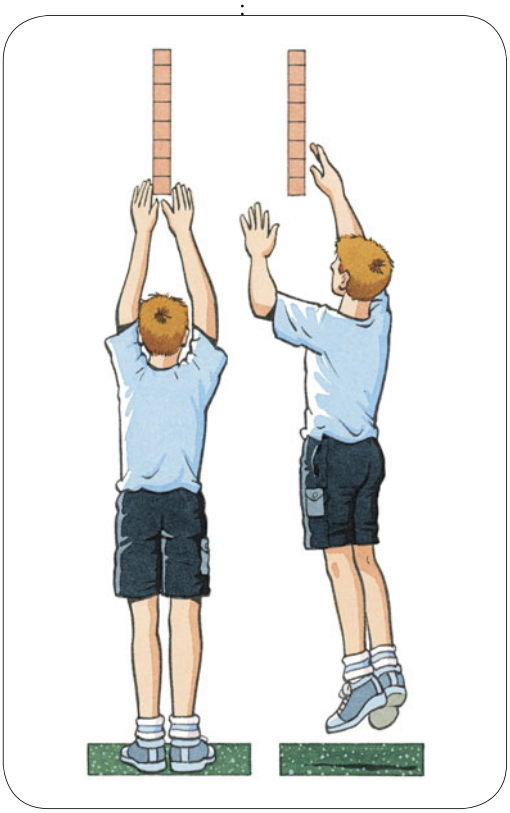


Figure 12.42
Vertical jump test

Agility

Agility is the ability to change the position of the body quickly and precisely and still retain balance. To be agile, you must be able to accelerate quickly, turn, dodge and weave. Agility relies on anaerobic energy for speed and requires muscular power and flexibility.

Agility is essential in team sports to avoid the opposition, to change direction rapidly to follow play, and to be able to recover quickly from a collision or fall. Contact sports, such as boxing, wrestling, judo and the martial arts, as well as dance, gymnastics and ball sports, all require great agility. In many sports the athlete has to be agile even when experiencing high levels of fatigue due to increased lactic acid as they have been working anaerobically during high-intensity efforts of the game. Therefore, tests that focus on agility using the creatine phosphate system and lactic acid system to supply the energy to resynthesise ATP anaerobically have been included.

Figure 12.43
Agility is essential in team sports such as basketball.

It is important to remember that fitness tests should mirror the demands of the game in terms of intensity, movement patterns and dominant energy systems. As a result, many sports at the elite levels have developed their own sport-specific fitness tests for this fitness component. Both sport-specific and traditional agility tests have been included.

The Illinois agility run

Equipment

- stopwatch
- 4 chairs or agility poles
- wet towel

(The wet towel may be provided so that you can wipe the soles of your shoes before the run. This allows better traction.)

Procedure

1 Start in a front lying position behind the starting line, with your arms flexed and hands placed just outside your shoulders.
2 On the command 'Go', the timekeeper starts the stopwatch. Jump to your feet and run as fast as you can to the end line, 10 m away (see figure 12.44).
3 Stop when one foot touches or crosses the end line; then sprint back to the starting line.
4 Weave in and out around the four chairs or markers, spaced 3.3 m apart, to the end line.
5 Turn and weave back through the chairs to the starting line.
6 Sprint to the end line, touch or cross it with one foot, and then turn and sprint past the finish line.
7 The timekeeper records the time taken (to the nearest tenth of a second) to complete the run.
8 Compare your result with the norms in figures 12.45 and 12.46.

Improper procedure

1 Failing to touch the lines at each end
2 Touching (accidentally or on purpose) any of the chairs or markers
3 Not following the prescribed course

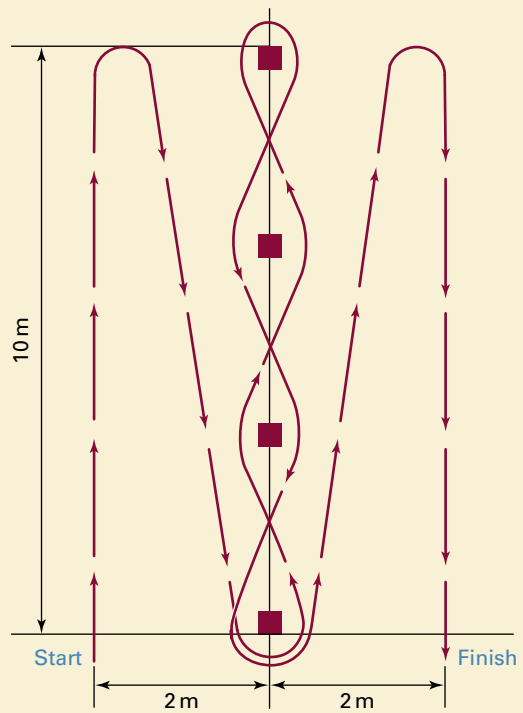


Figure 12.44 The course for the Illinois agility run

Figure 12.45 Norms for power (height of vertical jump) and agility (time taken for Illinois agility run) (men)

	Vertical jump (cm)	Illinois agility run (s)
Super	69.9 67.3 64.8	15.3 15.7 16.1
Excellent	63.5 62.2 61.0	16.3 16.5 16.7
Good	59.7 58.4 57.2	16.9 17.1 17.3
Average	55.9 54.6 53.3	17.5 17.7 17.9
Fair	52.1 50.8 49.5	18.1 18.3 18.5

(continued)

	Vertical jump (cm)	Illinois agility run (s)
Poor	48.3 47.0 45.7	18.7 18.9 19.1
Very poor	44.5 41.9 39.4	19.3 19.7 20.1

Figure 12.46 Norms for power (height of vertical jump) and agility (time taken for Illinois agility run) (women)

	Vertical jump (cm)	Illinois agility run (s)
Super	51.0 47.0 44.5	15.9 16.8 17.7
Excellent	43.2 42.0 41.0	18.1 18.6 19.0
Good	38.1 36.8 35.6	19.5 19.9 20.4
Average	34.3 33.0 31.8	20.8 21.3 21.7
Fair	30.5 29.2 28.0	22.2 22.6 23.1
Poor	26.7 25.4 22.9	23.5 24.0 24.4
Very poor	21.6 19.1 16.5	24.9 25.8 26.7

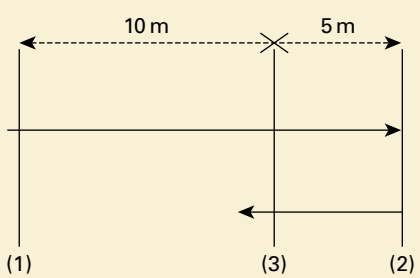


Figure 12.47
The marker positions for the test

5-0-5 agility test

Ideally, this test would be conducted with the use of electric timing lights—if this is not possible, use a stopwatch. Instructions are as follows:

1 The course is set up as illustrated in figure 12.47, preferably using a line on the ground at (2). If using timing lights, they are set up at marker (3).
2 The student starts at marker (1) and when ready, sprints forward to turn at (2) by placing their left or right foot on the line and accelerating back to the start.
3 The time is recorded from when they first pass the marker identified as (3) and timing is stopped when they again pass this marker (i.e. the total distance of the test is 10 m). Three trials are recorded for each foot.

Figure 12.48 Ratings for 5-0-5 agility, measurements in seconds

Rating	Males age 15–17 years	Females age 15–17 years
Excellent	<2.33	<2.66
Good	2.34–2.50	2.67–2.87
Average	2.51–2.67	2.88–3.08
Fair	2.68–3.84	3.09–3.29
Poor	>3.85	>3.30

Glycolytic agility test

This test was specifically developed for sports that involve forwards, backwards and sideways running over a moderate period of time, such as touch football and rugby league. Due to the duration of the test, it taxes both anaerobic systems, particularly the lactic acid system (O'Connor 1989).

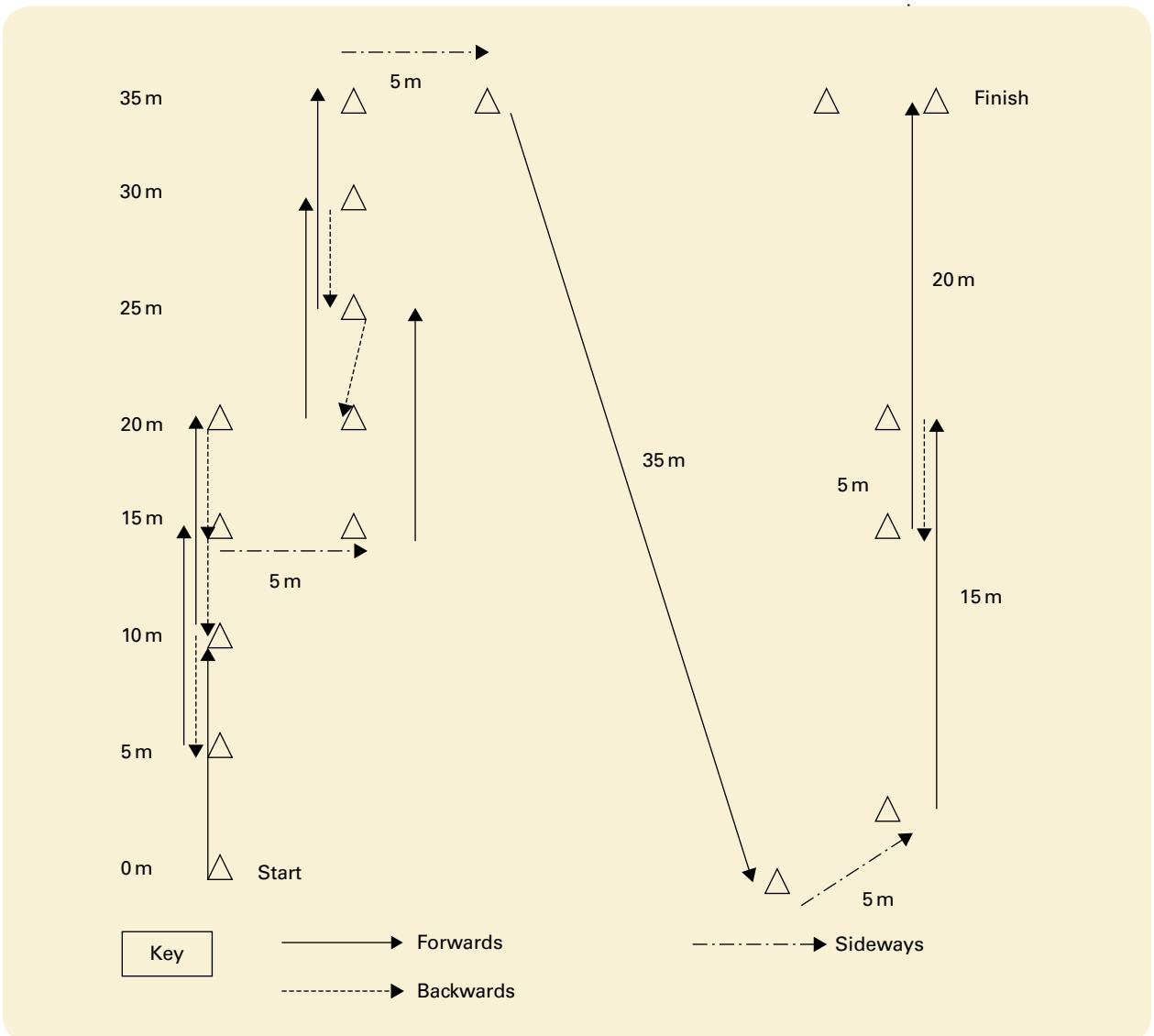


Figure 12.49
Glycolytic agility course

Equipment

- stopwatch
- markers

Procedure

1 Start on the outside of the cones and on the command 'Go' run forward 10 m to the second marker and then back 5 m to the first marker. The stopwatch is started on 'go'.
2 Continue running up 10 m and back 5 m until you have been to all markers in the first line.
3 Slide sideways to the next row of markers and continue running up 10 m and back 5 m until have been to all markers.
4 At the last marker in second line slide 5 m right to the third line and turn around this marker to run 35 m to the bottom marker.
5 Turn and slide 5 m right to next line of markers and then run forward 15 m, backwards for 5 m and then forward to the finish for 20 m.
6 Stopwatch is stopped when the person crosses between the 2 finishing markers. (See figure 12.49 for the course of the glycolytic agility test.).
7 Compare time in seconds with the ratings for senior high school students in figure 12.50.

Figure 12.50 Glycolytic agility results and ratings for senior high school students

Glycolytic agility		
Rating	**Girls**	**Boys**
Excellent	<45.44	<41.69
Good	45.44–50.58	41.69–44.56
Average	50.59–55.73	44.57–47.43
Fair	55.74–61.08	47.44–50.31
Poor	>61.08	> 50.31

Anaerobic capacity (speed)

Anaerobic capacity is the ability to persist at the maintenance or repetition of strenuous muscular contractions that rely substantially on anaerobic (without oxygen) mechanisms of energy supply.

Speed is the rate of travel of a body without regard to direction.

Anaerobic capacity is defined as the ability to put body parts into motion quickly and to sustain high-intensity efforts, for which anaerobic energy is required. Sporting activities such as sprinting (e.g. in running or swimming), the javelin throw, speed skating, long jump and triple jump require anaerobic (**speed**) fitness. This component of fitness is closely related to both strength and power, as activities requiring this component also usually require muscular strength and muscular power.

Factors affecting anaerobic capacity

There are five factors affecting anaerobic capacity:

- energy production
- muscle fibre type

- duration of the activity
- speed of transmission of nerve impulses
- flexibility.

Figure 12.51 Soccer requires many components of sport-related fitness as well aerobic endurance and coordination.

Anaerobic capacity and speed tests

As there are two anaerobic energy systems, we classify tests according to the energy system used to complete the test:

- alactacid tests
  - the 40 m sprint
  - phosphate recovery tests
- lactacid tests
  - the 400 m run.

The 40 m sprint

Procedure

1 Mark out a flat 40 m track with start and finish lines.
2 Give each subject the normal starting commands of 'On your marks', 'Set', 'Go'.
3 Measure the time from the starting command until the subject crosses the finish line.
4 Compare your time in seconds with the results and ratings of senior high school students in figure 12.52.

Note: During the 40 m sprint many sports also record split times over 10 m or 20 m, depending on the requirements of the sport.

Figure 12.52 10 m and 40 m sprint ratings for senior high school students

	Girls	Boys
Rating	**10 m sprint**	
Excellent	<2.14	<1.84
Good	2.14–2.41	1.84–2.10
Average	2.42–2.68	2.11–2.36
Fair	2.69–2.96	2.37–2.62
Poor	>2.96	>2.62
	40 m sprint	
Excellent	<5.94	<5.59
Good	5.94–6.54	5.59–6.20
Average	6.55–7.15	6.21–6.81
Fair	7.16–7.74	6.82–7.43
Poor	>7.74	>7.43

Phosphate recovery tests

These tests stress the phosphate energy system and the associated recovery mechanisms needed to allow repeated short-duration high-intensity efforts. These tests are relevant to the fitness required in a wide variety of sports, e.g. football, netball, basketball, soccer, hockey and squash.

There are two recommended phosphate tests:

- the long-course test, which requires ten 7-second sprints, departing every 30 seconds
- the short-course test, which requires ten 5-second sprints, departing every 30 seconds.

Preparation

1 Set up a grid on grass so that the distance between the end markers is 80 m or 50 m, depending on the test, and the width of the grid is between 20 and 40 m, according to the size of the squad (see figure 12.53).
2 Align the grid so that players run with a cross-breeze.
3 Place cones numbered from 1 to 10 every 2 m on each side of the grid, starting from the centre. To assist the scorers, all numbers should face in the same direction.
4 Organise the squad into pairs, with one partner running while the other records the scores.
5 Each partner should record for their partner only.
6 The runners and the scorers must all understand the test before they start.

Test procedure

1 The test is controlled by a timekeeper who has two stopwatches and a whistle.
2 Each runner performs either:
   - ten 7-second sprints, departing every 30 seconds, i.e. each 7-second sprint is followed by 23 seconds of recovery (which gives a 1:3 work-to-recovery ratio), or
   - ten 5-second sprints, departing every 30 seconds, i.e. each 5-second sprint is followed by 25 seconds of recovery (which gives a 1:5 work-to-recovery ratio).

   Both these tests are considered suitable for intermittent team games.
3 Five seconds before each sprint, the timekeeper gives a verbal warning. All runners take up a starting position between the end markers, ready to begin the sprint.
4 A whistle starts the sprint, and another whistle blast after 5 or 7 seconds stops it.
5 The timekeeper keeps the stopwatch going as the runners jog or walk through to the other end of the grid.
6 At the 25-second mark, the timekeeper warns the runners to take up their start positions.
7 At the 30-second mark, the timekeeper blows the whistle to begin the next sprint. Timing 5 or 7 seconds then begins on the second stopwatch.
8 Repeat this procedure until 10 sprints have been completed.

Scoring

1 The scorers, who each need a pencil and a scorecard, should position themselves on one side of the grid so that they can clearly see both sets of numbered cones.
2 If the runners sprint from left to right (according to the diagram in figure 12.53), they are scored using the top set of numbered cones. The scorers should take up positions to the right of the centre of the grid.
3 The runners receive points for each sprint according to the number of cones passed at the instant of the whistle blast to signal the end of the 5-second or 7-second sprint. The runner must pass a cone to receive its designated point value. For example, if a runner had passed cone 4 at the sound of the whistle, but had not quite reached cone 5, their score would be 4 points.

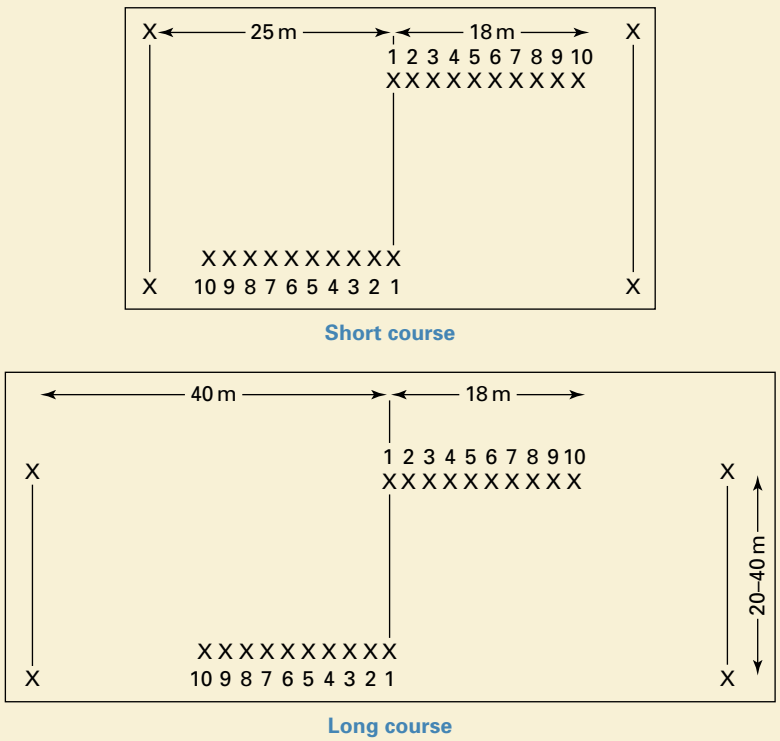


Figure 12.53
Grid markings for phosphate recovery tests

4 When the runners sprint from right to left (according to the diagram in figure 12.53), the scorers must use the bottom set of numbered cones and need to be to the left at the centre of the grid.
5 Calculate the total score by adding the points from each of the 10 sprints, or for a better measure of performance, calculate the percentage decrement over the 10 sprints (see figures 12.54 and 12.55).

Figure 12.54 Calculations of performance in phosphate recovery test

10 sprints/7 S W:R* 1:3	Performance									
Repetitions	1	2	3	4	5	6	7	8	9	10
Cones reached	8	7	7	6	6	6	4	4	4	3
Decrement		1	1	2	2	2	4	4	4	5
Best possible performance	Best score × reps = 8 × 10 = 80									
Total decrement	Sum of decrements = 1 + 1 + 2 + 2 + 2 + 4 + 4 + 4 + 5 = 25									
% decrement	Total decrement/best possible performance × 100 $= \frac{25}{80} \times 100$ = 31.25%									

*W:R = work-to-recovery ratio

Figure 12.55 Norms

Rating	% Decrement
Poor	>40%
Below average	30–40%
Average	20–30%
Good	12–20%

Lactacid test

The 400 m run

Equipment

- athletics track, or oval with a 400 m circuit
- stopwatch

Procedure

1 Mark the start and finish lines.
2 All subjects must complete a full warm-up.
3 Give each subject the normal starting commands of 'On your marks', 'Set', 'Go'.
4 Measure the time from the starting command until the subject crosses the finish line.

Balance

Balance is the ability to control your state of equilibrium.

Balance is the ability to maintain the body in equilibrium while stationary (static) or moving (dynamic). You are in equilibrium if you do not fall over, or fall off a piece of equipment. All sporting activities require balance.

However, in some sports it is more important than in others. Sports such as gymnastics require dynamic and static balance, whereas surfing, cycling, water skiing, in-line skating and horse riding require continuous dynamic balance.

Balance test

The stork stand

Procedure

1 Stand comfortably on both feet and place your hands on your hips.
2 Lift one leg and place the toes against the knee of the other leg.
3 When the signal is given, raise your heel and stand on your toes, balancing as for long as possible without your heel touching the floor or the other foot moving away from your knee.
4 Compare your results with the norms shown in figure 12.56.

Figure 12.56 Norms for the stork stand

Rating	Seconds
Excellent	41–60
Good	26–40
Fair	11–25
Poor	0–10

Coordination

Coordination is the ability of your body's senses (especially sight and hearing), your nervous system and your muscles to work together so that you can perform specific movements smoothly and accurately. The more complex the task, the greater the level of coordination required.

Coordination is the ability to control motor movements and patterns with either the hands or the feet.

Different sports require different types of coordination, e.g.:

- Sports such as soccer and Australian Rules football require foot–eye coordination to correctly time the contact between foot and ball.
- Activities such as tennis and softball require excellent hand–eye coordination to correctly position and time the contact between racquet/bat and ball.

Coordination test

The alternate hand rebound test

Procedure

1 Stand 2 m away from and facing a wall.
2 At the starting signal, throw a ball underarm against the wall with your right hand and catch it in your left hand.
3 Next throw it with your left hand and catch it with your right.
4 Do this as quickly as possible for 30 seconds.
5 Compare your results with the norms shown in figure 12.57.

Figure 12.57 Norms for the alternate hand rebound test

Rating	Males	Females
Excellent	31–36	22–27
Good	29–30	20–21
Average	24–28	15–19
Poor	0–23	0–14

Figure 12.58
Tennis players require excellent coordination to time their movements to return serves that often clock over 200 km/h.

Fitness test results

Learning experience

TEST RESULT ANALYSIS

1 Record all your results for the fitness tests completed. *Note:* Your class may not have completed all the tests or completed others that are more specific to the physical activity you are currently studying.
2 How do your results compare with the given norms?
3 What problems did you notice or experience when completing the battery of fitness tests? Do you think these problems affected your results? How could they be avoided in future?
4 Why is it important to evaluate test scores against normative data?
5 Based on your rating for each test, highlight your strengths and weaknesses and identify:
   a how this information could be used
   b if the results were a disappointment or surprise to you
   c the sports that you believe you would be suited to on the basis of the fitness test results and the reasons for this. Use specific sport examples to justify your decisions.

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Test	Fitness component	Dominant energy system	Result	Rating

Learning experience

WHAT FITNESS COMPONENT IS THAT?

Your teacher will assign you a component of fitness.

1. You are to take video evidence that will demonstrate to classmates what this fitness component is. This will also test your understanding.
2. Play the video evidence for your classmates to guess what the assigned fitness component was.
3. Were you successful in visually relaying the concept?

The importance of fitness testing

Now that you understand the components of fitness and some of the relevant fitness tests, it is beneficial for the physical education student to understand why fitness testing is important. Increasingly, fitness testing is used not only for the elite and general athlete but in schools and even in the workplace. For example, recruits into the armed forces have to pass a battery of fitness tests to be considered. Fitness testing is essential for those interested in sport-related fitness for several reasons:

- It identifies strengths and weaknesses.
- It gives feedback about the effectiveness of training.
- It provides training incentive.
- It identifies specific attributes necessary for the sport, such as speed.

- It can form part of a selection process.
- It assesses recovery from injury.
- It can be used as a part of talent identification.

Learning experience

ELITE IRONMAN WANTS TO GO TO THE OLYMPICS

Read the article 'Caine still able to Tri for Oly gold' and then answer the questions below it.

Caine still able to Tri for Oly gold

This is Caine Eckstein like you have never seen him. These pictures, taken inside the Australian Institute of Sport's physiology lab, show how serious the iron-man champion is about realising his dream of competing in the triathlon at the London Olympics.

The triple Coolangatta Gold winner last week trained alongside Commonwealth Games gold medallist Brad Kahlefeldt and world champion Emma Moffatt in a group of 25 triathletes at a national team camp in Canberra.

He was subjected to a battery of physiological tests that will determine if he has the potential to make it in the elite ranks.

National coach Shaun Stephens said, with a bit of tinkering, Eckstein has the makings of an Olympian.

'I wouldn't put that (Olympics) past him,' he said.

Eckstein has been flirting with the idea of switching sports for some time. But it took his third Coolangatta Gold triumph in October to prompt the 24-year-old to publicly declare he wanted to go to London in 2012.

Eckstein, who expects to tackle some low-profile events next month, acknowledged his shortcomings in the run leg but was encouraged by the camp.

'It was good to get amongst it,' he said. 'I enjoyed training with those guys and it was great to see where I'm at.'

While time is not on his side, there are several reasons why the AIS is taking him seriously.

'He's been exceptional,' Stephens said. 'He's an outstanding swimmer from a triathlon perspective. He'll certainly be a front-of-the-pack swimmer.

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'And his commitment and work ethic is exceptional. Aerobically, Caine's up there with the best. He'll be an interesting project.'

So what's the bad news?

'There's some things he needs to work on,' Stephens said. 'His cycling's in the ballpark. Technically he needs a little work but he's very strong.

'On the run he's been very strong too but he needs to work on his speed.'

Stephens said it would take at least another year of training before a call could be made on whether Eckstein might reach the Olympics.

The team of experts surrounding him would suggest coaching will not be a problem. Craig Walton, the Gold Coast-based coach steering Emma Snowsill, and Denis Cotterell are the brains behind Eckstein's conversion.

The training camp was the first time Triathlon Australia has assembled its top guns for a screening session at the AIS. Comeback duo Felicity Abram and Erin Densham also attended and will add to Australia's depth this year.

Meanwhile, Eckstein's brother Shannon will defend his crown when the Kellogg's Nutri-Grain Ironman Series kicks off at Kurrawa next Saturday.

Source: *The Sunday Mail*, 10 January 2010

1 Briefly outline what the article was about.
2 Why is the AIS taking Caine seriously?
3 Conduct some online research into cycling technique and developing 10 km running speed.
   a What are some of the technical aspects that are important in cycling?
   b Recommend how an athlete who has a good base fitness develops speed over 10 km.

Selecting fitness tests

Research will reveal that there are a plethora of fitness tests for each component of fitness. Fitness tests should be selected for their ability to measure the components of fitness known to be important to your sport, e.g.:

- Games analysis has revealed that sports such as hockey and soccer rely on the phosphate and aerobic energy systems. Therefore a sprint test over 40 m and a 15-minute run test would be appropriate, but a 400 m lactic acid test would not.
- If the activity requires running, it should be tested with a run or treadmill test, and cyclists, rowers, swimmers and kayakers should be assessed on ergometers designed for their sport.

When selecting the fitness test to use, there are a number of criteria that must be met, to ensure that the testing is valid, accurate and suited to your purposes. These criteria are:

- relevance and specificity
- quality control
- accuracy and reliability
- practicality
- feedback (interpretable results and discussion on the significance of the results).

Types of fitness tests

Field tests

Most athletes will be exposed more frequently to field tests, as they can be conducted on the field, court, or in the pool or gym. They are low-cost,

simple to administer, require little equipment and can be delivered to large groups.

However, field tests are less accurate than laboratory tests, and few have standardised norms that can be used for comparing performances. In fact, the federal government through its 'Australian Better Health Initiative' is asking all of us to do a field test by measuring our waist circumference to identify if we are overweight or obese. You can even download the tape measure from the website. How easy, inexpensive and accessible is that?

Laboratory tests

Laboratory tests provide accurate measures of physiological capacities and have standardised norms for comparison. However, the equipment required is usually very expensive and cumbersome, which makes such testing impractical in many situations.

SNAPSHOT

Have you got talent?

The Australian Sports Commission has implemented the National Talent Identification and Development Program (NTID) to identify and fast track Australians with the potential to become elite athletes, world champions or Olympians—that is, to identify the naturally talented individuals who were born with long levers, the right physiology or the necessary height.

Compared with our sporting rivals, such as the United Kingdom or China, Australia is a small nation and therefore we have to work smarter to find our potentially talented athletes. One way of doing this eTID, a free and easy-to-use online program that allows individuals aged 12–29 years to assess their sporting potential. Individuals can do seven easy-to-implement fitness tests and submit the results online. Once the results are submitted, the individual receives feedback based on age and gender, and those who score above average are encouraged to attend one of the Talent Assessment Centres (TAC) for further testing and verification of results. The TACs are linked with 20 universities around the country.

Learning experience

HAVE YOU GOT TALENT? FITNESS TESTING GOES ONLINE

Visit the website <www.ausport.gov.au/participating/got_talent/test> and watch the short video explaining eTID, and then take the general tests. You may have already done this as part of your studies in Physical Education.

Tasks

1. Identify the fitness components being measured in each of the seven tests.
2. Which tests do you think you scored well in and why?
3. Which tests do you think you performed poorly in and why?
4. a Based on the fitness test results and online feedback, which sports do you believe you would be suited to?
   b Discuss the factors that you think affected your scores (e.g. previous sporting experience, genetics, current physical activity).
   c Discuss the effect of taking the tests on your self-esteem, and the benefits of being tested even if you are not identified.

Sport-specific fitness testing

While standard fitness tests do measure the fitness component for which they have been designed, often individual coaches or sports find it more useful, relevant and specific to design their own sport-specific tests. These tests then get added to the growing battery of fitness tests. For example, the Yo-Yo intermittent recovery tests were originally developed for soccer but are now used widely for many team sports that are intermittent in nature.

Fitness testing for elite level athletes—AFL

Every year talented young AFL players are put through a battery of fitness tests at the AFL draft camp, to ascertain their levels of fitness and impress recruiters from the AFL clubs. The tests have been specifically selected and designed to address the requirements of AFL players and highlight young players with talent (see figure 12.60).

Figure 12.59
A talented young AFL player at the AFL draft camp completing a mark during fitness testing

Figure 12.60 Battery of tests completed by up-and-coming AFL players at the annual AFL draft camp

Category	Tests	Comments
Fitness	Endurance: shuttle run (beep) test, 3 km time trial	Beep test ratings: Average 13.3; Very good 14+ The best result in 2009 was 15.6.
	Muscular power: vertical jump and running vertical jump tests	The ability to jump is important when taking a mark.
	Speed: 20 m sprint	Split times for 5 m and 10 m Acceleration over 5 m is important in AFL to get clear of defence.
	Speed: anaerobic sprint recovery test	The ability to recover quickly after high-intensity efforts is important in many team games.
	Agility: AFL agility test	This is a test developed by the AFL in which the athlete runs in and around obstacles over 40 m.
Physical	Height, weight: BMI; skinfolds Flexibility: sit and reach test Hand span, arm length	Height is an advantage in AFL.
Psychomotor	Kicking skill efficiency Decision making Reaction time	This was a new test in 2009 and was designed by Nathan Buckley. The test provides analysis of technique, speed of delivery, trajectory and accuracy.

Source: information adapted from <www.topendsports.com/sport/afl/testing-draft-camp.htm>

Learning experience

SPORT-SPECIFIC SNAPSHOTS

You have read about what the AIS is doing for talent identification nationally and with individual athletes and teams. It would appear that fitness testing is an incredibly important part of elite sport. Conduct some online research to investigate other examples of fitness testing and analysis in sport. To report on your findings either:

- post your examples on a 'forum' set up by your teacher within the school's online network, or
- share your results verbally in class discussion if this is not available at your school.

SNAPSHOT

The fittest of the fit? Who is the fittest?

While fitness testing is specific feedback for an individual athlete, we often cannot help comparing our results with others. No doubt if you have participated in any type of fitness testing you have compared your results with others as well as the norms, and have been impressed when others have rated highly.

However, when it comes to comparing which sportspeople are the fittest, opinions are varied. It is often difficult to define fitness as it has so many components, and the sports being compared all have different requirements. What sports do you think produce the fittest athletes? Here is what tennis great Pete Sampras had to say in 2009, in a statement that is sure to spark debate among sporting stars and followers:

> *I think tennis players are the best athletes, in my opinion. I'm not being biased. I know what it takes; I know hand–eye coordination. In an individual sport, you can't hide', Sampras said.*

He may well be biased, but with his record his opinion is worthy of respect:

> *People don't talk about it. I mean, in tennis, these athletes are incredible … what these guys do on the run … the guys that aren't maybe playing well and they come back—they're down two sets to love and they have the resolve to come back and can go on and on.*

Source: <www.topendsports.com/testing/fittest-sport.htm>

Learning experience

TENNIS PLAYERS. THE BEST ATHLETES IN THE WORLD?

1. To which qualities is Sampras referring when he talks about tennis players as the 'best athletes'?
2. Do you agree with the statement made by tennis legend Pete Sampras? Why/Why not? Recommend who you think are the best athletes in the world and justify your opinion with research.

Learning experience

YOUR FAVOURITE ELITE SPORTS STAR?

Conduct some research into your favourite sports star and outline what it is that makes them outstanding in their field. Consider their physiology, mental attitude or superior tactical ability. Report back to the class by:

1. posting your findings in a 'forum' set up by your teacher on the school's network, or
2. sharing your findings in a class discussion.

Learning experience

THE FITTEST OF THE FIT

Procedure

During one 50-minute class, participate in the following ironman/ironwoman test circuit:

- 50 m sprint
- maximum push-ups in 30 seconds
- standing long jump
- 1600 m run
- sit and reach
- grip strength
- 5-0-5 agility.

Scoring

Count the number of students in the class doing the test. This number is the top score for each test. The next best performance is allocated one less point, and so on, so that last place in each test gets one point.

On completion of the seven tests in the circuit, total your points to arrive at a final score.

Questions

1. Who achieved the best three scores, and what sporting activities do they perform in or out of school?
2. Is there any relationship between how participants perform on the class 'iron circuit' and other activities in which they participate?
3. Are there any gender differences in performances on any of the tests?
4. Did anyone in the class achieve the best score in each test? Why would this be hard to achieve?
5. Why are events such as the heptathlon and decathlon hard to train for?
6. Could the order of the tests be changed to minimise fatigue? If so, in which order would you place them?
7. Which fitness component does each test measure?

Learning experience

COMPONENTS OF FITNESS

Play a game of touch in which one team (or two players) is only allowed to run in straight lines in attack and defence (or both teams in defence only).

1. Analyse and evaluate the importance of agility in touch (personally and for implementation of game strategies as a team) using specific game references.

   Variation: one team (or two players) has to jog in attack in certain parts of the field; the players cannot sprint.
2. Analyse and evaluate the importance of speed/aerobic energy system for touch using specific game references.

Learning experience

ENERGY SYSTEMS

Tasks

- Play a game of touch, wearing heart-rate monitors.
- Upload and analyse the data for the relevant energy systems and fitness components that are used most often and the intensity at which the game is played.
- Design a training session to replicate the game, based on the data collected.
- Participate in the training session wearing heart-rate monitors.
- Upload and analyse data for the relevant energy systems and fitness components that are used most often and their intensity during the session.
- Compare and evaluate the effect of the training session in game preparation.
- Recommend and justify change if necessary.

Note: This task can be done individually or in groups. The teacher may wish to provide a generic touch training session for implementation and analysis at this stage of learning.

Chapter review

Fitness

Know	1	Collect a range of images from the newspaper, magazines and the internet and organise them into a collage of who you think represents good levels of health and fitness and poor levels of health and fitness. Discuss your choices with a classmate. Consider whether they represent the psychological, physical or social benefits of being healthy (see figure 12.2).
Comprehend	2	Use the collage you have created in task 1 to identify the main fitness components and energy systems that are dominant or not dominant in each activity/image.
Apply	3	Conduct a **SWOT** analysis based on your experiences and understanding of the concepts of fitness testing. Consider the **S**trengths, **W**eaknesses, **O**pportunities and **T**hreats that an individual, team or group could experience as a result of being tested and their results analysed.

Analyse
Evaluate
Synthesise

4 Design your own sport-specific fitness test. Work in pairs.

Aim

To design a sport-specific fitness test for the physical activity you are currently participating in (work with a partner). Consider the fitness components and energy requirements of the physical activity and what makes a valid, reliable and accurate fitness test.

Use the format as set out below:

- test name
- target fitness component
- target energy system
- procedure
- equipment
- subjects.

Give the test to another pair of students in your class to implement. Ask them to give feedback on whether the test:

- targeted the identified fitness component
- targeted the identified energy system (duration and intensity)
- was easy to follow and implement.

Question

Answer individually.

Using the feedback from your test subjects and your own observations, evaluate how effective the test was in achieving your purpose and recommend any modifications to enhance the design specificity of the test.

Games analysis

Chapter 13

What is games analysis?

Games analysis refers to the collection of relevant data or details of performance and is useful for both the athlete and the coach. It is the next step in designing an appropriate training program and can provide a thorough analysis of the physical requirements of a particular sport. Games analysis, also referred to as notational or performance analysis, shows a coach what is required of players during performance. This information can then be used to improve both individual and team play. Games analysis provides the essential link between game performance and practice by giving the coach the necessary detail to establish valid practice sessions.

Methods of games analysis

There are three possible methods of games analysis:

- observation
- observation plus statistical recording
- video evidence plus statistical recording.

Observation

The coach, selection committee or trainers make decisions about game demands, performance and training on the basis of their own biased views. This is the least reliable method of games analysis, as it is highly subjective and has no statistical support. Players who are 'dropped' or 'benched' may feel cheated, as there is no evidence of poor performance.

Observation and statistical recording

With this method, a panel of statisticians can directly record vital game proceedings as they happen. This is a better method of analysis than observation alone, because it gives the coach and training committee a databank of hard evidence on which to base training or game decisions.

Games analysis is a method of gathering data about the performance of an individual athlete or team to identify areas of strength and weakness and target training to ensure it is effective.

Video evidence and statistical recording

This is the most accurate method of games or player/athlete analysis. It allows the viewer to 'freeze' the play, replay it at a later stage and analyse data about the critical elements of the performance using performance-analysis software. Video evidence, particularly when linked with performance-analysis software, is a precise, accurate and objective method of collecting data about individual or team performance across a range of parameters that can be decided by the coach or athlete.

The advantage of video evidence is that it can provide immediate feedback or can be viewed later for more comprehensive analysis. The results can be stored for comparisons and evidence of improvement or change as the competition phase progresses. This information can then be used to modify training, thus making the athlete more finely tuned, or training more effective to increase the competitive edge. For teams, the video evidence and performance analysis can be used to reveal issues concerning field position and decision making or even opposition strengths, weaknesses or tactics.

At the elite level, there are some very sophisticated systems of sports performance analysis available, including software and portable tracking devices (e.g. GPS, high-speed video and accelerometers). Due to the declining costs of technology (laptops, digital cameras and software), performance analysis is now easier and more accessible across a wide range of sports and levels. For example, approximately $500 will provide a school with performance-analysis software to use with their sporting teams. At the very least, schools all have digital cameras, televisions and computers to use.

To undertake a comprehensive analysis requires a clear understanding of the critical elements or performance indicators that should be analysed for an individual or team. Indicators include tactical indicators (such as patterns of play) and physiological indicators (such as intensity profiles).

Figure 13.1
A cricketer undergoes skill analysis of his bowling action

As there are many factors that can impact on performance and the outcome of the game (critical elements), the coach must often decide which aspects of the game or performance will provide them and their athletes with the most valuable information and thus focus the analysis on these aspects. Basically, the data that is collected, and therefore the quality of the feedback for the coach or athlete, is only as good as the parameters that are set.

To conduct an individual player analysis, the camera must be focused on that individual during the entire game. If the focus is on the ball, the player being analysed may be out of view. The analysis would then be invalid.

Any game can be analysed in four areas:

- skill analysis—individual
- skill analysis—team
- fitness analysis
- decision-making analysis.

Learning experience

SPORTING ANALYSIS AND THE MODERN AGE

The terms 'performance analysis', 'games analysis' and 'notational analysis' all relate to the study and analysis of physical performance using critical elements of the game, whether that be movement patterns, skills or decision making. There is an increasing number of performance software that the coach or athlete can use to help with this analysis process. Due to lowering costs and a competitive market, this type of technology is not just for the elite athlete and teams.

Task

1. Research the range of performance software and technology that is available to assist with the process of performance or games analysis.
2. Select the products/systems/technologies that you think would be suitable for school and personal use. To assist with the selection process, you may wish to use one of these organising strategies:
   - SWOT (Strengths, Weaknesses, Opportunities or Threats)
   - PMI (Plus, Minus, Interesting)
   - decision-making matrix (this is useful when having to narrow a decision to a few choices).
3. Present your selections to the class outlining:
   - **a** what you selected
   - **b** why you selected it (reasoning, e.g. cost, ease of use, range of options, applicable to a range of sports)
   - **c** how it can be used to improve your own performance during your studies in Physical Education or in your own sport.

Developing the critical elements

In 1984 Franks and Goodman suggested a simple series of steps that can help the coach identify the critical elements they want to focus on as part of the games analysis. These are outlined below.

1 Describe your sport from a general level to a specific focus.
2 Prioritise key factors of performance. (These will form the basis of the analysis and ultimately can be simplified to what you want to know.)
3 Devise a recording method that is efficient and easy to use. (If you are lucky enough to have performance software, all that is required is the loading of the information into the program.)

Franks and Hughes (2004) have also analysed the various categories of games (net and wall, invasion and striking/fielding games). We know them as direct or indirect interceptive activities.

Below are the three categories of games and the factors that Franks and Hughes believe contribute to success or improve performance (see figure 13.2). This information may be useful for the coach when trying to decide what critical elements or performance indicators should be monitored as part of the games analysis and improvement in performance.

a Net or wall games

b Invasion games

c Striking or fielding games

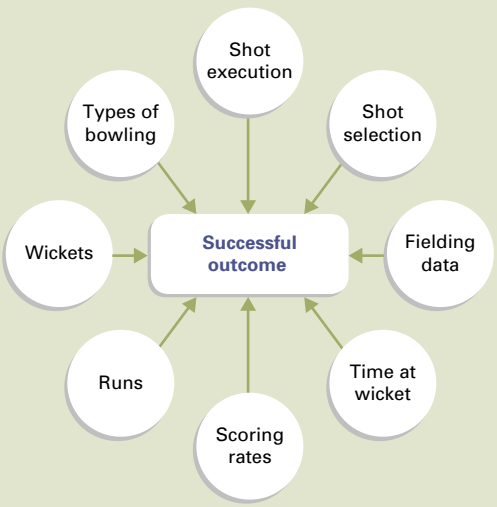


Figure 13.2a–c
The three concept maps of factors that contribute to success or improved performance

Learning experience

GAME ANALYSIS

It is understood that game and performance analysis provides the athlete and coach with valuable information on skills, strategies, tactical awareness and decision making.

Tasks

Consider the advice from Franks and Hughes on the process of developing the critical elements for games analysis and complete the 3-step process for the physical activity you are currently studying:

1. Describe your sport from a general level to a specific focus.
2. Prioritise key factors of performance. (What do you want to know?)
3. Devise a recording method that is efficient and easy to use. If you have access to performance-analysis software through your school, set up the data as per your particular program and the key factors (critical elements) you have identified.
4. Use some video footage of your class's participation in the physical activity and test the effectiveness of your recording method (e.g. ease of use, relevance of the key elements identified to the physical activity, validity of the data collected, etc.).

Research report

Evaluate the effectiveness of the games-analysis process you undertook to identify and record the critical elements of the physical activity you are currently studying. Use specific examples from your research to provide discerning and convincing justification of your evaluations.

SNAPSHOT

What time and motion analysis revealed about basketball training in drills, 5-on-5 and competition

Male players from the Australian Institute of Sport (AIS) Basketball Program participated in a study to identify the physical and physiological impacts of different training and competition scenarios. Advances in technology allowed accurate time and motion analysis to be conducted and the impact of the various training and competition scenarios to be immediately available. This was achieved by the use of heart-rate monitors and accelerometers, with the latter recording movement patterns in three planes so that the impact of jumping could be recorded. In other time and motion studies global positioning systems have been used to track player movement, but this is problematic for indoor sports such as basketball.

Previous studies of basketball show the following:

- It is intermittent and of variable intensity.
- Players cover several kilometres in a game. (*Note*: Considering that the court is 28 m by 15 m, this is a lot of up, back and sideways movement.)
- The average heart rates are approximately 171 bpm or 91% of MHR. (This puts the athlete into training zone 4–5.)
- 75% of the playing time is spent at 85% of MHR.
- Blood lactate levels reach approximately 7 mmol/L (≤4 mmol/L is considered aerobic).

>>

What do these factors reveal? Basketball is a highly anaerobic game and training should consider these factors to ensure it is specific in terms of intensity.

Utilising the wearable technology can actually inform the coach if the drills or a modified game (5-on-5 in a third of the court) are effective in targeting the intensity required. The study revealed that:

- the training drills caused a training effect due to intensity and duration
- defensive drills were more physically demanding, possibly due to the need to react to the offence and work hard to stay in defensive position
- 5-on-5 did not provide the required intensity to mirror game demands but it was effective in targeting the tactical elements of the game.

Source: information adapted from Montgomery, PG, Pyne, DB, Minahan, CL, 'The physical and physiological demands during basketball training and competitions: observation from wearable sensor data', research project, Australian Institute of Sport, 2010

Learning experience

ORAL REPORT: TIME AND MOTION ANALYSIS IN ELITE BASKETBALL PLAYERS

You have read the snapshot 'What time and motion analysis revealed about basketball training in drills, 5-on-5 and competition'.

Task

1. As a coach decide how you could modify the parameters of the 5-on-5 game so that the desired intensities were attained and training of the tactical and decision-making elements of the game were met.
2. Justify your recommendations with discerning and convincing examples and research based on your understanding of energy production, fitness, training principles and training methods.
3. Present your recommendations to the class in small groups, with appropriate visuals and commentary.
4. Hand in a written version of your oral report with correct bibliography and referencing details (i.e. use the Harvard system).

Skill analysis: individual

Skill analysis is used to determine how often and how effectively a player uses a particular skill. To gain this information, the coach or statistician must list the basic possession and disposal skills of the sport and then record both individual and team usage of each skill. Data can be presented to the individual athlete in three ways:

- relative to opponent's data
- relative to players of own standard
- relative to own profiles of previous performance.

Statistics sheets

Basic information (e.g. the information that would be recorded in the statistics sheet for soccer skills in figure 13.3) can be used to highlight skill deficiencies of beginners. For example, if a player shows nothing in the 'Head' column (which is common among young soccer players), training sessions must emphasise heading practice to build skill and confidence.

Figure 13.3 Statistics sheet for basic soccer skills

Player	Disposal skill				
	Inside foot	Outside foot	Heel	Laces	Head

Figure 13.4 Heading the ball in soccer is one of the disposal skills.

Learning experience

HEADING THE BALL IN SOCCER

Carry out the research in pairs.

1. Why is it common for young soccer players not to head the ball?
2. What are the teaching points that you would use to help a young player to develop the skill of heading the ball?
3. What is a drill that you could implement to develop a young player's ability to head the ball?
4. Teach the drill to another pair of students and video the session. Swap roles with the other pair so they also get to teach and video.
5. Review the training sessions and comment on how successful the drills were in teaching the skill. Outline any modifications you would make.

The statistics sheets shown in figures 13.5 and 13.6 give a more detailed picture of a player's performance. For example, a blank in the 'Dribble' column may indicate that this player never runs with the ball and therefore requires specific drills during training to rectify the problem.

Figure 13.5 Statistics sheet for hockey skills

Player	Possession skills				Disposal skills					
	Dribble	Free hits	Traps	Tackles	Push		Drive		Shots at goal	
					Effective	Ineffective	Effective	Ineffective	Effective	Ineffective

Figure 13.6 Statistics sheet for basketball skills

Player	
Possession skills	
Passes received	
Dribble steals	
Pass interceptions	
Rebounds	
Disposal skills	
Chest pass	Effective
	Ineffective
Overhead pass	Effective
	Ineffective

(continued)

Player	
Disposal skills (continued)	
Bounce pass	Effective
	Ineffective
Overarm pass	Effective
	Ineffective
Set shot	Effective
	Ineffective
Lay-up	Effective
	Ineffective
Jump shot	Effective
	Ineffective
Dribble	Effective
	Ineffective

Learning experience

SUITABLE DRILL FOR A SELECTED SKILL

Work in pairs.

1. Select one of the skills from the hockey or basketball statistics sheets in figures 13.5 or 13.6.
2. Conduct some research and develop a drill training session that could be implemented for this specific skill.
3. In small groups conduct the drill training session for your classmates.
4. Video the teaching and evaluate if the drill was effective in terms of:
   - **a** improving skill level
   - **b** the sport of hockey or basketball (i.e. whether it was specific)
   - **c** physical activity levels of the group (i.e. whether they have received any training benefit from participating in the session).
5. Of all the drill training sessions you participated in, which was the most effective and why?

Effective and ineffective disposals

The skills sheets in figures 13.7 and 13.8 incorporate the concept of effective disposals (the team kept possession) and ineffective disposals (the team lost possession). This information is most important, as the statistics in figure 13.7 show. In this example, both Amezdroz and Sargent had 19 disposals.

However, 12 of Sargent's disposals went to the opposition, whereas only 5 of Amezdroz's disposals did so. This shows the coach that Sargent, and possibly others in the team, need practice in disposal drills while under pressure. This will help to overcome the tendency to make forced errors.

Figure 13.7 Effectiveness of disposal skills under game conditions

Player	Disposals under pressure		Disposals not under pressure		Total
	To Snakes	To Opposition	To Snakes	To Opposition	
Dickens	|||||	|||	||||	|	13
Sargent	|||||	||||||||||	||		19
Egan	||||	|||||	||||||	|||	18
Amezdroz	|||||||||	||||	||||	|	19
Chang	||||	||||	||||||	|||	17
Lucas	||	|||	||||	|	10
Davis, D	||||||	|||||	||||||||	|||	22
Kostos	||	|||	|||||	||	12
Davis, L	|||||||	|||	||||||	||	18

Forced and unforced errors

An unforced error is one in which there is a breakdown in skill technique alone, whereas a forced error is one in which the player is not given an adequate period of time, by opponents or teammates, to complete the skill.

If there is a fault in technique, correct practice may remedy it. However, to remedy a forced error, the coach can set up a practice drill that initially involves little game-type pressure on the player and then gradually changes to a realistic, intensive practice followed by a small game.

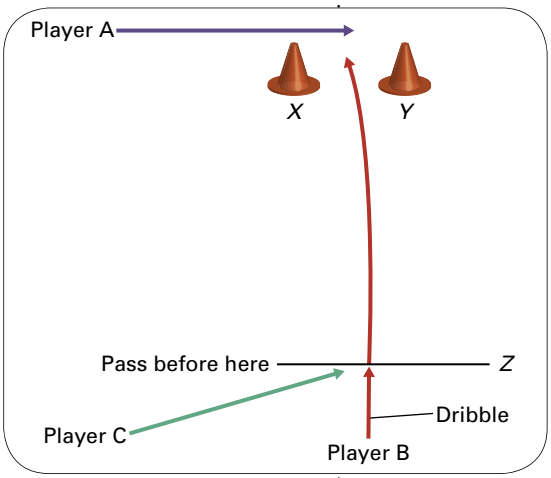


Figure 13.8
A disposal skill

An example of this process is shown in figure 13.8. The requirement of the task is for player B to dribble in and pass the ball before crossing the restraining line at Z. The ball must be passed to player A, who should receive it between the markers X and Y. The design of this drill enables different demands to be made on player B, as outlined below—demands that will assist the player to gradually develop the skill to meet the game conditions.

- Phase 1: the task is as described earlier—the time constraint is the running speed of player A.
- Phase 2: an opponent C is stationed to the side and makes a controlled attempt to 'stop' player B.
- Phase 3: opponent C is now situated in a position where they can place player B under game-type constraints and consequences.

Learning experience

DISPOSAL DRILL PRACTICE

1. In small groups implement the disposal drill described above (phases 1, 2 and 3).
2. Which was more challenging (complex/open)?
3. Was the drill effective in practising disposal skills?
4. For which sports would this drill be suitable?
5. How could you modify this so it still focused on disposal skills but became more game-like and had a physical-training effect on the participants?
6. Implement the modification of the disposal drill and evaluate how effective it was at:
   a. targeting disposal skills
   b. having a training effect on the participants.

Strengths and weaknesses

In the skills statistics sheet in figure 13.6, the coach can measure the effectiveness of the players when performing specific skills. However, other problems may also be identified. For example, a player may receive a high number of passes, yet give few passes. The same player might also make a larger number of shots, often ineffectively. Such a player is often classified as 'hungry' or 'has eyes only for the goal'. The coach must give such players offensive drills that involve passing to players in open positions, in an attempt to break them of the 'hungry' habit.

Skills analysis is not just used to identify weaknesses. For example, the statistics may show that a rugby player always disposes of the ball to a teammate or that a basketballer never misses a lay-up. The coach should use this information to develop drills that give this player more possessions so that their skill can be used more effectively.

Skills analysis: team

Skills analysis of a team is the gathering of information about team tactical play and style, e.g. about the effectiveness of different defensive or offensive patterns. Several sporting examples highlight the importance of team analysis.

Hockey

In hockey, a push is a far more effective means of passing the ball and maintaining possession than driving (see figure 13.9). Possession is maintained 90% of the time when the ball is pushed, compared to a miserable 32% when the ball is driven. This explains the emphasis in modern hockey on running play with frequent pushes. Coaches must develop push drills so that players can be proficient on both sides of the body.

Figure 13.9 Effectiveness of disposals in hockey

Disposal skill	No. of disposals	No. of shots at goal	No. effective	No. ineffective	No. ineffective and regained	% Effective
Drive	56	10	14	27	4	32
Push	30	—	27	3	0	90

Learning experience

PUSH DRILLS FOR HOCKEY

1. Conduct some research and suggest drills or games that could be implemented to develop this skill.
2. What other physical activities could they be used for?
3. If appropriate, implement the drills in small groups for the physical activity you are currently studying.
4. Were they effective?

Australian Rules football

An example of team analysis in Australian Rules football is shown in figure 13.10. Here the statistics show the possession patterns of two teams during a match. The team that controlled the ball lost the match. The coach should use this information to change the offensive pattern, probably from a short pass handball attacking strategy to long, penetrating kicks deep into the forward line.

Figure 13.10 Number of team possessions in an Australian Rules match

Team	Kicks	Marks	Handball	Total possessions	Total points	Scoring shots
Collingwood	200	40	75	315	85	28
Lions	205	64	112	381	70	29

Learning experience

OFFENSIVE STRATEGIES FOR AUSTRALIAN RULES FOOTBALL

1. Conduct some research and suggest drills or games that could be implemented to develop this skill.
2. What other sports could they be used for?
3. If appropriate, implement the drills in small groups for the physical activity you are currently studying.
4. Were they effective?

Soccer

In soccer, players have a number of different options for passing the ball. However, as figure 13.11 shows, a team is far more likely to keep possession of the ball if players use inside-of-foot passes. These passes must be drilled in training so that players become very capable with both feet and can make this type of pass an integral part of team play.

Figure 13.11 Effectiveness of disposals in a soccer match

Disposal method	No. of disposals	No. of effective disposals	No. of ineffective disposals
Inside of foot	410	380	30
Laces	154	94	60
Outside of foot	65	50	15
Heel	15	8	7
Head	217	162	55

Learning experience

INSIDE-OF-FOOT PASS FOR SOCCER

1. Conduct some research and suggest drills or games that could be implemented to develop this skill for both feet.
2. What other sports could they be used for?
3. If appropriate, implement the drills in small groups for the physical activity you are currently studying.
4. Were they effective?

Volleyball

In volleyball, the type of spike used in attack will often determine whether or not a team can win the point. Figure 13.12 shows that, for the team being analysed, a fast attack consisting of half and short spikes is more effective than high normal balls set to the front corner spikers.

The coach can now direct the setters and spikers to use only fast balls. Later in training, the team should practise spiking high normal balls to improve their effectiveness when corner spiking.

Figure 13.12 Volleyball attack statistics

Type of spike	No. effective	No. ineffective
Normal (right corner)	9	7
Normal (left corner)	10	9
Half (right)	12	2
Half (left)	11	1
Short (centre)	7	0

Learning experience

CORNER SPIKING FOR VOLLEYBALL

1 Conduct some research and suggest drills or games that could be implemented to develop this skill.
2 If appropriate implement the drills in small groups.
3 Were they effective?

Decision-making analysis

In sport, most games analysis focuses on fitness and skill. However, at high levels of performance, errors are often not the result of lack of fitness or skill, but of poor decision making, i.e. the player chooses the wrong response to a situation.

These wrong decisions can be made when a player is in possession of the ball or not in possession. For example, a player might dribble the ball when they should have passed it, or make an angled shot at goal when the ball should have been centred, or run deep into attack to receive a pass when they should have run out wide.

Learning experience

MY DECISIONS?

1 Consider your own performance in recent games and list the decision-making errors you have made during performances (drill or game play).
It may be necessary to watch class footage of practice sessions (drills and game play) or seek feedback from peers, teacher or statistical analysis you may already have conducted.
2 Select drills that would enhance or alleviate these decision-making errors.
3 If appropriate, teach the drills to a small group, and evaluate how successful they were in terms of:
   a the relevant skills of the game
   b the decision-making area you were targeting
   c the training effect the drill had on the players (e.g. heart rate increases).
   Your teacher may video these sessions for feedback.

Studying video evidence

The best technique for analysing decision making is by studying video evidence as it can be 'frozen'. Both the coach and player can then study the alternatives available and the final decision that was made. If the decision was incorrect, the correct alternative can be pointed out.

During a game that demands constant, high-speed, complex decision making, a coach can help players by drilling them in the basic principles of play. If players stick to these principles, they have fewer alternatives to worry about. For example, principles such as 'Never play the ball towards the goal mouth when in defence' or 'Play the ball square out of defence' or 'Lob

when you are caught out of position' all help the player to make the correct decisions.

At training, a coach can reinforce these principles and demonstrate correct decisions by 'freezing' the players on a given signal and then studying their positions and the possible outcomes. The coach must be keenly aware of the key principles of the sport and use small-side or small-area practices to drill the principles into the players.

Learning experience

PRACTICE GAME ANALYSIS: PERFORMANCE

As part of the learning experiences for the physical activity currently being studied, you may have participated in the following where appropriate:

- complex drill
- modified game (e.g. 2-on-2)
- full game.

Task

1. Video and review footage for each learning experience. (This may be conducted as a class activity.)
2. For each scenario record:
   - the decisions made (e.g. touch-pass, not pass)
   - the outcome of the decisions (e.g. successful or unsuccessful, or touch-try scored or not scored).
3. Design a drill or modified game that addresses the most common error you noticed from the video footage.
4. Implement and video the drill or modified game with a small group and evaluate how effective it was in addressing your objective.

Mental sets

In every team there are some players who find rapid decision making difficult. Consider a hockey player who gets possession in the back line. Some of the alternatives the player must choose from are to:

- prop and drive
- prop and push
- dribble and drive
- dribble and push
- draw a defender and pass
- deliver the ball to the nearest wing or down the corridor, or switch to the opposite wing.

While a poor decision maker is processing all this information, they may be tackled by an opponent and lose the ball.

To help a player who has difficulty making decisions, the coach can reduce the number of alternative actions to choose from by giving the player a mental set (i.e. a pre-programmed response), such as 'When you get the ball in the back line, push it to the nearest wing'. Now the player has only one choice of action and should deliver the ball before being tackled.

The coach also informs other players of the mental set so they can react appropriately to the situation, e.g. 'When you see Davo get possession in the back line, lead out to the nearest wing'.

Figure 13.13
A hockey player faced with a series of decisions in a game

Learning experience

WHAT IS YOUR MENTAL SET?

1. List the types of things coaches and teachers have said to you recently that have helped with your decision making during a game or complex drill.
2. Has this type of feedback helped you improve your decision making under game conditions?
3. Give some examples of mental sets you may have established in your own sport (outside of school) based on self-evaluation.

Fitness analysis

To develop an accurate fitness training program you must conduct an individual analysis of a top performer, playing the specific position in which you are interested, during a competitive game.

Once you have completed this analysis, you will know:

- the demands of a competitive game—you can then work out what you need to focus on in training to improve your competition performance
- the energy systems and fitness components your sport requires and the muscle groups used—you can then select training methods to improve specific areas
- the level of fitness, in each component, of a top performer—you can then set training and overload goals for yourself
- the components of fitness that need to be tested to find out your current strengths and weaknesses.

To obtain all this information, your fitness analysis must cover two broad areas:

- energy-system analysis
- additional involvements.

Energy system analysis

The most basic information collected in any fitness analysis is the input of each energy system into the sport. As discussed in chapter 11, the type of energy production in your muscles depends on the duration of the activity, the intensity of the activity and how well developed your oxygen delivery system is. The contributions of the different energy systems are summarised:

- Short high-intensity efforts of less than 10 seconds, such as sprints, require energy from the phosphate anaerobic energy system, and must be followed by adequate rest periods to replenish creatine phosphate (CP) stores.
- Longer intense efforts of about 30 seconds to 2 minutes require energy from the lactic acid anaerobic energy system. Repeated sprints with short rests in between also rely more and more on the lactic acid system as CP stores become depleted.
- Even longer, less intense, continuous activities of 5 minutes or more require aerobic energy. Rest periods after more intense activity also require aerobic energy to rapidly repay the oxygen debt and provide a complete recovery.

In a fitness analysis, several techniques are used to discover the involvement of each energy system. These are:

- analysing activity or movement patterns
- monitoring heart rate
- testing blood lactate levels
- calculating the work-to-rest ratio.

Learning experience

TRAINING

1. Research the energy requirements for the physical activity you are currently studying. (You may have already participated in some fitness testing and energy-system analysis as part of your studies.)
2. Research some training programs that would target the specific energy requirements for this physical activity.
3. Implement a session for an area of fitness in which you are lacking. Wear a heart-rate monitor to observe your intensity levels.
4. Evaluate the session for:
   - the training effect it had on the targeted energy system
   - your enjoyment
   - modifications to the session (e.g. increase or decrease intensity).

Analysing movement patterns

Movement pattern analysis involves charting and recording the on-field movements of players throughout a game. The most basic method is by recording on a chart. This method can be carried out from direct observation at the venue or, more accurately, by using video evidence of the performance and performance-analysis software.

The distances covered by each player are recorded on a scale diagram, and the intensity of each effort is also recorded (see figure 13.14). At the end of the game, quarter or half, the movement patterns from each scale sheet are scored onto a tally sheet (see figure 13.15). At the end of the game, the results from tally sheets are transferred to a summary sheet (see figure 13.16).

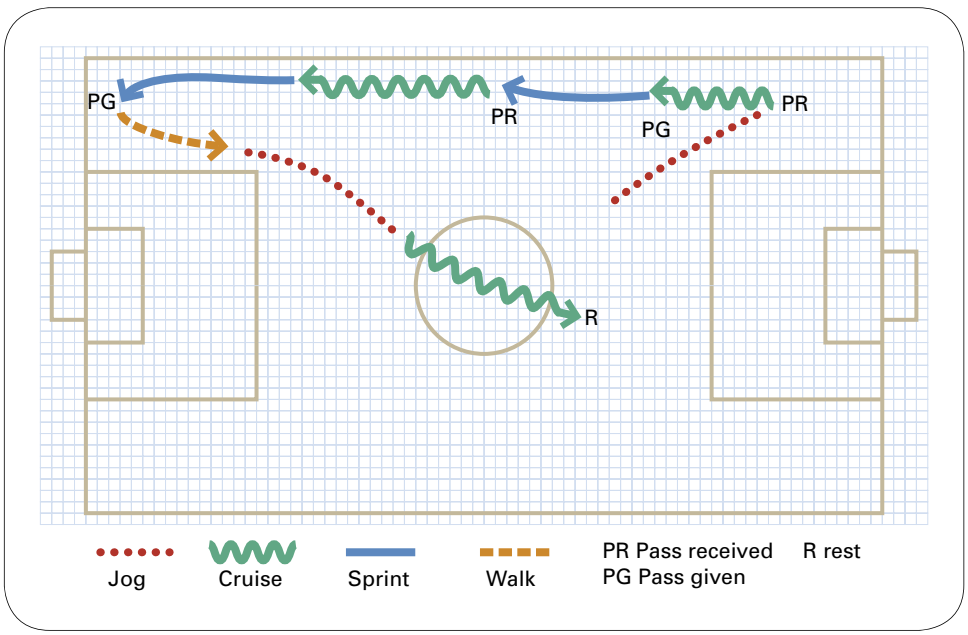


Figure 13.14 Chart showing movement patterns and game involvement of a soccer player

Figure 13.15 A sample tally sheet used to record data about the on-field movements of players

First half					
Intensity	**10 m**	**20 m**	**30 m**	**40 m**	**50 m**
Sprint	|||||| ⑦	||||||||| ⑩	||||| ⑤		||| ③
Cruise		||| ③	|||||||||| ⑫		|||||| ⑦
Jog	||||| ⑤	| ①	|||||| ⑥	||| ③	|||||| ⑥
Walk	||||||||||| ⑫	| ①			

Figure 13.16 Summary sheet showing the movement patterns for a full game of hockey

	0–10	11–30	31+	Total reps	Total distance
Sprint	24	24	4	126	856
Jog	36	92	16	152	2692
Sideways	20	—	—	20	80
Backwards	28	96	—	120	480

The movement patterns along with heart rates can be analysed to show which energy systems are being used:

- If the results show large numbers of short sprints, the phosphate system is the predominant energy system used.
- If the efforts are quite intense but significantly longer, or there is little or no complete rest between each sprint, the lactic acid system is the main one used.
- If the tally sheet shows mostly long efforts with few rests, the activity is almost continuous and the aerobic system will provide most of the energy.

To ensure that an analysis of movement patterns is as accurate as possible, data must be recorded for at least 20 minutes during a game. However, when analyses are completed through observation, there will always be an element of inaccuracy, due to the subjective evaluation of whether a player is jogging, cruising or sprinting, and the skill level of the person doing the charting.

The increasing use of performance-analysis software through computerised coding systems has made it easier to collect, manage and organise video images and enhance game analysis for athletes and teams.

Preparing players for the demands of the game

Using the information gained from the movement pattern analysis, a training program can be designed to duplicate exactly the demands of the game. Below is an example that demonstrates the relationship between movement-pattern analysis, energy-system evaluation and training-program planning.

Movement-pattern analysis in Rugby League

The work required by Rugby League players varies from position to position. Time and motion studies of movement patterns in professional Rugby League games were conducted before and after the defensive-rule change from 5 m to 10 m, and figure 13.17 demonstrates the impact this has had on the intensity levels and distances covered:

- The results revealed that under the 10 m defensive rule the distances covered have increased for forwards and backs, which means that their aerobic demands have increased.
- Periods of high-intensity activity for between 22 and 27 seconds tax both the creatine phosphate and lactic acid systems, and therefore a good aerobic base is necessary to recover from these bouts of high intensity. An increase in work-to-rest ratios could mean a higher intensity of work when actively playing, resulting in the need for longer recovery (Gabbett et al, 2008).

Consider also the limited interchange rule in Rugby League and the impact this would also have on fatigue levels if the players are covering approximately 1–3 km more during a game played at higher intensities.

In conjunction with the information in figure 13.17, the performance analysis will reveal that players are not just involved in running in a straight line. The high-intensity efforts are often done while carrying a ball, sidestepping, running backwards or sliding sideways, falling down, getting up or affecting a tackle. Therefore, straight-line running as a means of training may not be as specific to the game.

Figure 13.17 Distances covered and intensity levels based on 5 m to 10 m defensive rule change in professional Rugby League

Playing position	Defensive role	Total distance covered (m)	Time in high-intensity activity (%)	Work : rest ratio	Longest period of high-intensity activity
Forward	5 m 10 m	6647 9929	0.8% 3.3%	1:6 1:10 (hooker) 1:9 (prop)	* 22 s
Back	5 m 10 m	7336 8458	*	1:8 1:12 (halfback) 1:9 (winger)	* 27 s

* Information not available for comparison

Figure 13.18 The Australian Rugby League team in training

SNAPSHOT

Games-based analysis of sport

A study of professional Rugby League, the modern game

Recent studies conducted by King et al. revealed that at the professional level (ARL) the 'longest periods of high-intensity exercise players endured without recovery was 27, 35 and 22 seconds for the outside backs, adjustables and hit-up forwards respectively'. In that time they also performed, 'striding, sprinting, tackling and lateral movements of up to 25 seconds with rest periods where the players stood, jogged or walked for a short time (sometimes for as little as 2–3 seconds) before repeating a high-intensity effort lasting from 10 to 20 seconds'. Many of these repeated bouts of high-intensity effort were at critical stages of the game where players were either defending their try-line or attempting to score against the opposition.

Source: King, T, Jenkins, D, Gabbett, T, et al. 'Repeated high-intensity efforts in professional rugby league football' [abstract], Australian Institute of Sport Team Sport Conference, oral presentation, 21–22 June 2006, Canberra (ACT) cited in Gabbett, T et al. *Applied physiology of rugby league*, p. 129

Learning experience

RUGBY LEAGUE FITNESS TESTING AND TRAINING DRILL/GAME

Based on the excerpt of the study conducted into professional Rugby League by King and co-workers, complete the following, working in pairs.

1. List the main points relevant to the fitness components, energy systems and movement patterns.
2. Design a fitness test that would incorporate the relevant elements you have identified.
   Note: Do not include any tackling or heavy contact in your test drill/game, as this requires very specific safety precautions.
3. Design a training drill or game that would prepare the Rugby League player for this type of performance.
4. Compare your fitness test and training drill or game designs with those of a classmate and evaluate the effectiveness of each.
5. What difficulties did you encounter when trying to plan the fitness test or training drill game?
6. With your partner, write a brief report and upload it to your school's network as part of a class forum.

SNAPSHOT

Motion detectors assist monitoring heart rate

There are two kinds of heart-rate monitor:

- Basic monitors give a constant readout to the player, who must call out the heart rate to a recorder every 30 or 60 seconds.
- More sophisticated monitors store the information for retrieval after the game.

Heart rate can be used as an indicator of energy-system demands:

- Heart rates greater than 85% of maximum indicate anaerobic work.
- Heart rates in the range 70–85% of maximum indicate aerobic work.
- Heart rates below 70% of maximum indicate recovery.

For a 20-year-old player with a maximum heart rate of 200 beats per minute, a heart rate of 170+ would indicate anaerobic work, 140–170 would indicate aerobic work, and less than 140 would indicate recovery.

Testing blood lactate levels

The blood lactate method of assessing intensity of work is more costly and less practical than monitoring heart rate. For this method, a small blood sample is taken from the player's ear lobe during training or during a game, and the level of the lactic acid in the sample measured.

The blood level of lactic acid indicates the intensity of the work just completed. A blood lactic acid concentration of >4 mmol/L indicates high-intensity work (training zone 3–5); <4 mmol/L indicates aerobic work (training zone 1–2). See chapter 14 for an explanation of the training zones.

Calculating the work-to-rest ratio

The work-to-rest ratio refers to the amount of time a player is active (working) compared to the amount of time they are resting (recovering). These ratios are

most applicable to intermittent team sports such as touch, basketball, hockey (see figure 13.19), netball, soccer, football or volleyball.

Work-to-rest ratios are calculated using stopwatches to time each work period and rest period. Work periods and rest periods are totalled, and the two totals compared.

Figure 13.19 Work-to-rest results observed during a hockey match

Work	Rest
2 seconds	3 seconds
9 seconds	16 seconds
4 seconds	25 seconds
12 seconds	34 seconds
19 seconds	45 seconds
The above work-to-rest intervals are random samples from the total number of intervals.	
Total work	**Total rest**
8 minutes	17 minutes
1	2
Work-to-rest ratio is approximately 1:2.	

It is vital to clearly define 'work' and 'rest' before you begin a fitness analysis. For example, work may be defined as activities of intensity greater than jogging, such as cruising or sprinting; rest might include standing, walking or jogging.

If, during a 20-minute half, a player is working for 5 minutes and resting for 15 minutes, the work-to-rest ratio is 1:3. This ratio is common in team sports—with time-outs, injuries, ball out of play and other delays, players on average rest or recover for three times as long as they work.

The work-to-rest ratio is crucial in the analysis of energy-system usage:

- Ratios of 1:3 and 1:5, where the average work time is short, indicate use of the phosphate system, which will recover during most rest periods.
- Ratios of 1:1 or 2:1 indicate either lactic acid involvement or aerobic requirements, depending on the length of the work intervals and the intensity of effort.

Once you have calculated the work-to-rest ratio for your sport, this ratio must be incorporated into your training program. You must become used to the length of work intervals and take rest intervals only in accordance with the work-to-rest ratio that applies during a match.

An analysis of soccer

The Australian Institute of Sport conducted a study into the energy system demands of men's and women's soccer matches compared to soccer training sessions. Three players were studied:

- player A, a centre-half
- player B, a midfield
- player C, a forward.

Figure 13.20 shows the average heart rate for each player during both training and playing in a match. Notice that the work during the match is very intense and that the drills in training do not duplicate the intensity required during the game.

Figure 13.20 Average heart rates of three soccer players during a match and during training

Match/Training	Average heart rate (beats per minute)		
	Player A	Player B	Player C
Match	185	172	159
First half	192	172	155
Second half	177	171	162
Drills	150	155	124
Small-side game	170	167	161
Maximum heart rate	202	200	189

To remedy this, players supplement training with short-interval sprint sessions, using a work-to-rest ratio of 1:3. These sessions are designed to cover the sprint distances measured during the game (see figure 13.21), each distance being between 10 m and a maximum of 50 m. These intervals also include backwards and sideways running, because these are an integral part of the game (see figure 13.21).

Figure 13.21 Distances (in metres) covered by soccer player A

	Sprinting	Striding	Jogging	Walking	Backwards	Sideways	Total
Match							
First half	496	1017	2593	1060	618	277	6061
Second half	576	988	1846	1341	728	401	5880
Total	1072	2005	4439	2401	1346	678	11 491
Training							
Drills	0	298	882	808	681	148	2817
Small-side game	534	1108	2030	1166	591	361	5790
Total	534	1406	2912	1974	1272	509	8607

The results of the analysis show that soccer requires:

- a well-developed aerobic capacity, since large distances are covered
- an excellent phosphate system for the frequent short sprints.

These results are reinforced by studies of blood lactic acid levels during practice matches, which have shown minimal lactic acid accumulation.

Learning experience

PRACTICE GAMES ANALYSIS: PHYSICAL INTENSITY

Procedure

1 Participate in a team game organised by your teacher, in a direct or indirect interceptive sport such as touch, indoor soccer, netball, indoor hockey or volleyball.
2 Video the game, focusing on one player in each half. The player must wear a heart-rate monitor.
3 After the game, use this video to conduct a games analysis. Different members of the class will be assigned to record specific analysis tasks, as follows:
   - **a** work times
   - **b** rest times
   - **c** movement patterns
   - **d** heart rates
   - **e** frequency of skill use
   - **f** direction changes
   - **g** jumps, rebounds and leaps
   - **h** stretches or lunges involving various body parts
   - **i** contacts, bumps, collisions or tackles involving various body parts.

Results

1 Collate your information and then share your results with the group. Compile a complete set of games-analysis results.
2 Make tables of the following data:
   - **a** random work-to-rest intervals
   - **b** total work and total rest with work-to-rest ratios
   - **c** movement-pattern results/tally sheet
   - **d** heart rates
   - **e** additional involvements, with columns listing
     - the types of additional involvements
     - their frequency
     - fitness components involved
     - body parts or muscle groups involved
     - type of muscle contraction involved.

Discussion and conclusions

1 Participate in a class discussion about the difficulties people faced in completing each task.
2 Use your results to discuss the following topics:
   - **a** Energy-system usage in the particular sport

   Support your discussion with references to movement patterns, work-to-rest ratios and/or heart rates.
   - **b** The other fitness components required by this sport, as shown by the additional involvement results

   Support your discussion with references to the statistics you collected on:
     - skill frequency
     - jumps
     - direction changes
     - stretches
     - contacts.

Additional involvements

So far, we have looked at fitness analysis that allows us to draw conclusions only about the involvement of each energy system in particular sports (i.e. movement patterns, heart rates and work-to-rest ratios). However, to discover which other fitness components are required for a sport, statistics need to be compiled on all the essential physical actions in a game. These are called 'additional involvements'.

Examples of additional involvements include:

- *direction changes:* if performed quickly, changes of total body position, from lying to standing, or other changes greater than 90°, indicate a need for agility
- *stretches or lunges:* such actions require large ranges of movement in joints and indicate a need for flexibility
- *contacts:* collisions between players, whether deliberate or accidental, show a need for strength and power to maintain body position and prevent injury
- *skill frequency:* the type of skill performed and how often it is used indicate the requirements for specific fitness components, e.g. frequent passing, hitting or kicking might indicate a need for local muscular endurance or power according to the speed of execution
- *jumps:* explosive take-offs indicate a need for leg and hip power to reach maximum height.

As a result of additional involvement analysis, you should be able to draw up a table similar to figure 13.22, which records features such as:

- each additional involvement
- its frequency of use
- the fitness component it requires
- the muscle groups used
- the type of contraction performed.

Figure 13.22 Analysis of the additional involvements in hockey

Additional involvements	Frequency	Fitness	Body part	Muscle group	Type of contraction
Jumps	4	Power	Legs	Quadriceps, gluteals, calves	Concentric
Drives/hits	20	Power	Whole body	Quadriceps, gluteals, calves, triceps, wrist flexors	Concentric
Contacts					
Shoulder	40	Strength	Shoulder	Pectorals, lats, deltoids	Isometric
Hip	40	Strength	Hips	Hip flexors, gluteals	Isometric
Leg	12	Strength	Legs	Quadriceps, calves	Isometric
Stretches					
Leg	16	Flexibility	Legs	Hamstrings, calves	—
Trunk	76	Flexibility	Lower back	Erector spinnae	—
Arm	32	Flexibility	Arms	Pectorals, rotator cuff, deltoids, biceps	—
Direction changes: more than 90°	196	Agility	Legs	Quadriceps, adductors, gluteals, calves	Eccentric/ concentric

Additional involvements in Australian Rules football

In Australian Rules football, essential physical actions other than running include kicking, handball, punching, marking, tackling, bumping and jumping. As figure 13.23 shows, midfield player B in the example sustains 85 body contacts per game from either tackles or bumps. This suggests that the player will find it difficult to avoid injury and remain effective unless, during training, strength training is combined with suitable flexibility work for the appropriate body parts. The ruckman makes 48 jumps per game and therefore needs to develop leg power, hip power and endurance to outjump the opponent.

Figure 13.23 Additional involvements in a game of Australian Rules football

Player and position	Tackles	Bumps		Jumps	Chases
		Hit ground	Hit opponent		
Centre half-back	3	35	11	25	1
Full forward	3	44	17	21	7
Midfield A	14	52	15	10	8
Wing	3	9	7	16	7
Ruck	5	54	9	48	13
Midfield B	17	44	24	11	23

Additional involvements in volleyball

In volleyball studies, analysis of the additional involvements highlights the key fitness components that must be developed during training. For example, in figure 13.24, it can be seen that spikers (hitters) make between 13 and 20 jumps in each set, either to spike or block. In a best-of-three or best-of-five set match, this represents a huge workload for the hip and leg region. Therefore jump training to develop the necessary power and the local endurance in the required muscles must become an essential part of volleyball training.

Figure 13.24 Number of additional involvements for members of a volleyball team during one set

Players	Dig	Set	Spike	Block	Total contacts	Total jumps
Setters						
S1	6	23	—	11	33	15
S2	6	19	1	7	34	11
Hitters						
H1	9	1	7	6	16	14
H2	8	2	13	7	23	21
H3	4	1	9	7	15	18

(continued)

Players	Dig	Set	Spike	Block	Total contacts	Total jumps
Blockers						
B1	7	3	7	13	17	24
B2	6	1	7	18	14	29
B3	8	1	4	15	14	24

Figure 13.25 shows that volleyball players make between 286 and 510 direction changes per match or 3.5–4 per rally. Knowledge of these additional involvements, combined with information on movement patterns and work-to-rest ratios, leads to the development of volleyball-specific training routines.

Figure 13.25 The average number of direction changes volleyball players make during a match

	Total number of direction changes	Number of direction changes per 10 seconds of rally time
Player A	467	3.75
Player B	510	3.60
Player C	286	4.02

Learning experience

WHAT TRAINING WOULD BENEFIT VOLLEYBALL PLAYERS?

1. Identify the main fitness component the statistics in figure 13.25 relate to.
2. Identify the type of drills that would assist a player in enhancing direction change to be more effective on the court. Ensure suggested drills take 5–15 seconds and are followed by a break that adheres to the work-to-rest ratio of 1:2.

Figure 13.26 Blocks and spikes are additional movements in volleyball.

Full fitness analysis: examples

Netball

Comprehensive fitness analyses have been conducted on netball players. These analyses looked at the activity patterns, types of activity, and work-to-rest (or work-to-relief) ratios for top-level players in each netball position. Results for analysis were obtained from studying video-recordings.

Figure 13.27 presents the statistics on activity patterns that reveal the following essential information:

- Each position has a unique activity pattern.
- WAs do the most sprinting, while Cs are the most active, but at lower intensities.
- Defensive players tend to spend more time shuffling than other players.
- Players C, GD, GA and GS jump more often than others.
- The majority of passes are made by the centres, WAs and GAs.
- GKs do the most guarding.

Additional involvements in netball

In addition to providing information of movement patterns, figure 13.27 contains additional involvement information, e.g.:

- Each C averages 52 jumps (upwards off two legs) and 20 leaps (forwards off one leg) each match. This shows a huge demand for power in the gluteals, quadriceps, hamstrings and calves to outjump the opposition without fatiguing.
- GAs, WAs and Cs all take more than 110 catches per match, showing a demand for isometric hand and forearm strength to catch rapid passes throughout the game and to avoid finger and wrist injuries.

Figure 13.27 Results of studies of netball movement patterns and additional involvements

The average number of repetitions of each locomotor and non-locomotor activity during match play							
Activity	**Position**						
	GS	**GA**	**WA**	**C**	**WD**	**GD**	**GK**
Standing	311.3	252.3	321.5	293.8	303.3	275.0	332.0
Walk forward	247.3	296.5	387.3	367.5	370.0	332.3	270.5
Walk backward	168.5	132.8	149.0	156.8	160.8	148.0	115.5
Walk sideways	91.5	92.8	96.3	80.0	99.8	89.3	74.8
Shuffle	155.0	204.3	201.3	304.3	234.5	200.0	116.3
Jog	97.5	189.8	237.8	378.5	213.3	163.3	51.5
Run	47.0	68.5	87.3	106.3	81.5	44.0	15.0
Sprint	0	4.8	5.0	3.3	1.8	0	0.3
Rebound	2.0	2.3	0	0.3	0	4.0	5.5
Pass	65.3	76.3	113.3	103.0	41.3	58.5	56.8
Catch	95.3	110.0	113.3	115.0	37.0	52.8	33.5

The average number of repetitions of each locomotor and non-locomotor activity during match play							
Activity	**Position**						
	GS	**GA**	**WA**	**C**	**WD**	**GD**	**GK**
Jump	39.5	43.0	32.5	52.3	36.5	49.8	36.3
Guard	86.8	49.5	23.0	59.8	78.3	116.0	135.8
Defend	17.8	10.5	20.3	38.0	57.3	49.0	48.3
Leap	11.0	10.8	11.8	19.5	21.0	18.0	8.8
Toss-up	1.8	1.5	0.8	1.3	0.5	2.8	0.5
Centre pass	0	0	0	47.3	0	0	0
Shoot	32.8	35.3	0	0	0	0	0
Successful goal	22.8	26.5	0	0	0	0	0
Missed goal	9.0	8.3	0	0	0	0	0
Other	0.5	2.5	0.5	0.5	1.5	1.5	1.5
The average time (in seconds) spent per activity during match play							
Activity	**Position**						
	GS	**GA**	**WA**	**C**	**WD**	**GD**	**GK**
Standing	5.4	4.3	3.3	1.8	2.8	3.1	5.4
Walk forward	2.3	3.4	2.8	2.4	3.1	3.3	2.1
Walk backward	2.2	2.0	2.3	1.9	2.1	2.3	1.7
Walk sideways	1.2	1.0	0.9	0.9	1.0	1.1	1.9
Shuffle	1.6	1.7	1.3	1.6	1.7	1.9	1.9
Jog	1.3	1.4	1.5	2.1	1.7	1.7	1.2
Run	1.2	1.2	1.1	1.5	1.1	1.2	1.2
Sprint	0	0.4	0.6	0.7	0.5	0	0.3
Rebound	1.2	1.3	0	0.1	0	1.1	1.5
Pass	1.0	0.9	0.9	0.9	1.1	1.0	1.0
Catch	1.3	1.2	1.0	0.9	0.9	0.9	0.8
Jump	1.0	0.8	0.7	0.7	1.0	1.1	1.2
Guard	2.1	2.0	1.6	1.6	1.7	2.4	3.4
Defend	1.4	1.6	1.4	1.3	1.3	1.5	2.0
Leap	0.9	0.9	0.7	0.8	1.0	1.0	0.9
Toss-up	2.3	1.9	0.9	0.6	0.7	1.6	1.1
Centre pass	0	0	0	0.9	0	0	0

(continued)

The average time (in seconds) spent per activity during match play							
Activity	**Position**						
	GS	**GA**	**WA**	**C**	**WD**	**GD**	**GK**
Shoot	1.2	1.1	0	0	0	0	0
Successful goal	1.2	1.1	0	0	0	0	0
Missed goal	1.3	1.1	0	0	0	0	0
Other	0.8	1.3	0.4	4.2	1.3	1.7	1.5
The average percentage of total game time for activities during match play							
Activity	**Position**						
	GS	**GA**	**WA**	**C**	**WD**	**GD**	**GK**
Standing	45.5	31.0	29.0	14.3	23.5	23.3	48.3
Walk forward	15.5	28.0	30.5	24.5	31.8	30.0	15.3
Walk backward	10.3	7.3	9.3	8.3	10.0	9.5	5.5
Walk sideways	2.8	2.8	2.5	2.0	2.5	3.0	2.5
Shuffle	7.0	9.0	7.5	13.3	10.8	10.3	6.3
Jog	3.8	7.5	10.3	21.8	9.5	7.8	1.8
Run	1.5	2.5	2.8	4.3	2.8	1.5	0.8
Pass	1.5	1.8	2.5	2.5	1.0	1.8	1.8
Catch	3.3	3.8	3.3	3.0	1.0	1.0	1.0
Jump	1.3	1.3	0.8	1.0	0.8	1.3	1.3
Guard	5.0	2.8	1.3	2.5	3.8	13.0	13.0
Defend	0.8	0.3	0.5	1.5	2.0	2.8	2.8
Leap	0	0	0	0.3	0.8	0.3	0.3
Centre pass	0	0	0	1.0	0	0	0
Shoot	1.0	1.3	0	0	0	0	0
Successful goal	1.0	1.0	0	0	0	0	0

This information must then be used to select appropriate fitness tests and the best overall method of training, to improve each fitness component.

The results of a work-to-rest analysis of netball are shown in figures 13.28 and 13.29. The work periods were grouped into three categories:

- those less than 4 seconds
- those of 4–10 seconds
- those greater than 10 seconds.

Each work period was compared to the rest period that immediately followed it, to obtain a series of work-to-relief ratios.

Figure 13.28 Average number of occurrences of different periods of work for each of the seven netball positions

Position	Less than 4 seconds	4–10 seconds	Greater than 10 seconds	Number of work periods
GS	43	20	3	66
GA	40	29	9	78
WA	49	26	3	78
C	52	26	4	82
WD	39	30	4	73
GD	31	34	10	75
GK	37	30	4	71

Figure 13.29 Average number of occurrences of different work-to-relief ratios for each of the seven netball positions. 'Work' was defined as a sprint, jump or shuffle, and 'rest' or 'relief' was any movement of jog intensity or less

Position	1:1 Or less	1:2	1:3 Or greater	Total number
GS	8	6	52	66
GA	10	11	55	76
WA	5	9	63	77
C	8	11	62	81
WD	7	6	57	70
GD	12	11	50	73
GK	7	7	52	66

The results show that for all positions in netball:

- most work periods are under 10 seconds
- most of the work is performed with a work-to-rest ratio of 1:3 or greater.

Therefore, netball training should use short-interval sessions at a 1:3 work-to-rest ratio, to develop the phosphate energy system. Training should also develop a solid aerobic base so that recovery during rest periods is as rapid and efficient as possible.

Figure 13.30 Centres jump more than other players during a game.

Learning experience

NETBALL TRAINING SESSIONS

1. Research some training sessions that adhere to a 1:3 work-to-rest ratio and are specific to netball.
2. Share your research with classmates.
3. If appropriate, select and implement a training session with the class. Wear heart-rate monitors and evaluate how effective the session was in targeting the creatine phosphate energy system.

Surfing

There have been several studies of the fitness demands of surfing. These studies found that the aerobic system is the major energy system used in surfing.

The main results of the studies were as follows:

- Movement analysis showed that the paddle out to the take-off zone, either through or around the breaking waves, can be over distances of 20–50 m and may take 4–10 minutes. For this reason, elite surfers have been shown to have high VO_{2max} scores compared to many other competitive sportspeople.
- Once at the take-off-zone, the surfer requires anaerobic power to catch the wave and execute manoeuvres. Surfers require between 2 and 20 powerful strokes to position the board and gain momentum so that the wave will pick them up.
- Once on the wave, a surfer may execute between 5 and 10 moves during a ride that lasts 10–30 seconds.

To develop the energy systems for surf paddling, a specific program would include:

- board paddling or swimming with the head up for 30 minutes
- interval swim or paddle sessions with efforts varying from 1 to 5 minutes
- sprint sessions of 10–20 seconds.

Additional involvements in surfing

There are a number of additional involvements in surfing which emphasise fitness components other than aerobic and anaerobic capacity. The take-off and wave manoeuvres involve a combination of balance and agility that must be developed in training.

Skateboarding, wobble-board work, and using a gymnastic beam all improve balance. Modified burpees are used to simulate the take-off from prone paddling to crouched side-on standing.

Figure 13.31
Manoeuvres on the face of the wave are additional involvements in surfing.

Most surfing manoeuvres involve rapid twisting movements of the trunk, which require strength and endurance to perform effectively and to avoid injury. These movements can be incorporated into a gym routine involving:

- twisting sit-ups
- modified burpees
- bench jumps
- trunk extensions
- appropriate flexibility work.

Learning experience

AGILITY: A COMMON FITNESS COMPONENT IN MANY SPORTS

1 Conduct some online research and select four exercises that would target agility specific to the physical activity you are currently studying. (If this is not appropriate, select a physical activity that you participate in outside of school.)

2 Working in a small group of 3–4, pool your research and select the best 6–8 agility exercises specific to your chosen physical activity and organise them into an agility circuit. (Read the section on training methods in chapter 15 to assist you.)

3 In your group, implement the circuit and decide how effectively the session:
   - targeted agility and the chosen physical activity (specificity)
   - was organised (e.g. order of exercises).

Note: Your teacher may take the class for a group warm-up and cool-down to ensure safe training practices are adhered to.

Learning experience

ENERGY SYSTEMS IN TOUCH

Identify, compare and evaluate fatigue levels in touch, during a game where various parameters are manipulated. Wear heart-rate monitors to assist you with the analysis. Your teacher may also wish to video this for further analysis of movement patterns and errors.

1 Team A vs Team B (6 vs 6)
   - Team A has to retreat 10 m in defence during the game.
   - Team B retreats 5 m in defence during the game.

   Compare and evaluate fatigue levels, energy systems and the impact this had on performance.

2 Team A vs Team B (6 vs 6)
   - Team A is replaced every 5 minutes with fresh players.
   - Team B has no replacements.

   Compare and evaluate fatigue levels, energy systems and the impact this had on performance.

3 Students suggest a variation to explore.

   Discuss the impact the various parameters had on the game (skill, strategy/tactics, decision making, enjoyment, intensities).

Chapter review

Games analysis

Know **Comprehend**	1	Collect a newspaper or internet article that reports on results of a particular game, sport or athlete. Highlight any aspects that talk about the skills, game strategy tactics or decisions made. From the way the article reads, what do you think was the outcome of the game?
Apply	2	Conduct a **SWOT** analysis based on your experiences and understanding of the concepts fitness testing and games analysis. Consider the **S**trengths, **W**eaknesses, **O**pportunities and **T**hreats that an individual, team or group could experience as a result of being tested and analysed.
Analyse **Evaluate** **Synthesise**	3	Now that you have been tested, videoed and analysed, create a concept map (or another form of visual representation) that evaluates your personal profile for the physical activity currently being studied. Consider your personal strengths and areas for improvement based on fitness components, energy systems, psychological aspects, sociological aspects and games analysis (relevant skills and strategies, tactical awareness, decision making) and any other observations from internal or external sources.
	4	Ensure the concept map is as visual and comprehensive as possible and, where appropriate, gives details for your decisions based on test results, class examples (drills, games) and feedback (self, peers, teacher, video).
	5	Share your concept maps during a class discussion, and where appropriate ask questions and give further feedback that will enhance either your own concept map or that of a classmate.
	6	Do you think the concept maps you observed and provided feedback on were an accurate reflection of the individual's performance and abilities in the physical activity currently being studied? *Note:* Your teacher may wish to upload your concept map onto the school's network so feedback can be given in an online wiki.

Exercise physiology principles

chapter 14

Training principles

An effective training program is not a matter of chance. Very careful consideration must be given to the planning phase so the athlete can see the relevance of the training, can see improvement, does not become bored and, most importantly, is not injured.

For your training program to be successful, you should follow all the essential **training principles**, i.e. the principles of:

- individuality
- specificity
- progressive overload
- frequency
- intensity
- duration
- detraining
- measurable progress
- diminishing returns
- variety.

These principles govern:

- your choice of training methods
- the content of each session
- your rate of improvement
- your level of motivation
- the overall effectiveness of your program.

Training principles are the rules that an athlete should follow to ensure that individual training sessions and whole training plans are effective in targeting performance goals.

Individuality

Individuality acknowledges that each athlete is different, and as a result training should consider their abilities (physical skills and fitness), gender, potential, maturity, culture, psychological needs, learning styles, the specifics of their sport and, in team games, the specifics of their position. The last is particularly difficult for coaches and why many elite teams have an overall coach, as well as specialised coaches for various skills or positions, such as the goalkeeper in soccer or the back row in rugby union. Often in elite teams there is also the fitness trainer, who has to work in conjunction with the other

Individuality acknowledges that no two athletes respond to training in the same way, therefore to be truly effective a training program or session must consider the individual's needs, goals, fitness levels, motivation and skills.

coaches and specialists to get the best out of the team or individual athlete. Coaches or individuals will get the best results when they follow certain rules or principles to plan a training program and maximise its effect.

Specificity

Specificity of training is the principle underlying construction of a training program for a specific activity or skill, and the primary energy system(s) involved during performance, e.g. a training program for sprinters would consist of repeated bouts of sprints in order to develop both sprinting performance and the ATP–PC system.

Specificity of training is the main training principle that guides the development of your training program. It can be summarised as 'You get what you train for'. A training program must stress the physiological systems (fitness components, energy systems and body parts) to achieve specific training adaptations (changes or improvements).

For your training program to be a success you must apply the specificity principle in the following ways:

- Perform a games analysis to find out the specific fitness components, energy systems and skills required by your sport and in which specific body parts they are required. The analysis must be of a player playing in your specific position.
- Select specific training methods that will develop the specific fitness you need. Within each training method you must choose specific exercises that will develop the specific body-part fitness that you need.

Specificity for different requirements

Endurance

The most important factor in training for endurance sports and events is the specificity of intensity. Billat and colleagues (2003) reported that marathon runners who were able to train at a velocity at or exceeding their VO_{2max} were the most successful.

Team sports

Training drills (e.g. small-sided games), when carefully planned by the coach, can be just as effective as formal interval training in improving aerobic capacity as well as technical elements. Variables such as playing area, number of players, rules and playing time must be monitored to ensure training of the specific fitness components, energy systems and skills is taking place. Sassi and colleagues (2003) found that, if planned well, small-sided games could have a greater training effect on the oxygen-transport system than traditional interval training without the ball.

Strength and power training

Resistance training is an ideal way to target muscular strength, power or endurance. The exercises in a resistance program should be specific movements of the muscles in the game. For example, the specific exercises should mirror the movements in terms of velocity, range, joint angle and type of contraction. Sports that have a speed or power component should use resistance exercise at a similar velocity. For example, for leaps and jumps in AFL, plyometric exercises could be used with the body weight as the resistance.

The following is an example of the application of the specificity principle.

- Games analysis reveals a specific requirement for leg power and aerobic capacity.
- You select the vertical jump and multistage 20 m shuttle tests to make a specific assessment of these components.

- After your fitness testing, you decide to utilise circuit training to specifically develop your aerobic capacity and leg power simultaneously.
- You make a specific choice of a 3-lap, 10-exercise individual circuit to develop your aerobic capacity, and select box jumps to specifically develop leg power as one of the 10 exercises. This training method will produce the specific training effects you need, i.e. improved cardiorespiratory (aerobic) efficiency, and hypertrophy of the white muscle fibres (fast twitch) in the leg (power).

Learning experience

SPECIFICITY OF TRAINING

For the physical activity you are currently studying, rate in order of effectiveness the three specificity requirements (i.e. endurance, training drills and resistance). Post your rating and reasons for your decision on the school's network as part of a class forum. (If this is not available at your school, share your decisions as part of a class discussion.)

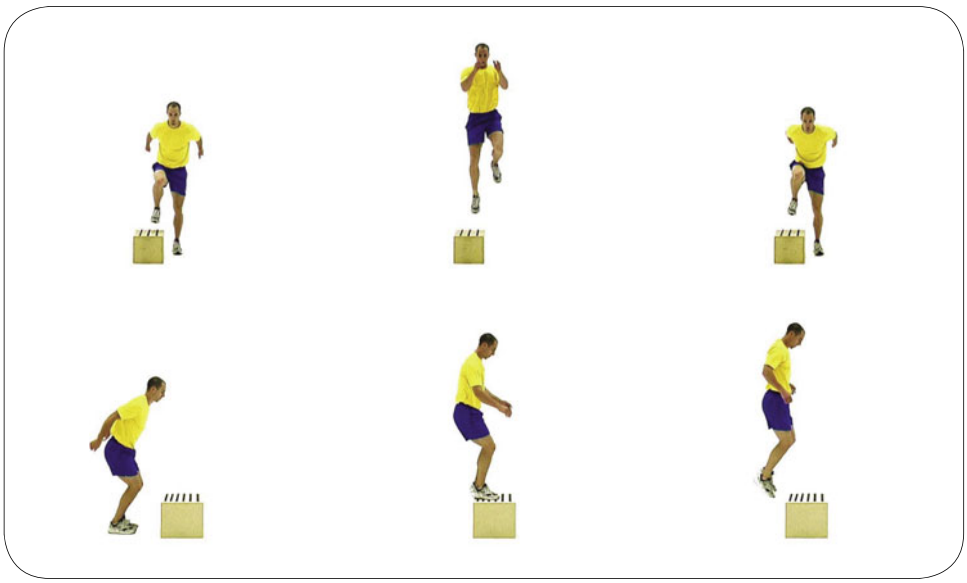


Figure 14.1
Just two variations of the box jump exercise that can increase speed, power and aerobic capacity. Variations are limited to your imagination.

Learning experience

LEG POWER + AEROBIC CAPACITY

Work in pairs.

1. Conduct some research and select eight other exercises, as well as those in figure 14.1, to make up a 10-exercise circuit. Remember the focus is to develop leg power and aerobic capacity.
2. Video either you or your partner demonstrating the 10 exercises.
3. Share your videos with another pair and evaluate how effective each of the 10 exercises would be in targeting the specific fitness components of power and aerobic capacity.

Progressive overload

Progressive overload is the gradual increase in the load of training to ensure that fitness continues to improve.

Progressive overload or the overload principle (see figure 14.3) governs all fitness training. If you want to improve, you must exercise at an intensity greater than your existing capacity, and this intensity must move towards your performance objective. If the training load exceeds the load to which the body is accustomed, the body will adapt physiologically so that a higher load is required for further improvement.

Figure 14.2
To increase the load during the leg press exercise the athlete should add more weight.

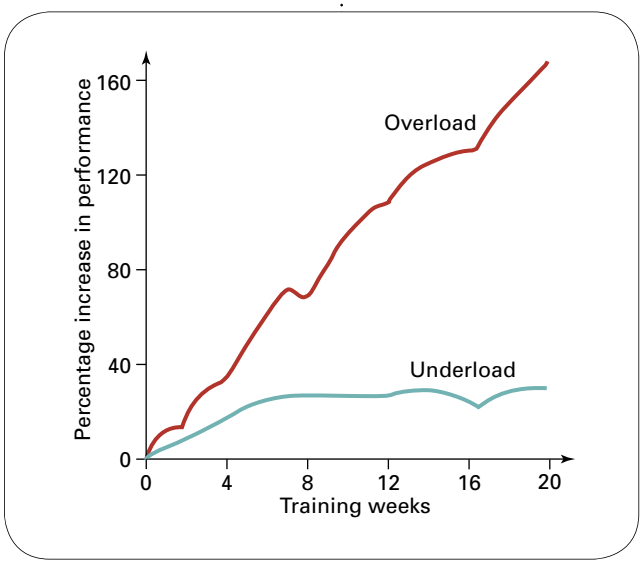


Figure 14.3
Comparison between the results of progressive overload training and underload training. Gains in strength and endurance are most pronounced when the muscle is exercised in the overload zone, i.e. against resistances above those normally encountered by the muscle.

For example, weight training for strength involves performing three sets of 10 repetitions using a weight that can only be lifted 10 times. When you first use such a weight, usually you can only perform 10 repetitions in the first set, about 8 repetitions in the second, and about 6 repetitions in the third set.

However, after several weeks you will be able to make three sets of 10 repetitions because your body will have adapted to the stress and improved in strength. At this stage, more weight is added to the bar to create overload and stress the body into developing greater strength.

The following is another example of overload training with the goal of being able to jog continuously for 20 minutes:

- weeks 1–2: jog for 10 minutes
- weeks 3–4: jog for 15 minutes
- weeks 5–6: jog for 20 minutes.

Overload can be achieved by increasing distance, duration, frequency and intensity of training. Not every training session should be an overload session, and when overload is incorporated into a training program, the changes should be gradual. For example, in a 6-week (macrocycle) training program, your training overloads must be organised in steps, to allow a gradual increase in training effects without undue fatigue (see figure 14.4). The increase in overload each week should be about 10%.

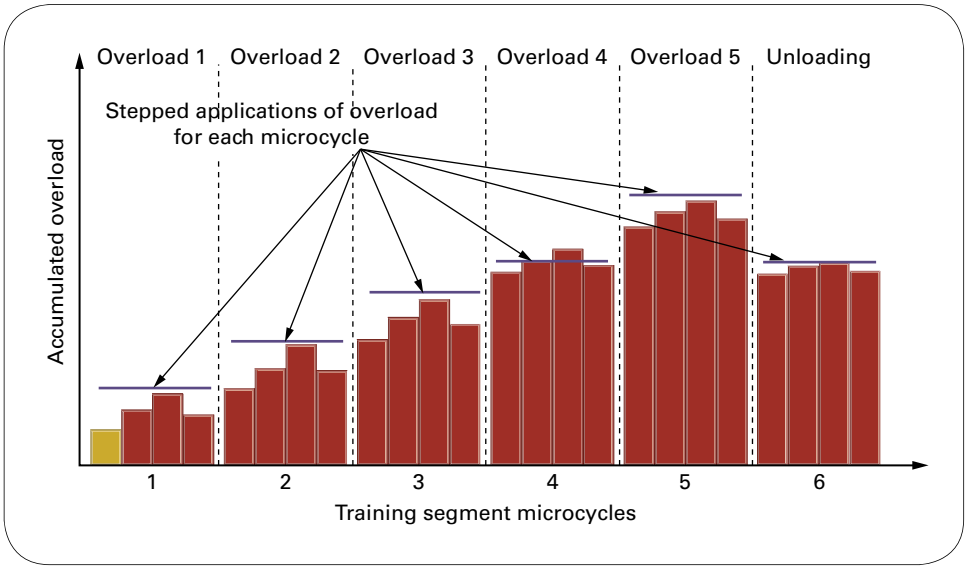


Figure 14.4
The step-like application of overload for a 6-week macrocycle. Within each microcycle (i.e. each week), overload is held constant for three sessions. The fourth session involves a reduction in the overload intensity. The sixth microcycle is the unloading one in which the degree of overload intensity is reduced.

Within each week (microcycle) of the program, you should overload up to three sessions. If you plan a fourth session, it should be an underload session to allow recovery.

The last week (microcycle) of your 6-week (macrocycle) training program should be an unloading week during which your training intensity and volume are reduced to allow active recovery. This should maximise performance on the post-tests.

When working out training overloads, it is wise to follow the Roux Principle: small increases are useless, moderate increases are useful and excessive increases are harmful.

Frequency (number of sessions per week)

Training improvements are the summation of biological adaptations induced by the stress of regular exercise. Generally, the more frequent the training, the greater the fitness improvement, although all programs must include rest days to allow the body to recover.

The training **frequency** varies according to the chosen activity. However, it is possible to make the following generalisations:

Frequency of an event is the number of times it occurs within a certain period.

- For fitness to improve, the minimum number of sessions per week is three. However, fitness can be maintained in two sessions, or possibly one session, per week. Therefore, if you wish to develop a fitness component, you must train at least three times a week; if you wish to maintain a fitness component, you must train twice a week.
- To improve aerobic capacity, the ideal training frequency should be 4–5 days per week, although runners, swimmers and triathletes may need to increase this to 6–7 days per week. Training for two sessions per day is not necessarily more productive than training for only one session per day (see figure 14.5).
- To improve strength, power and speed (anaerobic components) requires less frequent training, with the ideal being 3–5 days per week.

Figure 14.5 Guidelines for frequency, intensity, duration and distance of aerobic and anaerobic training programs in running

Training aspect	Endurance (aerobic) training	Sprint (anaerobic) training
Frequency	4–7 days per week	3–5 days per week
Intensity	Heart rate = 70–85% of maximum heart rate	Heart rate = 85–100% of maximum heart rate
Sessions per day	1	1
Duration	12–16 weeks or longer	8–10 weeks
Distance/workout	5–8 km	3–4 km

Learning experience

GENERAL INFORMATION ABOUT YOUR TRAINING

1. How many times a week do you train?
2. Using any of the methods for describing intensity, identify the intensities at which you work during your training. Give specific examples.
3. Is the training specific to your individual needs? Why/why not?
4. Is the training for general fitness or sport-specific? What sort of things do you do?
5. Where do you train, how much does it cost and how do you get to training?
6. Share this information with classmates through:
   - a discussion
   - an online class forum
   - a blog.

Intensity

Intensity in relation to exercise is the degree of difficulty or the amount of strength and/or energy required.

Training **intensity** refers to how hard each session will be. It has been described as the most important training variable and should be carefully monitored to ensure that training is effective and that the athlete is working at the appropriate levels to gain fitness benefits. As you progress through a training program, the intensity increases because of progressive overload. However, the initial intensity and the rate of overload depend on your beginning fitness, as identified in the pre-tests, and the long-term goals of the program.

There are several factors that indicate intensity and ways of measuring or calculating the intensity at which you are working during a training session or during competition. McArdle and colleagues (2007) lists several different methods. You may be familiar with these:

- energy expended per unit time, e.g. 37.8 kJ/min
- percentage of VO_{2max} (e.g. 85% VO_{2max})

- exercise heart rate, often called **target heart rate (THR)** or target training zone, is a percentage of **maximum heart rate (MHR)** (e.g. 80% maximum heart rate)
- **Rate of perceived exertion (RPE)** developed by Borg (e.g. RPE 14) (see figure 14.6).

However, for some athletes using heart rate and a graph (such as figure 14.7) is enough.

Training intensity is most accurately measured by measuring oxygen consumption and blood lactate levels, but this requires expensive testing equipment to which the average athlete does not have access. An effective alternative is to use heart rate to determine exercise intensity, since we know that heart rate increases linearly with increasing intensity of the exercise—the harder you exercise, the more your heart rate increases. What the THR should be when training will depend on what you are training for; that is, specificity of intensity and training at the correct THR will bring about the desired improvements of the predominant energy system for your sport.

Target heart rate (THR) is the heart rate the athlete is aiming to work at to achieve the correct intensity for the energy system(s) being targeted.

Maximum heart rate (MHR) is the theoretical maximum rate (not intended as an exercise rate) at which a person's heart can beat at a given age; the formula used to calculate the maximum heart rate of a healthy individual is 220 – age in years.

Rate of perceived exertion (RPE) is a scale developed by Borg to describe how an athlete felt when completing the exercise or training.

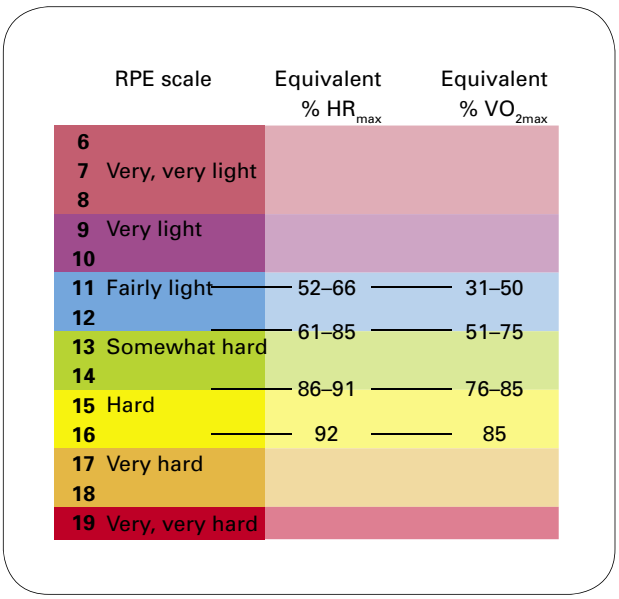


Figure 14.6 The Borg scale for obtaining RPE during exercise

Source: modified from Borg, GA, 1982, 'Psychological basis of physical exertion', *Medicine & Science in Sports & Exercise*, 14, p. 377

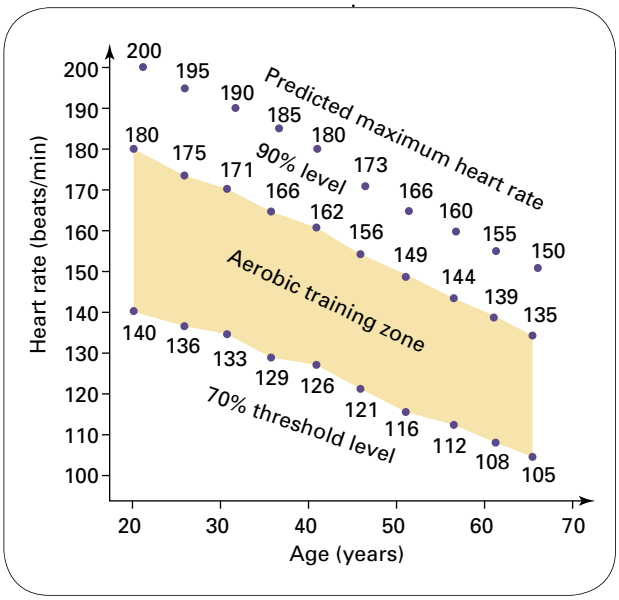


Figure 14.7 Maximum heart rates and training-sensitive zone for aerobic training of men and women of different ages

Learning experience

WHAT INTENSITY?

Of the methods listed by McArdle and colleagues as ways to describe our levels of intensity, which have you:

- heard of, and
- used in your own training?

Lactate threshold 1 (LT1) is the first intensity at which there is a sustained increase in blood lactate concentration above resting levels.

Lactate threshold 2 (LT2) is the intensity indicating the upper limit of equilibrium (balance) between lactate production and lactate clearance (also referred to as anaerobic threshold).

The following generalisations can be made about intensity:

- For those interested in aerobic fitness, the lowest THR that will produce aerobic fitness improvements is 70% of MHR. This is called your **lactate threshold 1 (LT1)**. As the maximum heart rate is approximately 220 minus your age, for a 20-year-old person the lowest THR is 140 beats per minute. Heart rates above 85% of maximum result in the accumulation of lactic acid and are very demanding sessions. These **lactate threshold 2 (LT2)** sessions are only included in an aerobic program about every third session.
- For most endurance sessions, THRs fall within the range of 70–85% of MHR.
- For sprint (anaerobic) training programs, the THR should be 180 beats or more per minute, representing 85–100% of MHR. Note that for interval training, the most important factor is intensity of training, not frequency or duration. Therefore, two or three intense sessions per week are adequate for interval training.

Figure 14.8
Training with a heart-rate monitor gives instant feedback on the intensity of training.

Due to the individual nature of our responses to exercise, you may have to adjust these target heart rates or training zones after implementation. For example, if you cannot finish the training session at the intensity recommended because it is too hard, then you have not met one of the other principles of training, duration, and so training may not be as effective. Conversely, if you are not working hard enough during a session then you will not be gaining the benefits of training and may be training in the incorrect energy system for your specific needs.

For accurate assessment of intensity of training, heart rates should be measured, either during the activity with a heart-rate monitor, or immediately after the exercise by taking the radial or carotid pulse.

Modern heart-rate monitors are relatively inexpensive and may be another tool the athlete can add to their training arsenal by consistently monitoring training heart rate, resting heart rate or heart rate during recovery. Many heart rate monitors can be manipulated to include target heart rates so an athlete can have immediate feedback about whether they are in their training zone and therefore working at the appropriate intensity (see figure 14.8).

There are also many online calculators that can be used to identify your MHR and from there calculate the various training intensities. By using a variety of these calculators and methods you can obtain a fairly accurate MHR and therefore accurate training zones.

Learning experience

ONLINE MHR CALCULATORS

1 Conduct an internet search of the various online methods of calculating your maximum heart rate (MHR). You may find some handy calculators at the following site: <www.brianmac.co.uk/maxhr.htm>.
2 It is most likely that you will need to identify your resting heart rate (RHR). To do this take your pulse at the radial or carotid pulse for 15 seconds before you get out of bed in the morning. Multiply the result by 4 to get your RHR for 1 minute. For example, if your pulse was 15 beats for 15 seconds then your RHR is approximately 60 bpm.
3 Load the required information into the calculators and record the results. How do they compare with the formula of 220 – age (higher, lower, the same)? If there are differences, what impact will this have on your 5 training zones (see figure 14.10)?
4 There are also practical methods using field tests that can be performed to calculate MHR. Conduct an internet search and report back to the class on the methods you found. Select one to implement.
5 How does the result of the MHR field test compare with the online calculators and percentage of age formula?
6 What was your RPE while conducting the MHR field test? (See Borg's scale for a rating of perceived exertion in figure 14.7.)

SNAPSHOT

Standardisation of physiology terminology

As you may have realised, there many terms in exercise physiology that represent the same thing and a study by Tanner and Bourdon (2004) recommended that a national standardisation of terms in relation to endurance training, particularly lactate thresholds and training zones, be implemented, to reduce confusion among scientists, coaches and athletes.

Lactate thresholds are a very good indication of training intensity and our elite athletes, particularly endurance athletes, have their blood lactate levels measured regularly. There are three reasons for testing blood lactate levels during exercise:

- They are an indicator of training adaptation—blood lactate levels can increase even when there is little or no change to the volume of oxygen consumed.
- There is correlation with endurance exercise—blood lactate levels have been suggested as better indicators of endurance performance than volume of oxygen consumed.
- They provide an optimal training stimulus—better indicator of training intensity therefore a more effective way to optimise training.

Therefore it is recommended by Tanner and Bourdon that the lactate threshold terminology be simplified (see figure 14.9).

Figure 14.9 The blood lactate thresholds

Blood lactate threshold	Abbreviation	Definition
Lactate threshold 1	LT1	The first intensity at which there is a sustained increase in blood lactate concentration above resting levels
Lactate threshold 2	LT2	The intensity indicating the upper limit of equilibrium between lactate production and lactate clearance

It was also found that across sports, institutes and academies and even textbooks there exists a range of endurance training zones. Using one set of descriptors and definitions would simplify what is a complicated concept and would go a long way to benefiting the athlete at both an elite and general fitness level. Tanner and Bourdon recommend five training zones (T1–T5), which are outlined in the table below, along with links to the lactate thresholds, Borg's RPE scale and duration. This information should be very beneficial when planning your own training program (see figure 14.10).

Figure 14.10 The recommended training zones that will assist you in working at the correct intensity for your fitness needs

Training zone	Description	Blood lactate threshold relationship	Blood lactate (mmol/L)	HR_{max} (%)	VO_{2max} (%)	Borg's RPE scale	Critical duration	Personal training zone based on % HR_{max}
T1	Light aerobic	Below LT1	<2.0	60–75	<60	Very light	>3 h	
T2	Moderate aerobic	Lower half between LT1 and LT2	1.0–3.0	75–84	60–72	Light	1–3 h	
T3	Heavy aerobic	Upper half between LT1 and LT2	2.0–4.0	82–89	70–82	Some what hard	20 min–1 h	
T4	Threshold	LT2	3.0–6.0	88–93	80–85	Hard	12–30 min	
T5	Maximal aerobic	Above LT2	>5.0	92–100	85–100	Very hard	5–8 min	

Source: Tanner, R, & Bourdon, P, 2004, 'Standardisation of physiology nomenclature', Australian Sports Commission, National Sport Science Quality Assurance Program, pp. 1–7

Learning experience

PERSONAL TRAINING ZONES (T1–T5)

Using figure 14.10 calculate your 5 training zones. This will help you identify the correct intensities at which you should be training based on your specific fitness needs and objectives. For example, if you want to increase your ability to tolerate high levels of lactic acid, then you should train at T4 or T5.

1. Calculate your MHR.
   MHR = 220 bpm – your age
   For example, a 20-year-old person would have an MHR of 200 bpm.
2. Use the HR_{max} (%) column to calculate your 5 personal training zones as per the last column of figure 14.10. For example, a 20-year-old person with an MHR of 200 bpm would have a T1 of 120–150 bpm.

Duration

Duration refers to the length of a training program or the length of each session. The minimum duration of any fitness program to develop training effects is six weeks.

Aerobic fitness improvements tend to take longer to develop than other fitness components. Ideally, therefore, aerobic fitness programs should run for not less than 12 weeks, and anaerobic fitness programs should run for 8–10 weeks (see figure 14.5).

Learning experience

HOW EFFECTIVE WAS YOUR LAST SESSION?

Recall the last time you trained to improve an aspect of fitness.

a What was the activity?

b What fitness component and energy system were you targeting?

c What physical skills were you targeting (if it was sport-specific, e.g. running technique)?

d How long did the session last (duration)?

e What was the intensity? (Use the RPE scale or training zones if you know what your heart rate was.)

f Was the session specific (i.e. did it meet your objectives for the session?)?

Detraining

Training effects are reversible, and this phenomenon is sometimes called the '**detraining** principle' or 'principle of reversibility'. It can be summarised by the saying 'If you don't use it, you lose it'.

The physiological adaptations that occur when an individual stops training are known as **detraining**.

As figure 14.12 shows, the biological adaptations that are produced by training will be reversed if training ceases. Therefore, it is essential that anyone involved in training, whether sport-related or health-related, never takes a complete break from training. Even if you are injured, you still need to train the uninjured parts of your body so that you avoid detraining.

Maintenance periods, during which training is of lower intensity or sessions are less frequent, are fine in the off-season or to allow physical and psychological recovery. However, complete cessation of training results in a rapid loss of the fitness you worked so hard to develop.

Detraining affects all fitness components (see figures 14.11 and 14.12). However, aerobic (endurance) losses are more rapid than strength (power) losses. In fact, research shows that the results of 5 months of endurance training can be lost in 6–8 weeks.

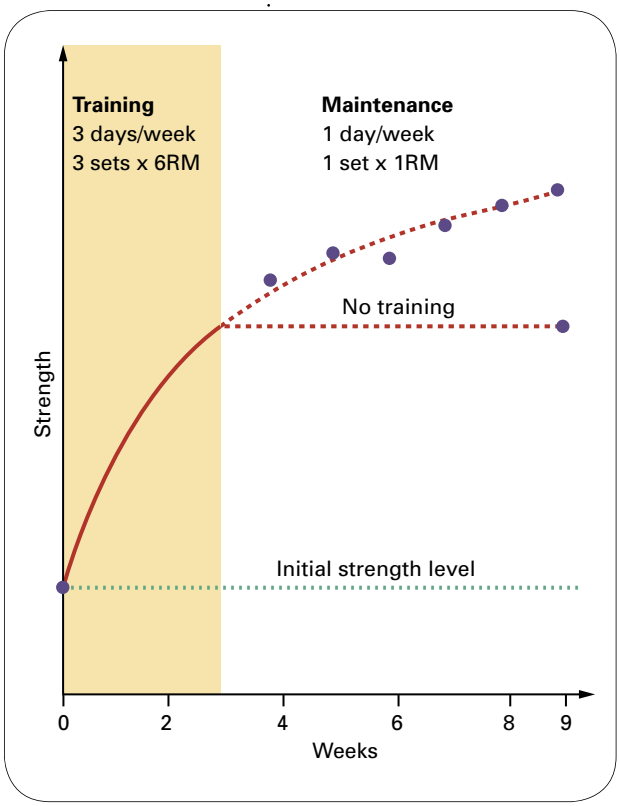


Figure 14.11 Retention of strength. The strength gained during a 3-week isotonic training program (three sets of 6 RM, 3 days per week) was not lost during a subsequent 6-week period of no training (dotted line). Strength was further improved during a subsequent 6-week training program (one set of 1 RM, 2 days per week).

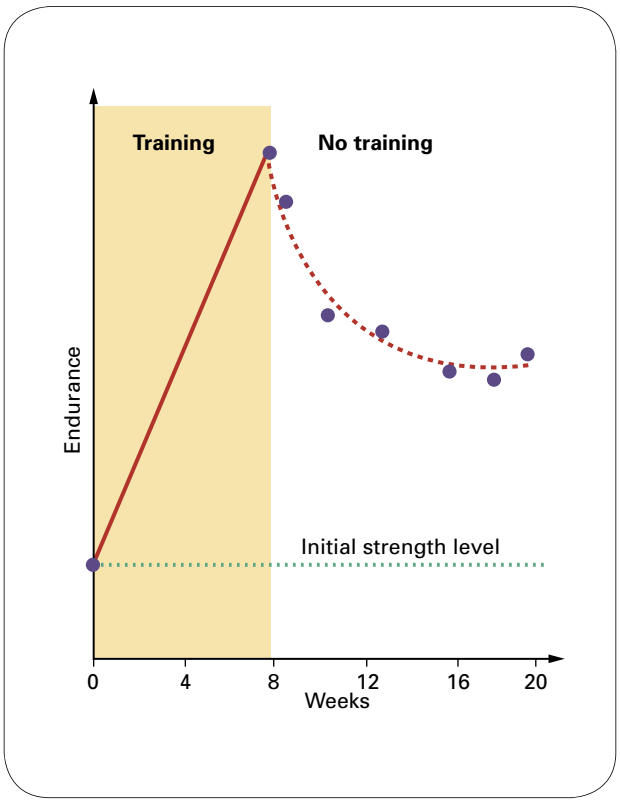


Figure 14.12 Retention of muscular endurance. The program was performed 3 days per week for 8 weeks, with each session consisting of an exhausting bout of elbow flexions at a work rate of 40 repetitions per minute against a 5 kg load. Although endurance was lost most rapidly during the first few weeks of the detraining (no training) period, 70% of the endurance gained was still retained after 12 weeks of no training.

Learning experience

'YOU CAN DO IT!'

Many people begin a training program, either at home, at the gym or with a personal trainer only to quit after a few weeks.

Task

On your school's online network, contribute to a class forum that could be used to persuade an individual to persist with their training program. (*Note:* if you don't have this type of network access at your school write a paragraph instead.)

Measurable progress

You should be able to see improvements in your performance. Such improvements should be tested regularly.

The minimum amount of measurement recommended is a pre-test, to evaluate fitness before the program is planned, and a post-test at the conclusion of the program, to allow evaluation and assist in planning follow-up programs.

Learning experience

HOW DID YOU MEASURE UP?

List the methods you have used to ascertain whether your training was effective and that your training goals were being met.

Diminishing returns

This principle states that for any athlete:

- gains in fitness are more rapid early in a program, and later gains are more difficult to achieve (see figure 14.13)
- gains are most rapid for those who begin a program with a lower level of fitness, whereas those with a solid fitness base gain more slowly.

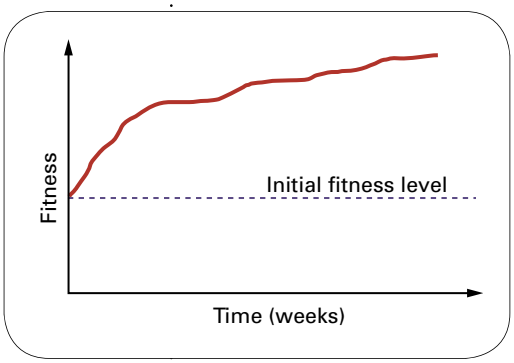


Figure 14.13 The fitness curve, demonstrating the law of diminishing returns: the gains are greatest during early training

Variety

Variety adds spice to your training program and helps to maintain your motivation.

Initial gains in fitness are made quickly. However, fitness levels tend to build up, then reach a plateau, i.e. stay at one level. Plateau performances may last for varying lengths of time (see figure 14.15).

You may experience a number of plateaux during a season, but they can be shortened by maintaining your motivation. One strategy for doing this is to vary your training sessions in the following ways:

- Vary how you train, e.g. aerobic capacity can be developed through swimming, running, floor classes or circuit training, as long as the specificity principle is not violated.
- Vary where you train, e.g. do beach runs, hill runs, park runs, road runs; train in the gym; swim at the local pool.
- Vary how hard you train, e.g. 2 easy days, 1 hard day, 2 easy days, and so on.
- Vary the selection of people you train with, e.g. schoolmates, friends, family, teammates, workmates.

Figure 14.14 Swimming is a great way to vary your training and develop aerobic fitness.

Figure 14.15 A road run is another way to enhance aerobic fitness and add variety to your endurance training.

Learning experience

SPICE IT UP!

Consider an athlete who is completing a jogging program similar to the example described for endurance (aerobic training) in figure 14.5. Suggest some alternative sessions that would add variety to the 12-week training program while still adhering to the other principles of training.

Learning experience

SPECIFICITY AND VARIETY

Two important principles of training are 'specificity' and 'variety'. Explain how these seemingly contradictory principles can both be applied in training. Give specific examples to justify your decision from the physical activity you are currently studying or your own training.

Learning experience

DO YOU HAVE VARIETY?

1. Construct a time line from birth to the present which shows the variety of sports, physical activities and leisure pursuits you have participated in and at what ages.
2. Which of these do you currently still participate in?
3. What were the reasons for you opting out of some activities?
4. Which of the activities do you only do for fitness purposes?
5. On a weekly basis (microcycle) what is the frequency, intensity and duration of these activities?

Learning experience

WHAT IS AVAILABLE IN YOUR COMMUNITY?

'With so many health problems related to lack of exercise it is little wonder that local, state and federal governments are working hard to provide opportunities for people to exercise.

The local community provides adequate opportunity for its residents to experience a wide range of sports, leisure and fitness activities.'

Task

1. Write 600 words either supporting or refuting this statement, using the evidence you have collected to justify your opinion.
2. Research your local area and find out:
   - what variety of activities (sports, leisure or fitness) are available
   - their cost

>>

- where you can go to access information about what is available in your community
- who runs the activity or provides the facilities (local, state, federal government, private business)
- who could participate (youth, adult, elderly, male, female, experienced athletes, novice or beginners, fitness levels)
- when the activities are run.

3 Organise your information into a table and share it with classmates.

4 If possible participate in one of the activities. Share your experience with the class by considering the following:
- Why did you choose that activity?
- Did you enjoy it?
- Would you go again?
- Did you feel it would benefit your fitness levels (is it health or sport related)?

Training methods

Training methods are the various types of training that can be included in a training program. Which methods you choose will depend on which fitness components have been identified through games analysis as essential to your sport. There are six broad training methods:

- continuous training
- interval training
- resistance training
- circuit training
- flexibility training.

Each training method can be used to develop specific fitness components and energy systems (see figure 14.16).

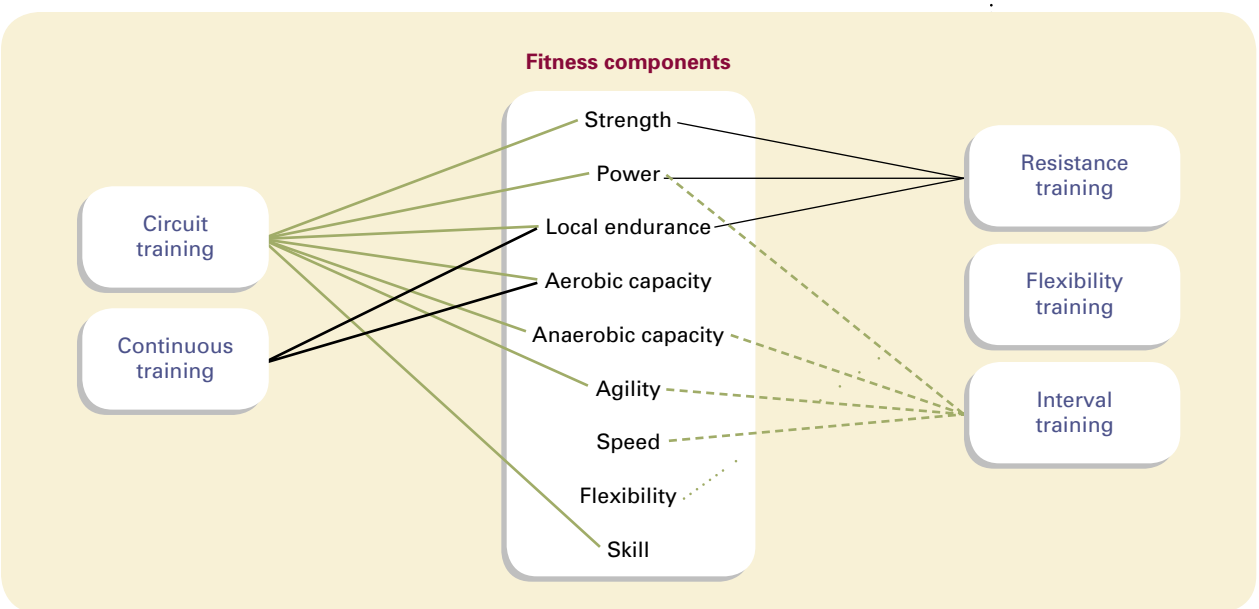


Figure 14.16 Fitness training methods. Specific training methods are directed towards developing specific components of fitness. Coaches and athletes must choose the methods that best suit the requirements of their particular sport.

Figure 14.17
Jogging is an excellent, low-cost form of continuous training that can be done anywhere.

An **aerobic steady state** is reached after the first 3–4 minutes of exercise, when oxygen uptake meets the oxygen demand of the tissues, and heart rate, cardiac output and pulmonary ventilation have reached fairly constant levels.

Continuous training

The purpose of continuous training is to improve aerobic capacity, raise the lactate threshold 2 levels (also known as anaerobic threshold) and improve local muscular endurance. Continuous training must be sufficiently intense to increase the heart's stroke volume and cardiac output. Or, put simply, it must increase the ability of the heart to deliver oxygen to the working muscles.

Continuous training is the foundation of all sport-related and health-related training programs. The improvements in the aerobic system created by continuous training allow the exerciser to reach an **aerobic steady state** faster, accumulate less lactic acid and recover more rapidly between efforts or after exercise.

The FITT formula

To develop your aerobic capacity through continuous training, follow the FITT formula:

- **F**requency
- **I**ntensity
- **T**ime
- **T**ype.

Frequency

To develop your aerobic capacity through continuous training, you need to take part in sessions three or four times per week. A recent study on body fat loss of previously untrained or detrained individuals revealed that those who experienced the highest percentage of body fat loss trained four or more times per week. Training sessions were 30 minutes in length and 70% of maximum heart rate (or training zone 2). This gives further credibility to the National Physical Activity Guidelines for Australians, which recommends daily moderate to vigorous physical activity for at least 30 minutes.

Intensity

Heart rate (HR) increases linearly with exercise effort, so HR is generally used as a measure of intensity. Research has shown that for continuous training to produce effective improvements in aerobic capacity, a specific training zone must be reached and maintained throughout training. This is the point at which there is a rise in blood lactate levels. This point is represented by a target heart rate and is referred to as lactate threshold 1 (see figure 14.9). It is sometimes called the 'aerobic threshold'.

This zone occurs at approximately 75–85% of the estimated HR maximum (see figure 14.6). Athletes interested in higher levels of aerobic fitness must

combine training sessions within the 75–85% HR maximum zone with more intense sessions of 85–95% HR maximum to increase lactate threshold 2 (the anaerobic threshold) and VO_{2max}.

Continuous training sessions are classified according to intensity. There are three types.

Long slow distance (LSD) or lactate threshold 1 training (low-intensity aerobic)

This type of continuous training produces a gradual but steady aerobic improvement. It should be used early in an aerobic training program or the pre-season phase and then throughout as a recovery session when residual tiredness is present. This is submaximal aerobic training at about 75% HR maximum (T2, see figure 14.10), with the emphasis on distance not speed (see figure 14.18).

Lactate threshold 2 training (anaerobic threshold training)

This is faster race-type work at about 85% HR maximum (T3 and above, see figure 14.10). This is equal to or greater than the lactate threshold 2. Lactic acid accumulates throughout this training, making it very fatiguing but essential since it duplicates competition conditions.

Fartlek

'Fartlek' is a Swedish word meaning 'speed play'. It is continuous training, usually cross-country, but with regular changes of pace (intensity). It is a blend of continuous and interval training in which the athlete can increase the intensity depending on how they feel, similar to rates of perceived exertion. Changes of pace may occur because of natural obstacles, such as hills and sand, or because of deliberate short bursts of speed every few minutes. If used correctly, this type of training can overload all three energy systems (depending on the intensity and duration of the surges) as it is a blend of continuous and interval training. The athlete has the freedom to decide when to increase intensity (i.e. if they feel sufficiently recovered they can surge ahead at an increased pace). However, this freedom can also be a disadvantage if the athlete is not disciplined to work at the higher rates of intensity required to tax the lactic acid and creatine phosphate systems. During the lower intensity efforts, the aerobic system is heavily used to remove lactic acid and resynthesise ATP so the performer is ready for the next surge of high intensity (see figures 14.18 and 14.19).

Figure 14.18 Continuous training sessions

Session	Intensity	Time	Type	Venue
1	LSD HR = 140	30 min	Running	Street run
2	Fartlek	20 min 30 s surge every 2.5 min	Running	Park run

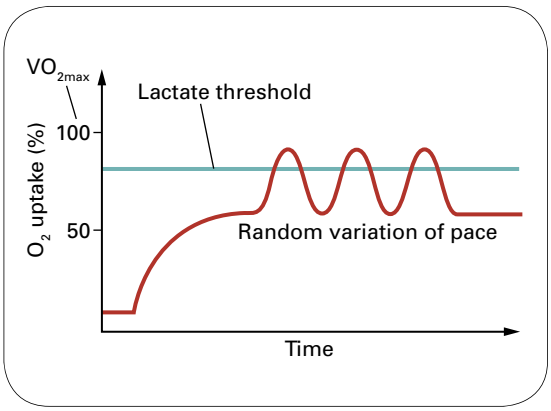


Figure 14.19 The effect of Fartlek or speed play on VO_2

Learning experience

CONTINUOUS TRAINING

Refer to figure 14.18, which outlines two types of continuous training.

1 Have you participated in either of these types of continuous training?
2 If you have, which did you prefer?
3 In your own time, implement one of the continuous sessions and compare your experiences with those of your classmates. Points to consider for your discussion:
   - Could you complete it? If not, how did you modify the session (e.g. time, intensity)?
   - What was your heart rate before, during and after the session? (Wear a heart-rate monitor if you can access one or take your pulse.)
   - Did you enjoy the session and would you make this type of continuous training part of your regular training program?

This information can be shared with the class as part of a discussion or by using the school's online network in the form of a blog.

Your teacher may even organise for you to do the sessions as a class learning experience.

Learning experience

FARTLEK AND VO_{2max}

Refer to figure 14.19, which shows the effects of Fartlek training on the athletes VO_{2max} (or volume of oxygen consumed, delivered and utilised by the body).

1 How many surges did the athlete make?
2 Describe what you think happened to the intensity of the session towards the end of the training?
3 What system is being utilised when the graph drops below the line after peaking?
4 Describe in your own words the relationship between exercise intensity, lactate threshold 2 and VO_{2max}.

Time

The minimum length for an effective aerobic session is 20 minutes of continuous activity. For those interested in health-related fitness, 30 minutes is sufficient as a maximum, and for those interested in sport-related fitness, the specific sport may demand sessions up to 1 hour long or over 10 km, depending on the findings of your games analysis.

Type

To develop aerobic capacity using continuous training, the only suitable activities are whole-body activities that use large muscle groups and can be kept up for at least 20 minutes. These activities are:

- running and jogging
- cycling

- swimming
- power walking
- fitness classes
- in-line skating.

Individual sports (such as tennis, squash and badminton) or team sports (such as soccer, hockey, football and basketball) all require aerobic fitness, but do not really develop aerobic fitness. Although these sports are intermittent (stop–start), a well-developed aerobic capacity is essential to prevent a build up of lactic acid and allow rapid recovery between efforts.

Figure 14.20
Water aerobics classes are another form of continuous training.

Learning experience

WATER AEROBICS: IS IT FOR YOU?

1 Have you ever participated in a water aerobics class?
2 What is your perception of water aerobics as a form of continuous training?

Interval training

Interval training is a form of training during which work intervals are followed by rest intervals. It is designed to improve speed, power and agility, and aerobic and anaerobic capacity.

Interval training is the best way of improving your ability to play team sports such as netball, soccer, basketball, football or field hockey. These sports all involve periods of activity or work (e.g. chasing the ball, followed by periods of rest or recovery when the ball is down the other end of the field).

Key variables in interval training

It is possible to develop all three energy systems during interval training by altering the length of the work interval. It is also possible to make interval training highly specific to a particular energy system or sport, as well as adhere to the overload principle by manipulating the key variables involved in interval training. These are:

- work interval
- recovery interval
- sets
- repetitions.

Work interval

The work interval is the distance and duration of the work effort, e.g. running 400 m in 70 seconds. The intensity of the work interval must activate the energy systems that require improvement or are specific for the activity for which you are training. For example, to train the three energy systems requires the athlete to work at an MHR of:

- ATP-CP 90–100% (T5)
- Lactic acid 85–100% (T4–T5)
- Aerobic 70% (T2–T3).

The main concept of interval training is to enable the athlete to work at higher intensities, because a rest period will follow. Therefore, the general guide is that during the work interval the heart rate should always reach lactate threshold 2 or above (≥85% MHR).

Recovery interval

The recovery interval is the time between work efforts. The recovery interval can be passive (standing) or active (walking or slow jog). The specific energy system and fitness component being targeted will determine what the heart rate should be during the recovery interval. For example, a sprinter will complete intervals with complete recovery so they can work at the highest intensity, but a 400 m runner may reduce recovery to tax the lactic acid system and increase lactate threshold 2 levels, so that they will able to work harder for longer during the race. As a general guide, 140 bpm or less would be appropriate, but this will differ for each individual athlete.

Set

A set is a group of work-and-recovery intervals. For example, a set of 10 intervals of 50 m each is written as 10 × 50 m.

Repetition

Each individual work interval is called a 'repetition' (rep.). For example, the set of 10 × 50 m is 10 repetitions of 50 m each.

Learning experience

PHYSICAL EXPERIMENT: INTERVAL TRAINING AND HEART-RATE RESPONSES

The theory behind interval training is that the athlete can perform work at a higher intensity, stressing the anaerobic systems and then utilising the aerobic system during the recovery intervals.

Sessions

1. 1 × 400 m (max effort)
2. 10 × 40 m (max effort)

Equipment

- stopwatch
- heart-rate monitors
- tape measure

Procedure

1. On separate days perform the following training sessions and record heart rates as described in the table below.

Training session	Resting HR	Resting HR before activity	Resting HR after activity	Post-ex HR	Post-ex HR 1 min	Post-ex HR 5 min
1 × 400 m						
10 × 40 m						
Sprint 1 2 3 4 5 6 7 8 9 10						

2. On two separate graphs show the results of heart-rate changes (*x*-axis) as a result of recovery and time (*y*-axis) for the two sessions.
3. Based on your results, what interpretations can you make about the effect of the two types of training on your heart rate during the work effort and recovery?
4. In which training session did you recover more quickly? Why do you think this was the case?
5. What energy system was being targeted in both training sessions?

Types of interval training

There are basically three types of interval training: long interval, intermediate interval and short interval. Figure 14.21 gives an example of an intermediate interval training session.

Figure 14.21 An example of intermediate interval training

Set	Repetitions	Distance (m)	Time (s)	Recovery (s)	Work-to-rest ratio
1	10	100	15	45	1:3
2	5	200	32	96	1:3

Long interval training

Figure 14.22 gives an example of a long interval training session. This training includes maximal aerobic intervals and lactic acid tolerance intervals. It develops both aerobic and anaerobic energy pathways and is typically used by:

- athletes involved in sports with efforts of 1–6 minutes
- middle-distance athletes
- team-game athletes.

Note that, during all recovery periods, the athlete should be encouraged to continue with light activity, as lactic acid removal will be faster than when recovery is inactive.

Figure 14.22 An example of a long interval-training session

Component	Description
Warm-up	Jog 1–2 km; stretching exercises
Set 1 2 × 400 m; easy pace in 80–90 s	2–3 min jog recoveries; work-to-rest ratio 1:1, 1:2
Set 2 2 × 800 m; easy pace in 2.45–3.00 minutes	5–6 min jog recoveries; work-to-rest ratio 1:2
Set 3 2 × 400 m; easy pace in 80–90 s	2–3 min jog recoveries; work-to-rest ratio 1:1, 1:2
Cool-down	Jog 1–2 km
Total distance to be approximately 7 km	

Learning experience

PHYSICAL EXPERIMENT: INTERVAL TRAINING

Refer to figures 14.21 and 14.22.

1. Participate in one of the example sets in either the intermediate or long interval training sessions.
2. Record your heart rate during the session and discuss your results with classmates at the completion of the physical learning experience.
3. Devise a graph that shows heart rate (*x*-axis) and duration (*y*-axis) for the session you completed.
4. Based on the heart-rate results, what assumptions can you make about the training?

Intermediate interval training

Intermediate interval training is designed to develop the lactic acid energy system, which is essential for events such as 400 m and 800 m runs, 200 m and 400 m swims, and team sports played on large fields or during which the player has little rest.

This type of interval training results in an increase in lactate concentrations in blood and muscle, and muscular fatigue due to the effects of lactic acid build-up. It therefore must be followed by recovery training or rest days.

Short interval training

Short interval training develops the phosphate energy system, which is essential for successful performance in most team sports. Since the intervals are shorter, the work intensity is increased and the recovery periods are lengthened to allow for complete recovery of the phosphate stores (ATP and CP) and removal of lactate. Short interval training sessions can also include agility training, such as shuttle runs, obstacle sprints, and sprints starting from lying, sitting and kneeling positions.

Interval training variations

Other methods of training that incorporate the interval concept include:

- weight training
- circuit training
- game-based training
- plyometrics.

These methods add variety to a training program and can target a wide range of skills, sport-specific strategies and tactics, fitness components and energy systems.

Advantages of interval training

The great advantage of any type of interval training is that it allows high-intensity work to be performed without the fatigue associated with a continuous session of equal intensity. For example, equal work can be gained from:

- one continuous 400 m sprint in 60 seconds (high fatigue)
- 10 repetitions of 40 m, each in 6 seconds, with a 30-second recovery interval (low fatigue).

SNAPSHOT

Skill-based conditioning games (game-based training)

This type of interval training is beneficial in team sports where developing skills, strategies, tactical awareness, team cohesion and communication are just as important as the components of fitness and the energy systems that are required in the game. A good coach can incorporate skills training into small games and drills that require a game-related physical effort. They are hard work for the athlete but they are also fun.

This method of training also saves time as it is multifaceted. The focus is on fitness specific to the game and the appropriate periods of work and rest, as well as the skills or strategies and decision making when under pressure and fatigued. The coach can manipulate the variables of the skill-based conditioning games to target any weaknesses in the team (skills or strategies) and also produce a training effect. These games are often of high intensity and short duration, and target fitness components such as speed and agility.

To ensure that training using this method is effective, the coach needs to have a good understanding of the intensity requirements during the game and of the particular weaknesses either in strategy or skill that they would like to address with each game. This is where comprehensive game analysis from video feedback and statistical analysis would prove to be useful. For example, the coach might analyse movements during the game to see what fitness components and energy systems dominate, and then develop a game specific to those findings.

Some examples of game-based training in soccer could be:

- 4 sets of 2-a-side game in a field 30 × 20 m and a work-to-rest ratio of 1:1 (2 min on, 2 min off)
- 8-a-side game in a field 60 × 40 m, 10 min on and 1.5 min off.

Smaller side games generally work the athlete at 90–95% HR_{max} and the effect is an increase in VO_{2max}. Games with 5 or more players generally mean players are working at 85–90% HR_{max}, which has the training effect of targeting lactate threshold 2.

This type of training can also be used as part of a team warm-up, as it is sport-specific, dynamic and helps to promote team cohesion and bonding before a game.

Does skill-based training improve fitness? Gabbett et al (2008) recently conducted a study comparing the effectiveness of skill-based training and traditional conditioning for improving speed, agility, muscular power and aerobic capacity in rugby league players. The players completed a 9-week in-season conditioning program of either entirely skill-based conditioning games or traditional conditioning (i.e. running activities with no skill component).

Results revealed that skill-based conditioning was effective in improving 10, 20 and 40 m speed, muscular power and aerobic capacity, whereas traditional conditioning improved only 10 m speed and aerobic capacity. Although both groups won the same number of games, the skill-based group scored more points in attack. These results suggest that skill-based training could be a good alternative to traditional methods of coaching and have a wider array of benefits to the individual and team.

As an athlete which would you prefer for a training session: 100 100s or 3–4 skill-based games with your team?

Source: Gabbett, T, King, T, and Jenkins, D, 'Applied physiology of rugby league', *Sports Medicine*, 2008, 38(2) pp.119–38 and Marshall, J, 'Skills based training: female games players. peak performance' (accessed online 22 November 2009 <www.pponline.co.uk/encyc/skills-based-training-females-games-players>)

Learning experience

PHYSICAL TASK AND EVALUATION

Working in pairs, plan a game-based interval training session for the physical activity you are currently studying.

1 Research the fitness and skill/strategy requirements of the game to develop the training objectives, considering:
   - **a** the predominant energy system/s and fitness components
   - **b** the probable work-to-rest ratios experienced during a competitive game
   - **c** the skills/strategies required for the outcome of the game to be successful.

Note: You may already have conducted some games analysis or research regarding this.

2 Create a game that will target these three parameters. Ensure you consider the following so your game will be effective:
   - field/court size
   - number of players
   - targeted skills and strategies
   - dominant fitness components and energy system(s)
   - intensity (duration, work: rest ratios, sets)
   - equipment.

3 Share your game with a small group and discuss how effective each pair's game will be in achieving the training objectives. Modify if necessary.

4 In small groups implement the game in class time. Gather feedback to evaluate its effectiveness and if necessary modify to ensure it is specific to the physical activity, energy demands and fitness components. To gather this data it may be necessary to video the game, ask participants to wear heart-rate monitors or survey the participants/teacher.

5 Evaluate how successful the game was in meeting the training objectives. (Your teacher may wish you to provide oral or written evaluations in the form of a small presentation or written report.)

Resistance training

Resistance training is the key to developing the fitness components of muscular strength, power and endurance. For sport-related fitness programs, resistance training is essential for:

- improving fitness and skill performance
- protecting players against injury
- improving body composition by increasing muscle tone and mass.

There are two types of resistance training:

- weight training, which involves performing a series of resistance exercises, using either free or machine weights to stress the required muscle groups
- resistance callisthenics, which involves performing a series of specific resistance exercises using gravity acting on the body to provide the resistance.

With any resistance program, it is important to begin with light resistance and a general program. However, once you have established a good base, increase resistance progressively and use exercises specific to your particular sport. These exercises should mimic the specific movements of the sport, e.g. throwing or kicking actions. When designing a resistance program, it is essential to have an understanding of how muscles and tendons work so the right exercises can be selected to achieve the desired effect.

Weight training

Weight training is the most common form of resistance training. This and other types of resistance training rely on an understanding of the following key terms:

- A repetition (rep) is one performance of an exercise, e.g. one push-up or one bicep curl.
- A set is a number of repetitions of an exercise performed consecutively without rest, e.g. 8 bicep curls is 1 set of 8 reps, or 1 × 8.

Source: Visualcoaching® Pro software, <www.visualcoaching.com>

Figure 14.23
Weight training: incline cable bicep curls are an interesting variation on a common exercise, the bicep curl.

- A repetition maximum (RM) is the maximum weight you can lift a certain number of times, e.g. 1 RM is the maximum weight you can lift once; 10 RM is the maximum weight you can lift 10 times (but not 11).

Weight training is based on performing sets of RMs. Overload is achieved by increasing the weight at regular intervals.

Learning experience

WHAT'S THE DIFFERENCE?

1 If you have the opportunity and it is appropriate, complete:
   - 3 × 10 sets of the incline cable bicep curl, and
   - 3 × 10 sets of the traditional bicep curl. (Ensure this is completed on a different day and that the weights are appropriate for your level.)
2 Compare the difference between the two exercises. What are the advantages or disadvantages of each? Which did you think was more effective and why?
3 Share your experiences and opinions with your classmates.

Isotonic weight training can be used to develop muscular strength, muscle bulk (hypertrophy), power or local endurance by manipulating the weight lifted, the number of reps, the number of sets and the speed of movement. The prescriptions for developing these fitness components are given in figure 14.24.

Figure 14.24 Guidelines for resistance training to improve specific fitness components

Fitness	Weight % 1 RM or RM	Reps	Sets	Speed	Rest between sets	Frequency per week component
Strength	Very heavy 80–95% or 2–6 RM	2–6	5–12	Slow	3–5 min	3–4
Bulk	Heavy 70–80% or 6–12 RM	6–12	3–10	Slow	1–3 min	3–6
Power	Medium 60–80% or 8–20 RM	2–10	3–8	Fast	3–5 min	3–4
Endurance	Light 40–60% or 20–40 RM	15–40	2–5	Fast	1–3 min	3–6

A number of key points must be stressed when planning and participating in a weights program:

- The exercises in the program must be arranged so that the same muscle groups are not stressed by several exercises in succession. This is called cycling of body parts (see figure 14.25).

Figure 14.25 Order of exercises to rotate work on different muscle groups in a weight-training program

Exercise	Muscle group
1 Chin-ups	Back
2 Incline bench press	Chest
3 Squats (half)	Legs
4 Crunches	Abdomen
5 Seated press	Shoulders
6 Seated rowing	Back
7 Flat flys	Chest
8 Leg extension	Legs
9 Hanging leg raises	Abdomen
10 Bicep curl	Arms

- If the ultimate aim of the program is to develop muscular strength, it should begin with an endurance phase followed by a hypertrophy (bulk) phase, and then the strength phase (see figure 14.26). When targeting strength, the length of recovery between sets is longer.

Figure 14.26 Summary of optimal sequences for the development of muscular strength and muscular power

Fitness component	Sequence of phases to be improved
Strength	Endurance phase Hypertrophy phase Strength phase
Power	Endurance phase Hypertrophy phase Strength phase Power phase

- If the ultimate aim of the program is to develop muscular power, strength should be developed before power. Therefore the program should have four phases: endurance, hypertrophy, strength, then power (see figure 14.26).
- Solid gains in muscle strength can be made in 6 weeks of training.
- Strength training programs and intensities must be varied periodically to prevent staleness and stimulate improvement. For example, microcycles requiring different intensities and volumes of training should be spaced throughout the program (see figure 14.27).

A sample weight-training program is given in figure 14.28.

Figure 14.27 The alternation of high-volume and high-intensity microcycles to improve strength

Weeks	1–2	3–4	5–6	7–8	9–10	11–12
Reps	6–8	4–6	5–7	2–4	3–5	1–3
Sets	4	5	5	6	6	8
Intensity	78–82%	82–88%	80–85%	88–95%	80–85%	90–95%
Volume (total reps)	24–32	20–30	25–35	12–24	15–30	6–24

Figure 14.28 A sample isotonic weight program with the first session filled in

	Date: 28 May													
No.	**Movement**	**Maximum**	**Wt (kg)**	**Rep**	**Wt (kg)**	**Rep**	**Wt (kg)**	**Rep**	**Wt (kg)**	**Rep**	**Wt (kg)**	**Rep**	**Wt (kg)**	**Rep**
1	Incline bench press	3 × 10 RM	20	10 10 8										
2	Lat pulldowns	3 × 10 RM	20	10 10 8										
3	Lateral flys	3 × 10 RM	5 each	10 8 8										
4	Step-ups	3 × 20	10 each	20 20 15										
5	Barbell curls	3 × 10 RM	10	10 9 8										
6	Cable crossovers	3 × 10 RM	5 each	10 7 5										
7	Bent dumbbell rowing	3 × 10 RM	5 each	10 10 5										
8	Seated press	3 × 10 RM	15	10 7 5										
9	Calf raises	3 × 10 RM	20	10 10 9										

Learning experience

WHAT DOES IT MEAN?

Refer to figures 14.25 and 14.28, which outline examples of resistance training programs. In pairs, complete the following:

1. If you were given these exercises to do in a gym, would you know what to do?
2. Conduct internet research to check your understanding of what the exercises look like, the machine or equipment you would use and how effective they are in targeting the muscle group.
3. Could you do these programs in your school gym? If not, modify the exercises so you could do a resistance program targeting the same muscle groups in your school gym or with your own weights equipment at home (if your school does not have a gym).
4. There is often a higher ratio of males to females in the weights section of gyms and fitness centres. Why do you think this is the case? What would you advise female athletes about the benefits of resistance training?

Learning experience

RESISTANCE TRAINING

Your teacher may organise for you to complete the resistance training session outlined in figure 14.28.

1 Adjust the weights for each exercise to ensure you are not lifting a weight that is too heavy for you. Your teacher will be able to assist you with this.
2 Record the weight and number of reps you were able to do.
3 After you complete the session, discuss with your peers how you think you went. Consider:
   - if you enjoyed the session
   - if it is similar to what you do outside of school.
   - how you could vary some of the exercises to increase
     - the range of motion
     - the angle of the movement
     - the degree of difficulty of the exercise.

   Refer to figure 14.24 as an example of how the bicep curl has been varied by using a different machine and changing body position.

Isometric resistance training

Isometric resistance training involves contracting a muscle against an immovable resistance. There is no joint movement, but the muscle does exert force. Isometric training is really valuable only for:

- sports such as judo, wrestling or gymnastics, where force needs to be exerted in static positions
- sports such as tennis, softball or hockey, where hitting implements must be gripped tightly
- injury rehabilitation.

Strength gained in isometric training is specific to the joint angle; therefore, coaches must select angles that are specific to the sport being trained for.

To develop strength using isometrics, hold a maximal contraction against an immovable force for 6 seconds, recover briefly, and repeat 10 times, using two or three joint angles. It should not be used as the only form of strength training.

Resistance callisthenics

Resistance callisthenics are exercises such as push-ups or sit-ups where the resistance applied comes from gravity acting on the body. Resistance callisthenics can be overloaded and manipulated to improve muscular strength, power and endurance by increasing the number of reps or by progressively increasing the resistance to movement. For example, see figure 14.29 for the progressive increases in resistance made possible by altering body position when doing push-ups.

Source: Visualcoaching® Pro software, <www.visualcoaching.com>

Figure 14.29
Variations of the push-up that can increase or decrease resistance (difficulty) based on body position

Learning experience

WHICH IS HARDEST?

Refer to figure 14.29, which shows images of four different types of push-ups.

1. Rate the four push-ups from easiest (1) to hardest (4).
2. Perform each of the push-ups (rest after each exercise).
3. Are there any changes you would now make to your ratings? Explain why.
4. Select four different levels of sit-up exercises (easy to hard) and give them to a classmate to perform. Did they agree with your ratings of the exercises?

Safety precautions

Contrary to popular belief, resistance training is both safe and beneficial for pre-adolescents (10–14 years old), provided it is supervised, the correct training technique is taught, and weights of 10–15 RM are used.

For any resistance training program, there are common safety precautions and training guidelines that must be followed:

- Always stand close to the bar.
- Bend your knees to pick up the weight.
- Keep your back straight and your head up. (Never hollow or round your back.)
- Use your legs to lift.
- You must breathe during a set. Breathe in during the lowering (relax) phase of each repetition and breathe out during the press (effort) phase of each repetition.
- Always use correct technique. Do not cheat in an exercise in order to lift more.
- Always use a full range of movement so that flexibility is improved rather than lost.
- Train large muscle groups first.
- Allow 48 hours between workouts for any given muscle group.
- Machine weights are safer because the movement is more controlled and performed in the correct range of motion, therefore they are good for beginners. Free weights allow movements more specific to sporting actions, a greater range of motion and more weight to be lifted. Cable weights allow movements to be performed under constant load.

Learning experience

COMMON WEIGHT EXERCISES AND THE COMMON ERRORS IN PERFORMING THEM

If you have been to a gym you might have noticed the same exercises being done and of even greater concern the same errors in form or technique when they are performed. If you have not spent much time in a gym or weights room, talk to a classmate or friend who has.

1 List four exercises that you see commonly performed at gyms, e.g. the squat.
2 Identify the common errors that you see when individuals perform these exercises.

Plyometric training

Plyometrics is a form of training designed to improve muscular power in sports where an explosive powerful movement is demanded, such as hopping, jumping, skipping and bounding. This includes sports such as basketball, netball, volleyball and Australian Rules football. Other sports such as rowing, athletics (sprinting, jumps, hurdles, throwing) and weightlifting also benefit from this type of training.

Plyometric exercises develop strong fast movement by stretching muscles to their fullest extent and then suddenly contracting them.

Plyometric exercises invoke a rapid eccentric (lengthening) contraction followed immediately by a forceful concentric (shortening) contraction. In this type of training it is the speed of the contraction that is essential, as it aims to increase power, which is a combination of speed and strength. This can also be referred to as explosiveness. In a sprint start, for example,

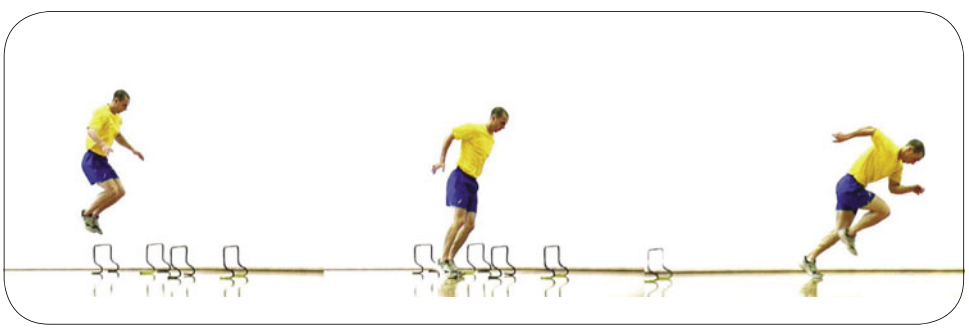
a maximal force is required to get the body from a stationary position to full speed as quickly as possible.

A protective mechanism known as the 'myotatic reflex' (stretch response) protects muscles from being overstretched. This myotatic reflex stimulates a forceful opposing contraction to the stretched muscle. The greater the stretch put on the muscle from its resting length immediately before the concentric contraction, the greater the load the muscle can lift or overcome. In other words, a muscle contracts more forcefully and quickly from a prestretched state than from a relaxed state.

A prestretch (eccentric contraction) in plyometrics represents stored (potential) energy that can be transferred immediately into the kinetic energy (work) of the following contraction. Human muscle also has the ability to store and transfer elastic energy. The natural tendency to bend the knees before performing a standing long jump is an example of this use of elastic energy.

With proper training, you can improve your ability to store and transfer energy. The elastic properties of your muscles, coupled with the reflex mechanism caused by the rapid eccentric contraction, produces a more forceful voluntary concentric contraction than you could achieve by performing a concentric contraction alone.

Should plyometrics be a form of training used by children? Consider the activities that are performed daily in playgrounds and parks: running, jumping, hopping and skipping. All are forms of plyometric exercises. As long as the child is taught good form and is not overloaded, then plyometrics is an excellent way to switch on the fast-twitch muscle fibres and improve strength, balance, agility and power, as well as being a fun way to do some different training.



Source: Visualcoaching® Pro software, <www.visualcoaching.com>

Figure 14.30
Barrier jumps acceleration is a plyometric exercise that develops speed and power.

Learning experience

DECREASING COMPLEXITY?

Refer to figure 14.30 and explain how you could modify the exercise so that it was less advanced (reduce intensity) but still focused on speed and power.

Guidelines for plyometric exercises

Although the exercises that can be included in a plyometric program are limited only by your imagination, it is worth following these guidelines:

- Perform exercises specific to the sport for which you are training, to ensure the adaptations that are made will enhance the action, movement pattern and force required in your sport. For example, in basketball some useful exercises to increase jumping ability would be starting with bodyweight squats and standing jumps and then advancing to single leg dips and single leg hops. Exercises should progress from low intensity to high intensity, i.e. alternate-leg bounding should precede single-leg bounding.
- Due to the heavy load of plyometrics on the body, it is advisable to have 2–3 rest days between sessions and for children to only do plyometrics training twice per week.
- The optimal volume for beginners is 3 to 4 drills per workout, 2 to 6 sets per exercise and 5 to 10 reps per set. Remember not all exercises require the same number of reps due to their intensity.
- Perform the exercises at the correct tempo. Where appropriate, plyometric exercise should be fast so the appropriate adaptation of power (strength and speed) occurs.
- Add weight (vest or free weights) only when the athlete is stronger and familiar with the movement patterns. Add only 7–15% of body weight, e.g. 5–10 kg for a 70 kg person.
- Plyometric exercises require skill and must be practised at low intensity to develop coordination before beginning complex exercises or high-intensity sessions.
- Ensure there is adequate rest between each set and exercise. This will influence energy recovery of lactic acid and ATP stores as well as quality of training. For adults a recovery period of 2–3 minutes is appropriate. Young athletes may get bored during long recoveries so this can be reduced to 30–90 seconds as long as the quality of performance is not affected.
- When fatigue interferes with technique, you should stop.
- Include plyometrics early in the workout or on their own to ensure the athlete is fresh and has the energy to perform at the appropriate intensity and with correct form.
- Base the exercises on the equipment that is available, e.g. medicine balls, cones, low hurdles, depth-jumping boxes or stairs.
- Vary the exercises in order to maintain motivation and prevent boredom.

Plyometrics is also an inexpensive form of training and a huge variety of exercises can be performed with minimal equipment such as medicine balls and marker cones.

Learning experience

WHAT CAN I DO?

1 List six plyometric exercises that you could do using only marker cones.
2 Share your exercises with a classmate.

Safety precautions

Plyometric training is productive and safe, provided all guidelines are followed:

- Warm up and cool down appropriately.
- Achieve a good level of conditioning before beginning plyometrics:
  - endurance to prevent improper technique caused by fatigue
  - strength (developed through weight training) to help reduce injuries to the muscles, tendons and ligaments.
- Avoid overtraining. Plyometric work should be performed for quality not quantity.
- Allow for adequate rest. Allow 1–3 minutes between sets and at least 48 hours between workouts.
- Use a proper progression of exercises, e.g. start with two-leg jumps, progressing to one-leg hops.
- Perform plyometric exercises on a resilient surface, such as grass or a firm mat.
- Wear proper athletics shoes.

Plyometric exercises

Some exercises that can be used in plyometric training are described below. (See also figure 14.31).

Spot hopping

Hop vertically on the spot as rapidly as possible.

Vertical jumps

Taking off from one foot or two feet, jump for maximum height.

360-degree jumps

Taking off from two feet, make a 360-degree jump.

Multiple long jumps

Taking off from two feet, jump for distance, or do 10–12 jumps over a distance of 20–30 m.

Tuck jumps

Taking off from two feet, jump up and grab the knees in the air.

Heel kicks

Taking off from two feet, kick your heels back to touch your hands in the air.

Lateral hops

Taking off from one foot or two feet, jump over each cone in a row of cones and back again (see figure 14.31).

Bounding

Bound forwards, keeping the knees high and using a powerful leg drive. Strive to cover a distance of 4 m per bound.

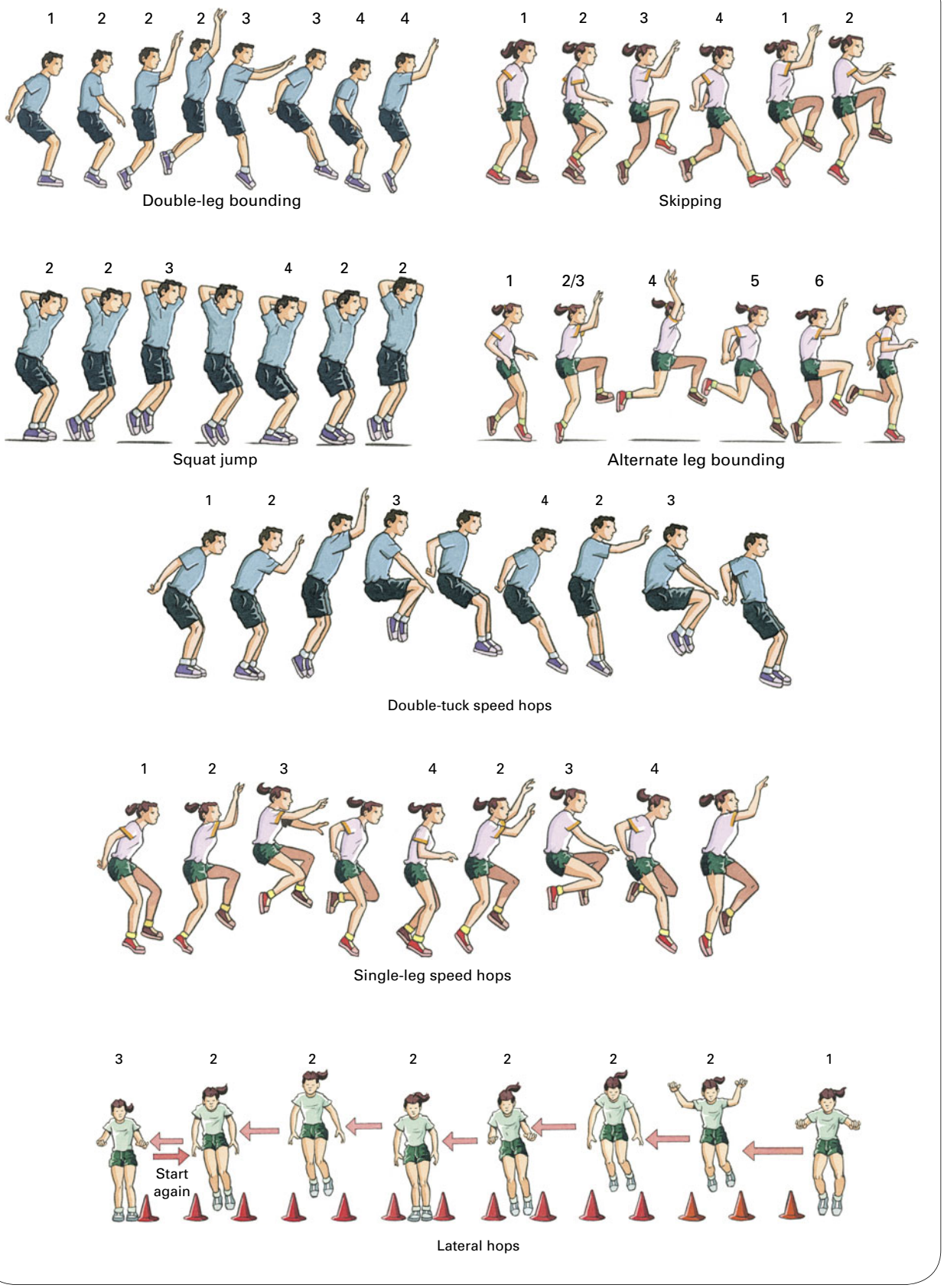


Figure 14.31 A range of plyometric exercises

Double-leg back and forth

Taking off from two feet, jump over a cone forwards then backwards.

Medicine ball blasts

Sit with your feet against a wall. Throw a medicine ball up to rebound off the wall. As you catch it, blast it back up as high as possible.

Clap push-ups

Push up to leave the ground, clap, land and repeat.

Triple jump variations

After a five-pace run-up, do one of the following combinations:

- two hops, a step and a jump
- two hops, two steps and two jumps
- four hops, a step and a final jump for height.

Depth jumps

Do one of the following combinations:

- From a standing position on a box, jump straight down (not forwards), and land on the balls of the feet before the rest of the feet touch the ground. Immediately on landing, touch the ground and jump explosively straight up as high as possible. Climb back onto the box and repeat 6–10 times.
- Stand about 45 cm away from a box and jump straight up onto it. Immediately jump back down to the original position and then jump right back up again. Repeat 6–10 times.

Learning experience

PLYOMETRICS AND COMPLEXITY

1 Consider the fitness components of speed, agility and power.

Select one of these fitness components and research plyometric exercises that would specifically target it.

2 Select three of those plyometric exercises and organise the order in which you would perform them (least complex and intense to most). A sample table below could be used to help you organise the exercises.

Fitness component or skill	Recommended sets and reps	Easy	Moderate	Hard
Modifications				

3 Compare your exercises with a classmate.

4 Implement the exercises and evaluate if they are specific to the fitness component and progress in order of complexity and intensity. Modify if necessary.

Note: Instead of targeting a fitness component, this activity could be done by targeting the specific skills involved in the physical activity you are currently participating in. For example, in Australian Rules football, basketball and volleyball jumping ability is important.

Learning experience

SMALL GROUP ACTIVITY: SPORT-SPECIFIC PLYOMETRICS SESSION

1 Working in pairs, create a sport-specific plyometric training session (3–4 exercises) that will enhance performance in the physical activity you are currently participating in. You will need to:
   - identify the main fitness components required in the physical activity (speed, power, agility, strength)
   - consider the training and safety guidelines
   - conduct further research through your library or the internet
   - in small groups (4–6) implement your training session.

2 Working in a group, implement your plyometric session during a lesson. Consider using heart-rate monitors, video evidence or feedback surveys to gather data on the effectiveness of the session in targeting fitness components, energy systems and individual needs.

3 Working individually, write an essay of 400–600 words evaluating the effectiveness of the plyometric training session in targeting the requirements of the physical activity and outline any modifications you would make to increase its effectiveness. Justify your decisions with a range of primary and secondary data.

Exercise ball training

Although the exercise ball has been used in rehabilitation programs for many years, only recently has its potential as a training tool been explored. (It is also referred to as a fitball or Swiss ball.) Exercise balls come in a variety of sizes, so it is important to get the right one for you. A major benefit of the exercise ball is that it can develop core stability (i.e. a more stable torso). Having core stability enables more efficient movements, because good postural technique is more energy efficient, and the risk of injury is reduced. For example, dancers are taught that controlled movements of their extremities (arms and legs) are a result of a strong core or 'centre'. As well as exercise ball classes, many fitness centres offer classes in Pilates, yogalates, yoga and power yoga, which also focus on the stability of the trunk through strengthening the core muscles. Understanding the musculature of the core will be of benefit when planning your exercise ball training or selecting core strength exercises. When the term 'core stability' or strength is used many think of the abdominals. However, the core actually refers to the many different muscles that stabilise the spine, pelvis and shoulders.

Learning experience

HOW DOES IT WORK?

Through the library or internet research the musculature of the core (spine, shoulders, pelvis) and report on:

- the number of muscles involved in supporting the core
- the movements they perform
- the muscles you had heard of
- exercise ball moves other than those shown on pages 345–347
- other core strengthening exercises.

To use the exercise ball effectively, you must adhere to the following guidelines:

- Detail to form is critical. Many activities look very simple, but the slightest deviation can alter the exercise, resulting in strength deficits and muscle imbalances.
- Once the muscle and nerve systems become fatigued, you should rest; otherwise the quality of exercise will be poor and the outcomes no longer positive.
- Care must be taken not to overload athletes. When using the exercise ball, even the strongest athlete may tire quickly. Athletes with a strength base developed through traditional methods often have under-trained stabilisers.
- The exercise ball must be the correct size. When the athlete is sitting on the firm exercise ball with the feet flat on the floor, their thighs should be horizontal, or slightly above.

Benefits of exercise ball training

Physical educators, coaches and athletes can complement their existing programs through the gradual introduction of exercise ball activities into their training routines. It is suggested that you begin with the simple exercises and build these into complex movement patterns. Once the athlete is able to perform an exercise in the stable environment, the coach can adapt it to the unstable environment of the exercise ball, providing:

- improved core stability
- increased prime mover strength
- improved kinaesthetic awareness
- improved balance
- increased dynamic flexibility.

This will all lead to greater functional movement.

Swiss ball exercises

PAUL CHEK

One of the benefits that Swiss ball exercises possess over more traditional exercises is that they allow movement in all three planes: the sagittal, transverse and frontal planes. Think of the many exercises that are found in typical training programs—bench press, shoulder press, lat pull down, low row, leg press, hamstring curl etc. These are all sagittal-plane dominant, yet how many sports are played without twisting, side bending or rotation? None (unless you are a professional tiddlywinks competitor)!

… Here we take a detailed look at three exercises, the dominant planes of motion, and how they tie into these concepts.

Supine lateral ball roll

This is what I call a 'big bang' exercise, because strength is gained in all three planes of motion at the same time. On the surface it is a very simple exercise, but also a very powerful one. This exercise is an excellent example of … core stability, strength and control, stabiliser strength and building strength at end ranges of motion. Use this exercise to condition athletes to withstand rotational forces, via the co-activation of many agonist and neutraliser muscles (see figure 14.32).

Figure 14.32
The supine lateral ball roll

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Start position

- Lie supine on the ball with the upper back, shoulders and head supported by the ball. Feet placed on floor, with knees at 90° and hips fully extended until the trunk and thighs are parallel to the floor.
- The deep abdominal wall is activated by gently drawing the belly button in towards the spine.
- Arms are extended, parallel to the ground, with the palms facing up. A wooden dowel rod resting lightly on the hands can assist in cueing. Make sure the athlete does not grasp the rod.

Performing the exercise

- The athlete rolls laterally on the ball, keeping the hips and shoulders parallel to the floor. Start with four to five small movements to each side as a warm-up.
- When the core is thoroughly warmed up, the amplitude of the movements can be increased.
- To support the head, the tongue must be held in the physiological rest position on the roof of the mouth behind the front teeth. To find this position, simply swallow and hold the tongue there. Failure to do this overworks the neck muscles, leading to forward head posture and posture imbalances.
- As the athlete increases in strength, they increase the magnitude of the roll. Adding a 3-count hold at the furthest point also creates a greater challenge. At this end point, there is a large torsional load between the shoulder and the opposite hip, which has to be counterbalanced by the hip extensors, core musculature and shoulder girdle.
- As the athlete rolls laterally, transversus abdominis (the deepest muscle of the abdominal wall) activation should increase in proportion to the demand for stabilisation.

Common errors

- The arm drops toward the ground, seen by the dowel rod losing its parallel relation to the floor. The arms should stay level, with the fingertips just visible from the corner of the eyes.
- The hips drop and twist towards the floor on the side opposite the supported shoulder. Keep the hips fully extended and the body in a flat tabletop position.
- The head lifted up. The neck and head should stay in the same horizontal plane as the trunk and hips at all times, on or off the ball.
- Over-recruiting and not graduating the transversus abdominis activation.

Suggested reps and sets

- 1 × warm-up set of 8–10 each side, small movements
- 2–3 sets of 8–10 each side, with a 1–3 second hold at each end

Prone jackknife

Great for integrating shoulder, core and hip flexor strength, this exercise also teaches hip–back disassociation, which is the ability to move the legs freely while maintaining a stable pelvis and neutral spine, a vital skill in sports. Athletes with poor hip–back disassociation will cause excessive wear and damage to their spines.

Start position (see figure 14.33)

- In a push-up position with the feet on the Swiss ball and hands underneath the shoulders. The head stays in line with the spine.
- Activate the deep abdominal wall by drawing the belly button in towards the spine.
- Maintain a neutral spine position, with normal amounts of lumbar and thoracic curvature.

Figure 14.33 Prone jackknife—start

Performing the exercise

- Slowly draw the legs up underneath the body (see figure 14.34).
- The hips should not rise up into the air—this is not a 'pike'.
- Keep the deep abdominal wall activated and maintain the spine in neutral.
- Slowly extend the legs straight to return to the start position.

Figure 14.34
Prone jackknife—drawing up legs underneath the body

Common faults

- Athletes with a faulty recruitment pattern in the core will try to use the rectus abdominis to perform the exercise. This will be seen by the back losing neutral curvature and flexing, often showing as increased kyphosis (forward curvature) of the thoracic spine. The belly button frequently moves away from the spine as the muscle contracts.
- Athletes with a weak core will tend to drop into extension at the start and end of the exercise, as they cannot hold activation of the deep and/or lower abdominals.
- Hips lifted too high—often seen with trunk flexion and rectus abdominus activation.

Modifications

- Those who have difficulty supporting themselves on their hands can use another Swiss ball under the upper body. As they get stronger, the ball can be progressively deflated to provide less support.
- The further away from the body the ball is, the harder the movement.

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- One leg on the ball at a time will decrease the base of support, making the exercise harder and requiring more core stabilisation.

Suggested reps and sets

- 1 × warm-up set of 6–8 reps
- 2–3 sets of 8–12 reps

Side flexion

A pure frontal plane exercise, which can also be used to assess any imbalances between the internal and external obliques (abdominal muscles).

Start position (see figure 14.35)

- Lie sideways over the ball, with the legs split for support. The feet may be anchored against a wall if the floor is slippery.

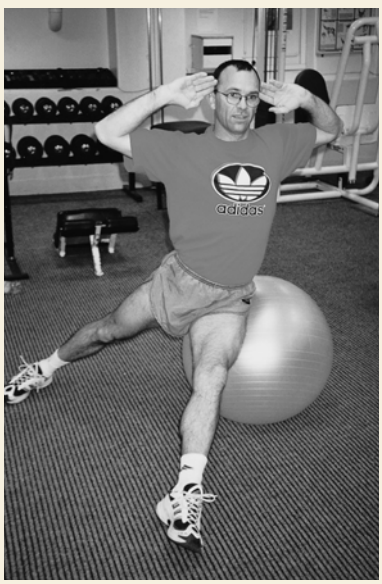

Figure 14.35 Side flexion—start

Performing the exercise

- Side flex up, staying in the frontal plane (see figure 14.36).

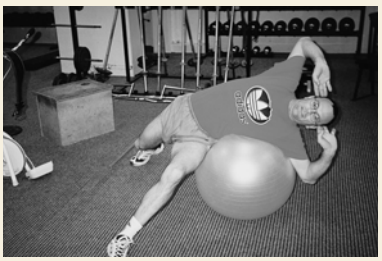

Figure 14.36 Side flexion—end

Common faults

- The athlete will rotate the trunk as they side flex. This generally shows an imbalance between the internal and external obliques. Coach the athlete to stay purely on the frontal plane.
- Loss of good postural alignment, often adopting a round back/forward head posture.

Modifications

- Vary the load—arms to side, arms across chest, fingertips resting by ears, arms extended over the head.
- Change the lever length—as the ball moves further away from the head, the exercise gets harder.
- Use a partner—interlock legs around each other's ball and side flex toward each other.
- Hold a dumbbell for advanced training. This is particularly useful for gymnasts, wrestlers, judokas, hammer throwers and rugby players.

Suggested reps and sets

- 1–2 sets of 6–8 reps

Take care not to overexpose an athlete to pure frontal plane movements as the quadratus lumborum can be strained.

Caution: The body is not accustomed to direct frontal plane loading. Progress slowly and keep the volume low to prevent training injuries!

This is just a small taste of the dozens of exercises that can be performed on a Swiss ball to correct posture and muscle imbalances, increase stabiliser and neutraliser strength and to improve balance, coordination and athletic ability. Ensure that both you as a coach and your athletes receive instruction on Swiss ball training from a skilled source to really gain the most from these versatile training tools.

Source: Chek, P, 1998, 'Swiss ball exercises', *Sports Coach*, vol. 21, no. 3

Learning experience

HOW IS MY FUNCTIONAL MOVEMENT AND CORE STRENGTH?

With a partner perform the three exercise ball activities outlined in the article 'Swiss ball exercises'. This can be done in the school gym, at home or at your local fitness centre.

1. Were you able to perform the suggested number of reps and sets for each exercise?
2. What were your common faults for each exercise (i.e. technique errors, such as dropping or twisting the hips on the supine lateral ball roll)?

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3 Did you experience any delayed onset of muscle soreness (DOMS) post completion of the exercise ball session? For how long did it last?
4 Did you enjoy doing the functional training session and would you include it in your own training? Why/why not?

Circuit training

Circuit training combines both continuous and resistance training, and consists of a series of exercises (usually 10) arranged in order and designed to develop health-related or specific sport-related fitness. It is an excellent training method, with the potential to develop aerobic and anaerobic capacity, strength, power, local endurance and agility. Because circuits are so versatile, they have become a popular form of training for the general performer and the elite athlete. It is common to see a personal trainer using circuit training with a small group at the beach or local park.

Selecting the exercises

If the circuit is designed for health-related fitness, choose circuit exercises that use several muscle groups and vary in terms of intensity, e.g. step-ups, sit-ups and push-ups. This will then enhance both aerobic and anaerobic capacities.

If the circuit is designed for sport-related fitness, exercises that work the specific muscles required for the sport must be chosen, (e.g. a volleyball circuit should include jumping and agility exercises to work the specific volleyball muscle groups).

Circuit exercises should require little or no equipment, and each exercise should be able to be performed rapidly, which rules out flexibility exercises.

Sequence of exercises

Circuit exercises should be cycled so that body parts are given a chance to 'recover' within the circuit. This is done, for example, by having a leg exercise followed by an arm exercise, followed by a trunk exercise and so on.

Types of circuits

Fixed-load circuits

In fixed-load circuits, everyone on the same circuit performs the same amount of work irrespective of initial fitness level or ability, as described in figure 14.37. Here each person begins on circuit A and tries to complete three laps within a time limit. When this is achieved in successive training sessions, the player attempts circuit B, and so on.

Figure 14.37 Sample fixed load circuit

	Circuit number		
Exercise station	**A**	**B**	**C**
1 Shuttle runs	10	15	18
2 Medicine ball rebound	20	30	40
3 Sit-ups	25	30	40
4 Skipping	85	100	120
5 Squats	15	20	30
6 Push-ups	10	15	18
7 Lying leg raises	15	20	25
8 Bench push-ups	10	15	20
9 Bench jumps	10	15	20
10 Bench dips	10	15	20

Individual-load circuits

Individual-load circuits are geared to each individual's strengths and weaknesses. Before doing the circuit, each individual is tested on each exercise to see how many repetitions they can complete in 1 minute. These repetition numbers are then halved to give the number that must be completed in each lap, and are called the 'initial loads'. Perform three laps each session, trying to improve your time for the three laps (see figure 14.38).

Figure 14.38 Record card for individual load circuits

Exercise	1-Minute maximum	Initial load
1 Step-ups		
2 Push-ups		
3 Vertical jumps		
4 Sit-ups		
5 Hops		
6 Burpees		
7 Treadmills		
8 Chin-ups		
9 Rear leg raise		
10 Zigzag runs		
Date	3-lap time	

Fixed-time circuits

In fixed-time circuits, individuals begin at different points of the circuit and, after a starting signal, complete as many repetitions at that station as possible within a fixed time, e.g. 1 minute. At the end of each minute, you move on around the circuit and begin the next exercise minute.

The aim is to perform more repetitions at each station in the set time over a number of sessions, or more repetitions at each station than other team members.

Intensity can be adjusted by modifying the exercise so that it is more or less demanding, e.g. squats with a medicine ball or push-ups off knees instead of toes.

Advantages of circuit training

Circuit training has several advantages over other forms of training:

- Circuit training can be performed in a limited space, in limited time and with little equipment.
- Overload can be achieved by reducing target times for completing the three laps, increasing the exercise resistance, increasing the number of repetitions or by increasing the difficulty of the exercise.
- Motivation can be maintained by providing stimulating background music, regularly retesting maximums, varying the circuit exercises or type of circuit, and by introducing skill work with equipment (e.g. rebound passing).
- Variety and intensity can be added by using a wide range of equipment, such as medicine balls, resistance bands, exercise balls, skipping ropes, benches, dumbbells, punching bags, punching pads and gloves.

Learning experience

SPECIFICITY THROUGH EXERCISE MODIFICATION

When planning a circuit, the trainer has to have in mind how they could adjust the load or intensity of the exercise.

1 Refer to circuit samples in figures 14.37 and 14.38 and recommend how the exercises could be modified to suit the beginner or less-fit individual where appropriate.

2 If appropriate, video the original exercise and modifications you have made for sharing with your classmates and discussion.

Learning experience

SPECIFICITY THROUGH CIRCUIT SELECTION

1 Conduct an internet search for a variety of sample circuit training sessions that target these four separate fitness requirements:
   - general fitness
   - strength
   - muscular endurance
   - sport-specific (for the physical activity you are currently studying).

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2 Share your research with classmates.
3 Select the circuit that is most specific to your fitness needs. Justify your choice.

Note: Your teacher may ask you to implement the circuit as part of a class or individual learning experience.

Learning experience

WHAT TO DO WITH A MEDICINE BALL?

Medicine balls have come back into fashion as a piece of training equipment. However, how to use them effectively is another question.

Task

Work in pairs.

1 Conduct some research into the use of the medicine ball as part of circuit training.
2 Prepare an 8–10 station medicine ball circuit session that suits your specific fitness needs and the requirements of the physical activity you are currently studying. Ensure you include an appropriate warm-up and cool-down.
3 Swap your circuit with another pair in your class and evaluate it for effectiveness. Provide feedback to your classmates by considering the following training principles:
   - specificity
   - intensity
   - duration.
4 Using the feedback from your peers, make any modifications that you deem appropriate.

Flexibility training

Flexibility training is possibly one of the most undervalued forms of training and much debate exists on the role that it plays in injury prevention. Flexibility refers to the range of motion around the joints. By observing a few sport-specific skills (such as drop kicking a ball in rugby, a lay-up in basketball or a bicycle kick in soccer), it is easy to understand why it is important. The skills just described are dynamic movements and an incredible range of motion around the joint is required for them to be performed effectively. However, any callisthenic that puts a muscle in a stretched position develops your flexibility. Even general daily living movements, such as running up the stairs, require a significant range of motion to be performed dynamically. Undertaking a flexibility training program as part of sport-specific preparation or for general conditioning can create many benefits.

General benefits of increasing flexibility are that it:

- increases in range of motion, which may reduce the risk of injury
- increases mobility (e.g. consider a lunge in tennis to return a serve and how difficult this would be to do quickly and effectively with tight muscles through the hips and groin)

- is an opportunity to relax
- corrects imbalances due to overuse on a particular side of the body.

Types of flexibility and stretching

Four types of stretching are:

- dynamic stretching
- proprioceptive neuromuscular facilitation (PNF)
- static passive
- ballistic.

Dynamic stretching

Dynamic stretching and flexibility refers to movements that are performed quickly within the full range of motion of the joint, e.g. swinging the leg in a forwards–backwards motion or arm circles. Put simply, it is like stretching a rubber band which then returns to its normal length. This kind of stretching is generally used as part of a warm-up prior to physical activity. It allows the muscles and tendons to be put through a specific range of motion similar to the movements that would occur during training or competition, such as kicking a ball or lunging to catch a ball. Dynamic stretching is a very effective way of warming up and increasing flexibility because it:

- mirrors the type of activities that the athlete will be performing during the game or training
- increases body temperature, as activities usually involve whole body movement
- maximises range of motion of a joint
- increases body awareness.

Safety precautions

The following safety precautions must be followed:

- Build from basic exercises or movements of low intensity to more intense exercises that put the muscles and joints through their full range of motion (see figure 14.39).
- Conduct a general whole body warm-up before implementing dynamic stretches, e.g. light jogging.
- Perform dynamic stretches that are similar to the movements that would be performed in a game, e.g. hip flexion and extension actions, such as knee drives, leg swings, rotations in preparation for an Australian Rules game or training.

Learning experience

ORDER OF INTENSITY

Figure 14.39 shows a variety of plyometric exercises. If you were to perform these as part of your warm-up, in which order would you complete them? Remember that exercises should increase from low to medium intensity.

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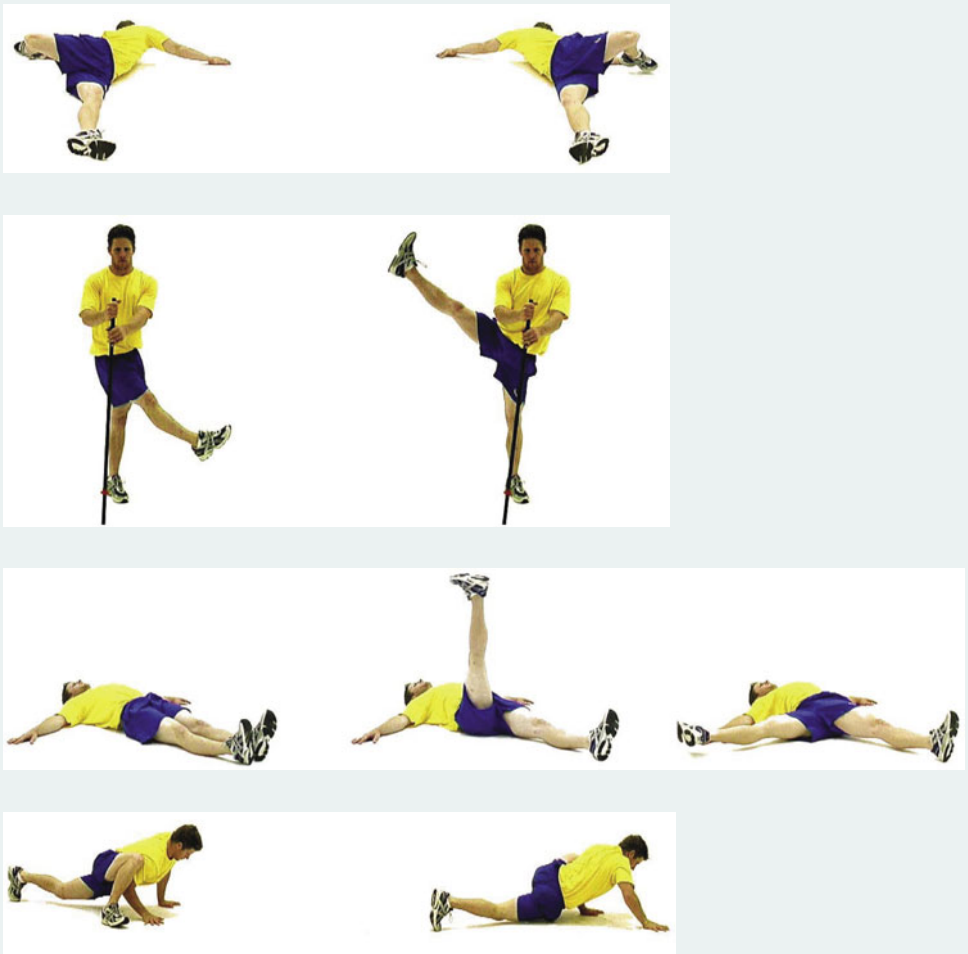

Figure 14.39 A range of dynamic exercises of low and medium intensity

Source: Visualcoaching® Pro software, <www.visualcoaching.com>

Proprioceptive neuromuscular facilitation (PNF)

In this method of stretching, the following procedure is used:

- Take a muscle to its maximum range and then contract the muscle against an immovable resistance, usually provided by a partner (isometric contraction).
- Passively increase the range yourself.
- Perform another isometric contraction and then a passive range increase.
- Repeat until you reach your limit.

This is the most effective method of increasing flexibility. Figure 14.40 shows how a partner's help is used during the isometric contractions.

Safety precautions

The following safety precautions must be followed when doing PNF exercises:

- Before doing PNF work, you must do a warm-up of at least 10 minutes. The warm-up must include total body activity, such as jogging, as well as general mobilising exercises. Muscles will not stretch easily unless they are warm.

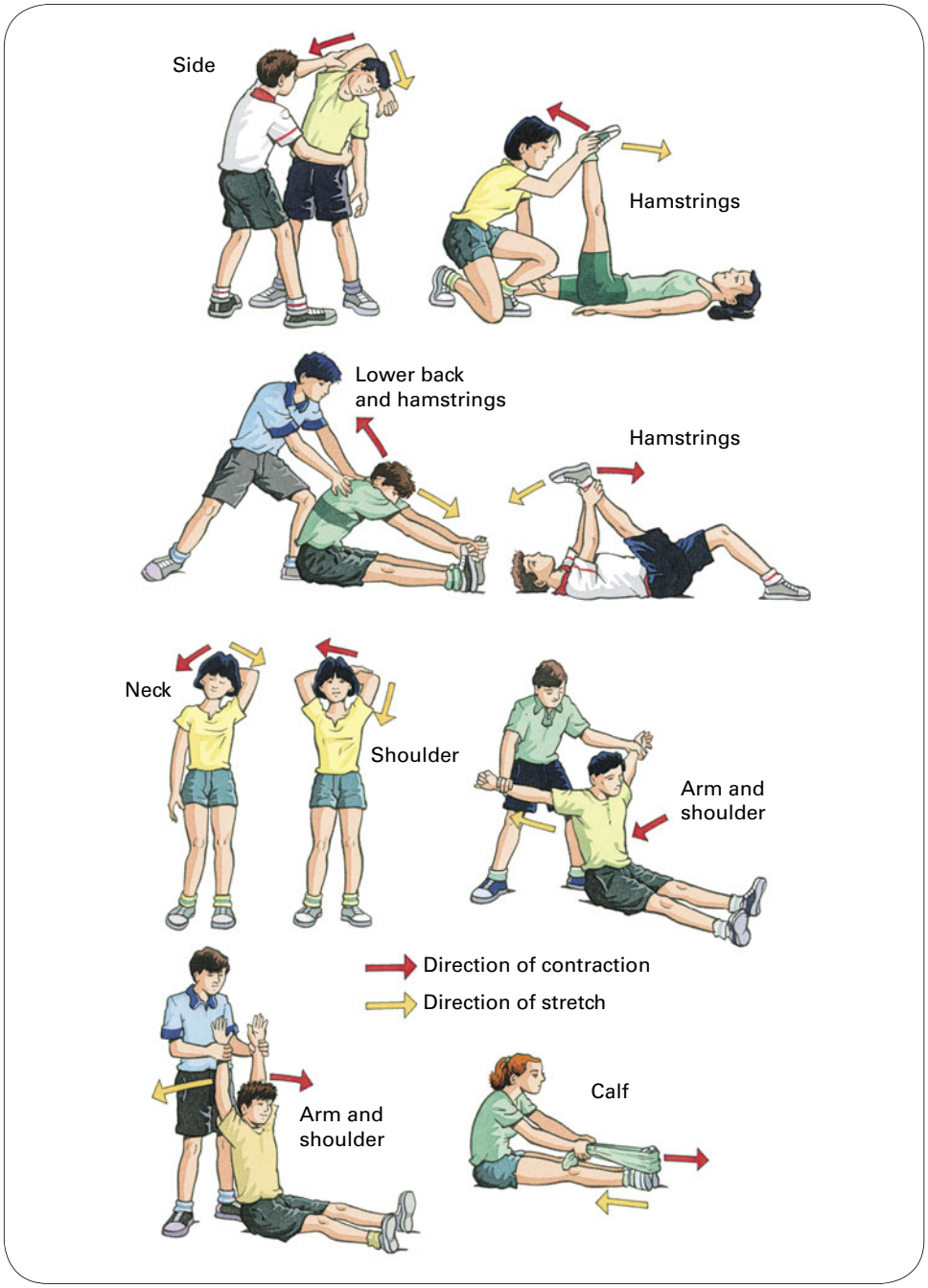

Figure 14.40 Stretching exercises that use the technique of proprioceptive neuromuscular facilitation (PNF)

- The isometric contraction should never be explosive, but should involve a gradual increase in effort in the first 2 seconds, which is then sustained for an additional 4 seconds.
- After the isometric contraction, the partner should not force the person into a new position of improved flexibility. This manoeuvre should be unaided or, at the most, assisted by only light pressure.
- The exercises should be performed with less than maximum effort until both the person and the partner are accustomed to them and confident that no injury will result.

Static (passive) stretching

Static (or passive) stretching involves taking a muscle to its greatest range and holding this position for 30 seconds. This is probably the type of stretching we are most familiar with as it has been traditionally used in body warm-ups and cool-downs. The advantages of this method, compared to other stretching methods, are that:

- it requires less energy
- it is less likely to damage connective and muscle tissue
- it prevents muscle pain and soreness, and relieves any existing pain and soreness.

Safety precautions

The following safety precautions must be followed when doing static stretching exercises:

- Never bounce or jerk in a stretched position.
- Never move quickly to a stretched position.

A variation of static passive stretching is *static active stretching* in which the muscle is put in a relaxed stretched position while the opposing muscle is under tension (contracted). For example, when holding one leg straight out in front of the body, the hamstring is stretched but relaxed and the quadriceps and hip flexors are contracted.

Learning experience

PASSIVE STRETCHING

You should be familiar with a range of passive (static) stretches as it is a traditional method of warming up.

Research a range of passive (static) stretching and suggest a passive stretch for each of the following muscle groups:

a quadriceps
b hamstrings
c calf (gastrocnemius)
d pectorals (chest)
e adductors (groin).

SNAPSHOT

Should we use static stretching as part of a warm-up?

The commonly held belief is that passive stretching is thought to promote better performance and decrease the risk of injury. What if it doesn't? What if it might actually be detrimental to activities requiring maximal force production? A recent study showed that passive muscle stretching can negatively impact on performance of a

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skill that demands repetitive high power outputs, such as jumping and sprinting. For example, in the study, after passively stretching the hamstrings and then performing a 20 metre sprint, times actually increased. There is also no conclusive evidence that static stretching prior to performance reduces injuries or reduces the delayed onset of muscle soreness. This is not to suggest that there is no place for static stretching in an overall conditioning program, but it does seem to suggest that there are better methods of preparing athletes for activities of high power and intensity, such as dynamic stretching.

Learning experience

WHICH STRETCH?

Work in pairs.

1. Research one of the main types of stretching (dynamic, PNF or passive).
2. Plan a stretching session that utilises the method you have chosen and is specific to the physical activity you are currently studying.
3. Video you and your partner demonstrating the stretches and present your video to the class or another pair.
4. Discuss how effective and specific the stretching session was in targeting the physical activity.
5. From the presentations, select a dynamic, PNF and passive stretching session. Over the lesson participate in all three types of stretching sessions.
6. After the class has participated in all three stretching sessions, discuss which session you preferred and which you think was most beneficial in preparing you for the physical activity you are currently studying.

Ballistic stretching

Ballistic stretching is NOT recommended for improving flexibility. It involves rapidly moving into a stretched position, then bouncing or jerking against the muscle in an attempt to produce greater muscle length. Ballistic stretching can cause muscle injury because the 'bobbing' movements activate the myotatic stretch reflex, and the following contraction under stretch has the potential to cause injury and pain.

Ballistic stretching occurs naturally during activity (e.g. when a footballer kicks the ball). It is this ballistic stretching during activity that causes some of the acute delayed-onset muscle pain that may be experienced in the following days due to microtears in the muscle fibres.

Cross training

Cross training is a routine that involves several different methods of training. It is a useful form of training for an athlete who has to train for two or more events, such as a triathlon, or an athlete who is looking to bring variety into their training routine. Cross training can enhance an athlete's performance in their main sport by including another mode of exercise. For example, increasing aerobic capacity by including swimming as well as running into the training routine.

Benefits of cross training

Benefits include:

- working different muscle groups as well as developing new skills and reducing the risk of injury through overuse and fatigue of a particular muscle group
- allowing the athlete to be flexible about their training plans; for example, if it is raining the athlete may go to the gym for a treadmill workout or take one of the classes, such as body pump or body combat
- assisting with motivation, as the athlete is not bored by completing the same types of training
- assisting with maintaining general fitness while rehabilitating, as some training is still taking place on another part of the body
- assisting athletes in the off-season to improve general fitness.

Although cross training has many advantages it can be generic in its effect. For specific training to occur the athlete must remember to select training methods and exercises that target their training objective.

Learning experience

Cross training

1. Research the specific fitness components aerobic capacity, strength, flexibility, speed and agility.
2. Develop a list of training methods or activities that would target the fitness components and incorporate cross training.
3. Share your list with a classmate and add any that you did not think of. Ideally the training methods or activities would be things you could access in your community.
4. Create a week of cross training that includes five different methods or activities and targets your main fitness objectives.

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
AM							
PM							

5. If you were to complete the training, consider the factors that would help you to complete the five sessions and the factors that would prevent you from completing it.

Learning experience

INTERNET SEARCH

Many sports clubs and organisations have their own web pages on the internet. There are also general sports directories on the internet.

1 At school or at home, conduct an internet search to find:
   - **a** the type of information available on fitness and training, and make a list of key headings and useful websites
   - **b** sample training programs either for teams or individuals. Copy a program and record the useful websites.
2 Contribute to a class discussion about useful internet material on sports training.

Learning experience

TRAINING PROGRAM DECONSTRUCTION

Through your teacher, the internet, personal contacts, sports clubs or the local fitness centre, gain access to a health-related or sport-related training program. Analyse this program to find the following information:

1 What is the specific purpose of the program?
2 If it is sport-related, is it designed for a specific playing position?
3 Identify and list the training methods used in the program.
4 Identify which fitness components each training method is used to develop. Support your answer with examples from the program.
5 Identify the parts of a training session that comprise the warm-up, conditioning phase and cool-down.
6 Within the program, identify the application of the following training principles, giving specific examples for each:
   - **a** specificity
   - **b** overload
   - **c** variety

Learning experience

PLYOMETRIC TRAINING

Using the information in this and previous chapters, design a plyometric training session for the physical activity you are currently performing in practical classes.

1 List the exercises in the session.
2 Name the body parts and muscles worked in each exercise.
3 What is the major energy system used in this type of training?
4 Which fitness components are developed by plyometric training?

>>

5 Describe the safety precautions that need to be taken when introducing plyometric training into a fitness program.
6 You should be prepared to teach the group some or all of your plyometric drills.

Learning experience

LSD TRAINING

You are to complete a long slow distance jog over 2 km wearing a heart-rate monitor to keep the heart rate between T1 and T2 (60–84% maximum heart rate, MHR).

1 Before completing the jog, establish what the T1–T2 training zones should be in terms of MHR.
2 Was it easy or difficult to stay in this zone during the jog?
3 Evaluate the effectiveness of this method of training to improve specific fitness for basketball (or other physical activity that the class is currently studying). You may compare data gathered from game analysis with the data gathered while completing the 2 km slow jog.
4 Design a specific training session to develop anaerobic requirements for basketball.

Learning experience

CIRCUIT EVALUATION

You are to participate in a circuit utilising five touch training drills (student or teacher designed).

1 Rank each drill in order of its effectiveness to touch (fitness components, energy systems, personal fitness, skills required in the game). Ranking should be from most effective to least effective.
2 Modify the drill you deemed least effective so that it becomes more specific to touch.

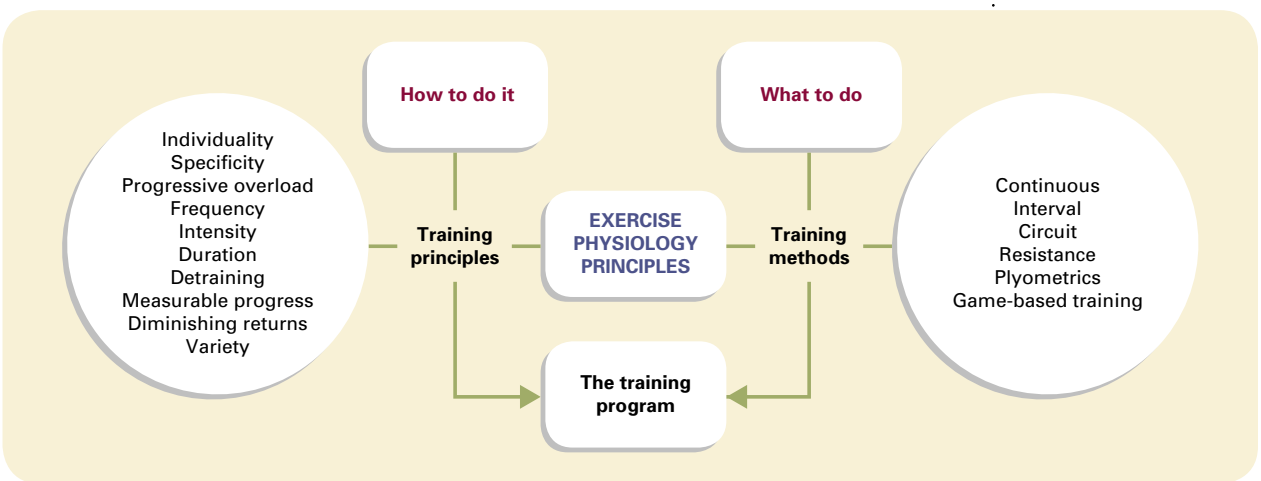


Figure 14.41 A summary of the exercise physiology principles

Chapter review

Exercise physiology principles

Know

1 Using this book, library research and interviews with coaches and athletes, find the meanings of the following training terminology and give real-life examples to illustrate them. Organise the information into a PowerPoint presentation that you can share with the class.

- a set
- b intensity
- c progressive overload
- d specificity
- e detraining
- f variety
- g repetition
- h individuality
- i duration
- j diminishing returns
- k frequency

Comprehend

2 Develop a table that identifies the advantages and disadvantages of the training methods that you have studied in this chapter.

Training methods	Advantages	Disadvantages

3 A player performs six repetitions of a 60 m run as part of a training session for their sport. Each repetition is performed in 8 seconds, with 30 seconds rest taken between repetitions.

- a What is the name given to this type of training?
- b The training program described above is performed three times per week for 6 weeks. What is the major energy system trained?
- c Illustrate two ways in which progressive overload can be achieved for this type of training.
- d Explain why this form of training will result in less fatigue after a training session than continuous training of the same intensity and covering the same total distance.

Apply

4 Conduct an internet search for information on the training principles and training methods and prepare a reference list of sites that you have found useful.

Select the top four sites and identify why you found them most useful. Share your reference list with the class.

Analyse
Evaluate
Synthesise

5 Team skill-based training

Aim

To establish if skill-based training is effective in improving your team's performance.

As part of your practice for the physical activity you are currently studying, your teacher will assign you to a team. In your team:

1 Identify:
   - the fitness components and energy requirements of the physical activity
   - the skills and main strategies required in the physical activity.

2 Review:
   - your individual fitness test results and as a team decide on 2–3 variables that are important in the physical activity and your own team's performance, e.g. speed, speed endurance, agility or muscular power
   - your individual skills and strategies and decide on 2–3 variables that your team is lacking or weakest in, e.g. draw and pass in touch football, ball control in soccer or penetrating the shooting circle in netball.

3 Research to create or adopt a skills-based game that will incorporate the variables and will not only improve skills and strategies (game play) but have a training effect.

4 Implement the skill-based training game, monitoring:
   - intensity, to identify if training demands have been met (*Note:* It may be necessary to wear heart-rate monitors or take heart rates during the session.)
   - skills and movement patterns during the session. (*Note:* It may be necessary to video the session to ascertain if the skills or strategies the team is focusing on are being addressed through the games designed.)

5 Review all the information gathered and modify the games if necessary.

6 Participate in class games with your team to ascertain if training has had an impact on your team's performance in terms of the skills or strategies your team's skill-based training session was targeting.

7 Individually, evaluate the impact the skills-based training session had on targeting the fitness and skills of the physical activity and the impact this had on you and your team's performance. Ensure you enhance meaning and impact of your written evaluation with justifications from primary and secondary data that are discerning and convincing.

Training program design

HOW DOES AN UNDERSTANDING OF TRAINING PROGRAM DESIGN HELP TO IMPROVE INDIVIDUAL PERFORMANCE IN PHYSICAL ACTIVITIES?

chapter 15

Training program design, evaluation and modification

Planning the training year

Whether a program is designed for a competitive athlete or an individual keen to improve their health-related fitness, it must be planned carefully so that the desired outcomes are achieved. Any annual plan must take into account:

- the individual's test results
- calendar dates of competitions
- rate of progressive overload
- fitness components to be developed
- climate and season
- the fact that a high level of competitive fitness cannot be maintained for the whole year.

Periodisation

Periodisation is the process of structuring training in phases or cycles.

Figure 15.1
An ironwoman finishing first reaps the rewards of a carefully planned training program.

For the above reasons, an annual plan must be divided into smaller phases of training (see figure 15.2). This is called '**periodisation**' of the training year. It basically means the cycling of specificity, intensity and volume of training to achieve peak levels of fitness for competition. The training year is divided into periods that will achieve different things.

An elite athlete may be preparing for a major event that is one or even four years away, such as the Olympic Games. They cannot maintain peak fitness for the whole time and may even have to peak several times before their main goal, such as for team selection or world championships. Therefore it is obvious that the program has to be divided into smaller chunks or periods.

Put simply, the training year may be divided into three main periods:

- the preparatory or pre-season phase, made up of two subphases:
  - the general preparatory subphase, or fitness foundation
  - the specific preparatory subphase, or game preparation.
- the competitive or in-season phase, also made up of two subphases:
  - the pre-competitive subphase
  - the competitive subphase.
- the transition or off-season phase.

Figure 15.2 A schematic representation of the division of an annual plan into phases and cycles of training

The annual training plan (macrocycle)					
Phases of training	**Preparatory (pre-season)**		**Competitive (in-season)**		**Transition (off-season)**
Subphases	**General preparation**	**Specific preparation**	**Pre-competitive**	**Competitive**	**Transition**
Mesocycles					
Microcycles					

Each phase and subphase should be divided into smaller parts known as mesocycles (6 weeks) and microcycles (1 week). Mesocycles and microcycles can have specific training objectives, while fitting in with the total objective of the training phase in which they occur.

The intensity, duration, frequency and type of training varies, depending on the phase of the training year. The length of each phase will vary according to the purpose of the program and the level of competition.

Terminology

- **Macrocycle**: This term is normally used to describe one entire training year. For athletes it is usually defined by the start and end of competition or the length of time between major competitions, for example the Olympic Games (4 years).
- **Mesocycle**: Originally it was used to describe training phases within the training year (e.g. preparation phase or 2–3 months). Now, with the understanding that training adaptations take place within 4–6 weeks and therefore changes should be made, it refers to a training period lasting 4–6 weeks.
- **Microcycle**: This can refer to 1 week or 7 days of training (or a period of training of 4 weeks). No matter what the length, a microcycle will always refer to a training period with a specific focus. For example, a distance runner in a typical training microcycle (1 week) will include a hill run, track interval session, long run, 3 easy runs and a rest day.

Benefits of periodisation

Benefits of periodisation are that it:

- matches the phase of training with the best type of training to get optimal benefits and effects
- manages fatigue and prevents stagnation and overtraining
- structures training to get the best out of the athlete at the right time of competition.

Learning experience

PERIODISATION

1 Collect a series of training programs (general and sport specific).
2 Identify the phases of the training program.
3 Identify the macro-, meso- and microcycles within the program.

The transition (or off-season) phase

The off-season period should be both a psychological and physical break from the sport in which you have been competing. It usually lasts 6–12 weeks.

Training during this period should be devoted to remaining reasonably active without staying involved in the chosen sport. If you are inactive during this period, you will rapidly lose the benefits of previous training. Monitor your percentage body fat and activity levels so that you begin pre-season training at or close to your 'playing weight'.

Suitable off-season training would include low-intensity weight and running training twice weekly, supplemented by active recreational games (such as basketball, tennis and swimming) played for enjoyment. The off-season period should also include specialised weight-training or speed programs to remedy any diagnosed weaknesses.

Training methods that suit this phase of training include continuous training, cross training and resistance training.

The preparatory (or pre-season) phase

During the general preparatory or fitness foundation phase, emphasis is placed on developing general fitness as a solid base on which to build and specialise in the following phases.

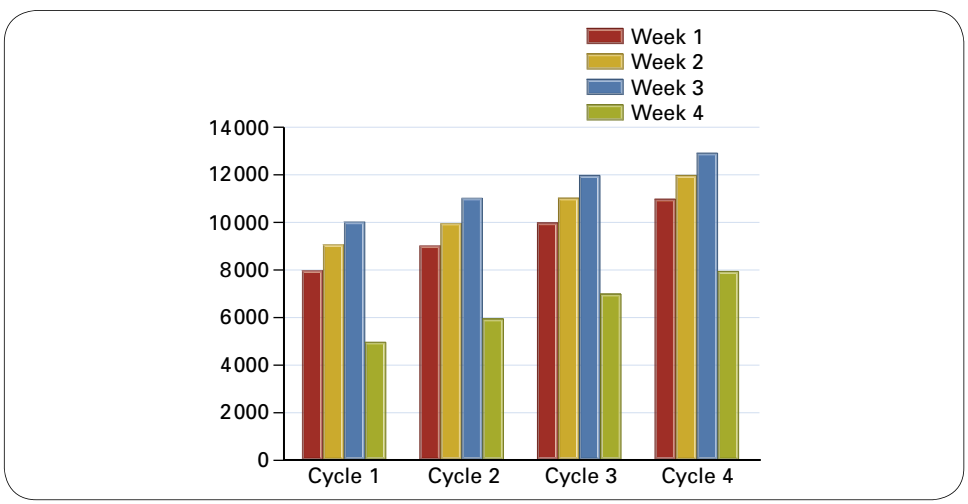
This subphase usually lasts 4–10 weeks and gives special emphasis to developing the aerobic energy system. During this subphase, the volume of training is high, but the intensity is low to start with, and increases very slowly. Specialised programs to remedy specific player weaknesses should be continued during this subphase.

During the specific preparatory subphase, there is a shift in training towards more specific game-related fitness work. The intensity of training should increase while the volume slowly decreases. This subphase usually lasts 2–6 weeks.

The competitive (or in-season) phase

The competitive phase usually lasts 4–6 months. During the competitive season, the emphasis is on maintaining pre-season fitness.

Because of the heavy demands of competition, not every training session during this phase should be long and intense. Training should work on a hard–easy cycle. Sessions early in the training week should be longer and



Source: Plisk et al 'Periodization strategies', *National Strength & Conditioning Association*, Vol. 25, Number 6, pp. 19–37

Figure 15.3
Progressive overload within a cycle of training in which every fourth week of the mesocycle is a recovery week to prepare for the next cycle's increase in load

more intense. Sessions later in the week should be lighter and less intense so that players are not still recovering from fatigue on competition day.

Peaking

Before giving examples of training periodisation and the development of fitness components for specific sports, it is important to discuss the phenomenon of **peaking**.

Peaking is the optimum state of readiness for an athlete coming into a major competition or performance.

Peaking refers to training techniques that result in players reaching their optimum state of readiness to perform. It is related to training intensity and must be considered on two levels: over the whole year, and for specific individual games or events.

Whole-year peaking

In a whole-year plan, the goal is to have players peaking during the in-season period. Several factors affect in-season peaking:

- High-intensity training throughout pre-season and early in-season sessions results in rapid improvement but a lower and shorter absolute peak level of performance (curve (1) in figure 15.4).
- A training program with a longer pre-season phase, which includes gradual overloads in intensity into the early in-season, will result in a slower improvement rate, but a higher final peak level that can be maintained longer (curve (2) in figure 15.4).

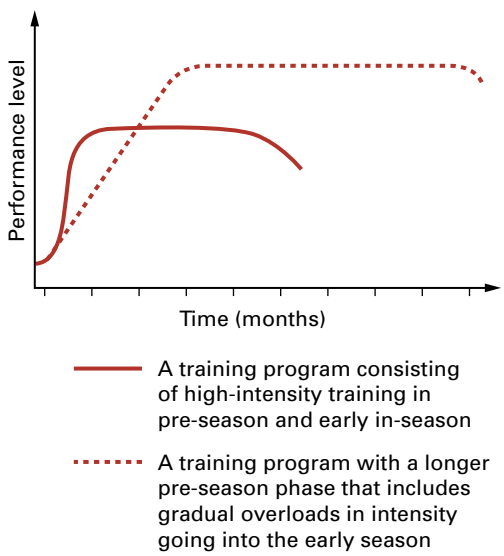


Figure 15.4
A proposed relationship between the rate of improvement and the absolute level of performance for training programs

In-season peaking

During the in-season period, peaking for specific matches or competitions during a season (e.g. a crucial match or a grand final) requires some rest from training or at least an easing up of the daily stress of training sessions. This allows the body time for complete recovery and a build-up of peak strength and endurance on the competition day.

Tapering is a reduction in training before a major event to allow for complete recovery and optimal performance due to reduced fatigue and maximum strength or endurance.

This reduction in training, called '**tapering**' or 'tapering off', usually begins a week before the big competition. It involves:

1 about a 40% reduction in the amount of training
2 a slight reduction in the intensity of training later in the week.

This whole process should be done in a planned step-like way, leading up to the big competition.

Figure 15.5 Details of the phases of training linked with the volume of training, referred to as generalised periodisation

Phase: Objective	General Preparation: Strength-endurance	Special Preparation: Basic strength	Competition: Strength and power	Peaking/Active Rest: Peaking/maintenance
Variable				
Intensity	Low to moderate	High	High	Very high to low
Volume	High	Moderate to high	Low	Very low
Repetitions	8–20	4–6	2–3	1–3
Sets*	3–5	3–5	3–5	1–3
Sessions/day	1–3	1–3	1–2	1
Days/week	3–4	3–5	3–6	1–5
Intensity cycle**	2–3/1	2–4/1	2–3/1	–

*Sets: excludes warm-ups
**Intensity cycle: ratio of heavy to light training weeks

Source: adapted from Stone et al (65, 66), cited in Plisk et al. 'Periodization Strategies', *National Strength & Conditioning Association*, vol. 25, no. 6, pp. 19–37

Planning a training program

The final planning of your training program incorporates all the analysis, assessment, principles and training methodology we have discussed in previous chapters.

For a training program to be successful in producing improvements in fitness, you need to establish goals and the means of achieving them in a careful step-by-step plan. Figure 15.6 on the next page outlines the steps in developing a suitable training program.

For health-related fitness programs, the key fitness components are aerobic capacity, muscular strength, flexibility and body composition.

Step-by-step plan

Step 1: identify the purpose of the program

A sample purpose could be to maximise your fitness during a 6-week period of pre-season preparation for an underage touch football team with a low initial fitness base.

Step 2: conduct a games analysis

To give you suitable goals to aim for, conduct your games analysis for a player or players of a high standard, although training requirements may need to be scaled back to your standard.

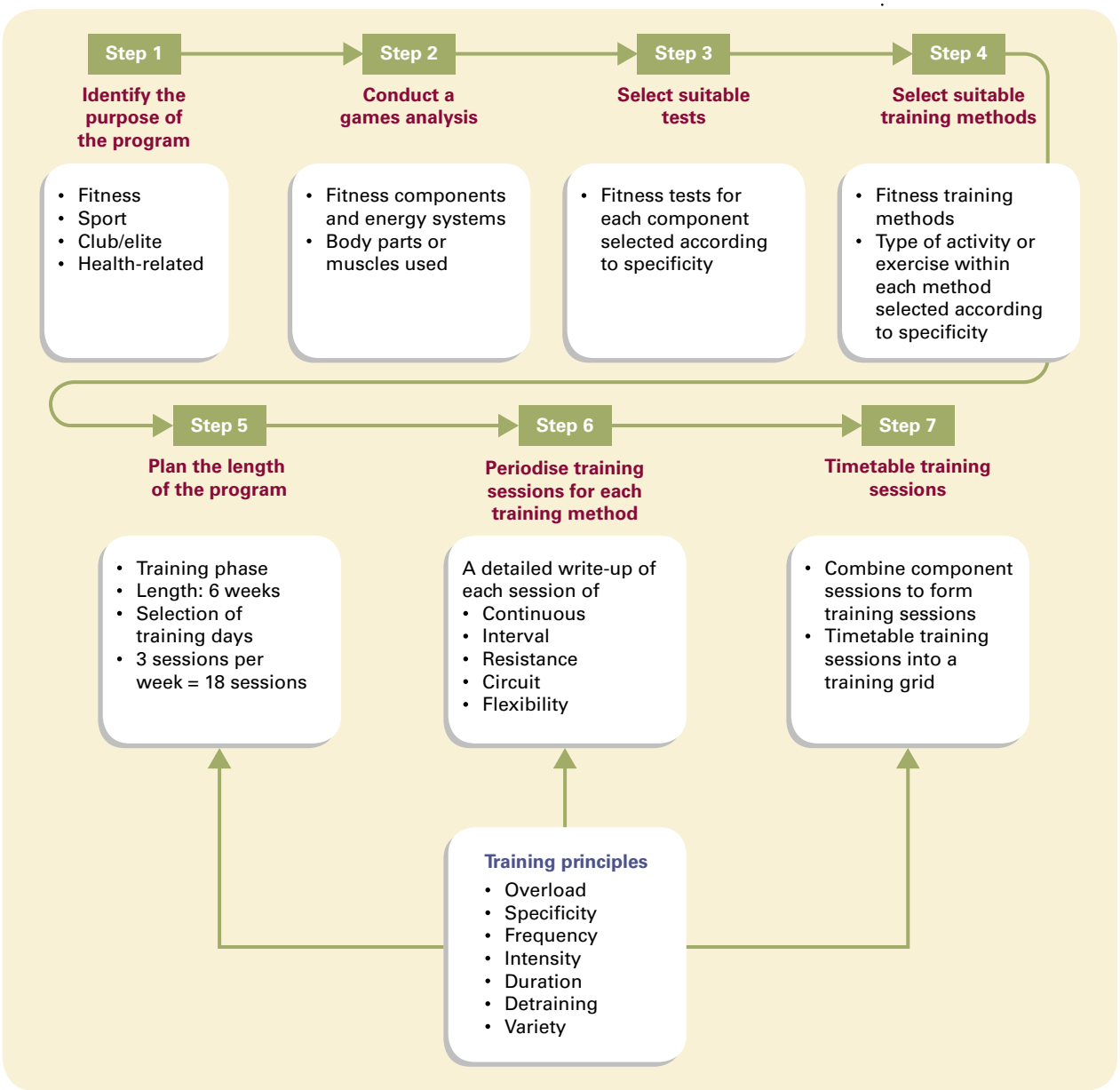


Figure 15.6 Planning a training program

Your games analysis should reveal the energy systems, fitness components, body parts, muscle groups and contraction types required by your sport.

For health-related fitness programs, the key fitness components are aerobic capacity, muscular strength, flexibility and body composition.

Step 3: select suitable tests

The choice of fitness tests to be used in a test battery should be based on:

- the results of the games analysis
- the time available for testing
- access to equipment and facilities.

Pre-testing is essential for identifying strengths and weaknesses and establishing a suitable starting point for program workloads.

Figure 15.7
There is probably no test for the bicycle kick in soccer, but to do it effectively requires power, coordination and flexibility.

Post-testing (at the end of the program) is important for identifying whether the program achieved the desired outcomes and whether your specific fitness improved.

Step 4: select suitable training methods

For sport-related fitness programs, select training methods to develop the fitness components that the games analysis has shown to be essential, or for which you have scored poorly in your fitness tests. Within each training method, select the activity or exercises that are most relevant to your sport. The phase of the training year will also impact on the methods of training that are given priority (see figure 15.8).

For health-related fitness programs, select training methods to develop the fitness components listed in step 2.

Figure 15.8 Priority of fitness elements in a soccer training program

	Early pre-season	Late pre-season	In-season
Continuous training	High	Low	Low
Interval training	Low	High	Maintenance
Strength training	High	Moderate	Low
Power training	High	Moderate	Maintenance
Speed training	Low	High	Maintenance
Flexibility training	High	High	High

Step 5: plan the length of the program

To achieve significant gains in fitness, your program must be 6 weeks in duration, with a minimum of 3 sessions per week, i.e. a minimum total of 18 sessions.

Decide which training phase applies to your program, e.g. pre-season. Decide which days of the week will be training days, taking into account outside influences, such as external training, competitions, work and school commitments.

Step 6: periodise training sessions for each training method

For each training method used:

- calculate the total number of sessions per week
- calculate the total number of sessions over the 6 weeks
- plan the content (i.e. exercise type, volume, duration and intensity) of the warm-up, the conditioning phase and the cool-down for each session.

For example, you might have decided to include three interval sessions each week and two weight sessions. You must therefore map out the content of 18 interval sessions and 12 weight sessions over the 6 weeks.

At this level, all training principles must be taken into account, particularly progressive overload and specificity.

Figure 15.9 provides an example of an in-season (competition phase) training microcycle.

Figure 15.9 In-season soccer training program

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Interval training	Team training—plyometrics and sprint work	Weights session and flexibility	Team training—interval training	Rest	Match	Recovery run and flexibility

Step 7: timetable training sessions

This is the final step in developing a training program. The idea is to combine the training sessions for each training method into a total training grid. This training grid represents a summary of the contents of each session throughout the program (see figure 15.10).

Learning experience

WHAT IS THE FOCUS?

1. Refer to figure 15.9 and decide what components of fitness each training method would be focusing on.
2. Use the same format as figure 15.9 to show the training methods you would use to organise a 1-week microcycle for the physical activity you are currently studying. To help organise your microcycle, note that it is in-season, the match is on Sunday and team training is on Tuesday and Friday.

Examples of practical training programs

Australian Rules football

Figure 15.10 gives an excellent example of the blocking of the various training methods into a final 6-week training macrocycle (see step 7 above) during the pre-season phase of a football fitness program.

Netball

Figure 15.11 shows a training grid or timetable (see step 7) for netball. This represents a summary of a 6-week training program. A detailed explanation of the activities included in the circuit, warm-up, cool-down and intervals (intensities, recoveries and work-to-rest ratio) would have been written up in step 6.

Features of a good training program

In summary, any good training program should include:

- the purpose and goals to be achieved
- a methodical games analysis
- a pre-test and a post-test
- a training session timetable based on periodisation of training methods and incorporating all training principles
- a justification of every chosen test, training method and exercise in relation to the program's purpose and the results of the games analysis.

Order of activities

1 Warm-up
2 Flexibility circuit
3 Running (8 running groups according to ability):
4 × 150 m; 4 × 100 m; 6 × 80 m; 4 × 100 m; 4 × 150 m
4 Exercise circuit (total group)
5 Group activities (15 minutes each):
- football activity (handball emphasis)
- tackling activity
- weight circuit

6 Running: 3 km run
7 Abdominal circuit
8 Flexibility circuit
Total time: 2–3 hours

Pre-season training program
Duration: 6 weeks, 3 sessions per week

Week 1
Session 1
- Jog 3–5 km (group run)
- Flexibility circuit introduction
- 6–10 × 100 m easy pace (60–75% intensity, 1:3 work-to-rest ratio)
- Exercise circuit
- Cool-down: flexibility exercises

Session 2
- Fartlek run (total group)
- Flexibility circuit
- 10 × 150 m (75% intensity, 1:3 work-to-rest ratio)
- Weight circuit
- Cool-down: flexibility exercises

Session 3
- Evaluation of endurance levels, e.g. 5-minute run test, or 4000 m time trial
- Weight circuit
- Flexibility circuit

Week 2
Session 1
- Warm-up: flexibility circuit
- 4 × 400 m (70–75% intensity, 3–4 minutes rest between each run); record the times
- Jog 2–5 km
- Cool-down: flexibility exercises

Session 2
- Fartlek run (total group)
- Flexibility circuit
- 10 × 150 m (75% intensity, 1:3 work-to-rest ratio)
- Weight circuit
- Cool-down: flexibility exercises

Session 3
- Timed continuous run (3–6 km)
- Flexibility circuit
- 4 × 200 m, 4 × 100 m (75% intensity, 1:3 work-to-rest ratio)
- Weight circuit
- Cool-down: flexibility exercises

Week 3
Session 1
- Fartlek run (3–6 km), easy pace
- Flexibility circuit
- 6 × 400 m (3–4 minutes rest between each run; record the times, trying to improve on last week's time)
- Introduction to skill training using balls
- Weight circuit
- Cool-down: flexibility exercises

Session 2
- Warm-up: flexibility circuit
- 10 × 200 m (80% intensity, 1:3 work-to-rest ratio)
- Group activities:
  – skill training
  – weight circuit
  – tackling
- Cool-down: flexibility exercises

Session 3
- Timed continuous run (compare with previous week)
- Flexibility circuit
- Group activities:
  – skill training
  – weight circuit
  – 10 × 100 m, 60–70% intensity, 1:2 work-to-rest ratio
- Cool-down: flexibility exercises

(continued)

Week 4

Session 1
- Fartlek run (3–6 km)
- Flexibility circuit
- Skill training (total group)
- 1 × 400 m; 1 × 300 m; 1 × 200 m; 1 × 100 m, 80–85% intensity, 1:2–1:3 work-to-rest ratio
- Weight circuit
- Cool-down: flexibility exercises

Session 2
- Warm-up: flexibility exercises
- 2 × 200 m; 2 × 150 m; 2 × 100 m; 2 × 60 m, 80–85% intensity, 1:3 work-to-rest ratio
- Group activities:
  – skill training
  – tackling: body contact
- Weight circuit
- Jog 2–5 km
- Cool-down: flexibility exercises

Session 3
- Fartlek run (3–6 km)
- Flexibility circuit
- Skill training
- 10–20 × 100 m (60–75% intensity jog recoveries, 1:3 work-to-rest ratio
- Weight circuit
- Cool-down: flexibility exercises

Week 5

Session 1
- Timed endurance run (meet standards)
- Flexibility circuit
- Weight circuit
- Cool-down: flexibility exercises

Session 2
- Warm-up: flexibility circuit
- 2 × 300 m; 2 × 200 m; 2 × 100 m, 85–90% intensity, 1:5 work-to-rest ratio
- Group activities
- Cool-down: flexibility exercises

Session 3
- Warm-up: flexibility circuit
- Skills training
- 6–10 × 200 m, 85–90% intensity, 1:3 work-to-rest ratio
- Group activities
- Run or fartlek run (3–6 km)
- Cool-down: flexibility exercises

Week 6

Session 1
- Warm-up: flexibility circuit
- Skills training
- 4 × 60 m speed training, 90–95% intensity, 1:5–1:8 work-to-rest ratio
- Group activities
- 10 × 100 m, vary intensity from 75% to 90%, work-to-rest ratios 1:2–1:5
- Cool-down: flexibility exercises

Session 2
- Continuous or fartlek run (3–6 km), hard
- Skills training
- 10–15 × 50 m, vary intensity from 75% to 90%, work-to-rest ratio of 1:1–1:4
- Weight circuit
- Cool-down: flexibility exercises

Session 3
- Warm-up: flexibility circuit
- Fartlek run (4 km)
- Skills training
- Weight circuit
- Cool-down: flexibility exercises

Figure 15.10 Sample 6-week pre-season training macrocycle for Australian Rules football

Figure 15.11 Netball fitness program: a 6-week mesocycle. The distances, efforts and exercises are all chosen to improve the fitness components for the position of centre.

Day	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Monday	Warm-up Circuit Intervals Cool-down	Warm-up Circuit Intervals Cool-down	Warm-up Circuit Intervals Cool-down	Warm-up Circuit Intervals Cool-down	Warm-up Circuit Intervals Cool-down	Warm-up Circuit Intervals Cool-down
Wednesday	Warm-up Intervals: 2 × 600 m 4 × 70 m 6 × 30 m Cool-down	Warm-up Intervals: 2 × 600 m 4 × 70 m 6 × 30 m Cool-down	Warm-up Intervals: 2 × 600 m 6 × 70 m 10 × 20 m Cool-down	Warm-up Intervals: 2 × 600 m 6 × 70 m 8 × 30 m Cool-down	Warm-up Intervals: 8 × 70 m 8 × 40 m 8 × agility runs Cool-down	Warm-up Intervals: 8 × 200 m 8 × 50 m 8 × agility runs Cool-down
Thursday	Warm-up Circuit Cool-down	Warm-up Circuit Cool-down	Warm-up Circuit Cool-down	Warm-up Circuit Cool-down	Warm-up Circuit Cool-down	Warm-up Circuit Cool-down
Saturday	Game	Game	Game	Game	Game	Game

Learning experience

WHAT DO YOU NOTICE?

1 Based on your understanding of the training principles, methods and structure of a training program, identify examples of each of the following from the Australian Rules football pre-season program in figure 15.10:
   - progressive overload
   - specificity
   - methods of training to increase aerobic capacity, agility and strength
   - periodisation
   - intensity
   - frequency.

2 How does the program change from week 1 to week 6? Give specific examples.

3 Select the weight, flexibility or abdominal circuit and plan a 10-exercise circuit session that is specific to Australian Rules football or the physical activity you are currently studying. Share with a classmate and evaluate how specific it is to the physical activity and the requirements of circuit training.

4 Design a game-based session for week 3, session 1: introduction to skill training using balls.

Learning experience

STEP 6

Refer to step 6 of the section 'Planning a training program'.

1 Pick one week of interval training from the netball training program for a centre (see figure 15.11) and outline the appropriate intensities and recoveries (work-to-rest ratios) for that session. You may wish to refer to the full fitness analysis for netball that was outlined in chapter 13 'Games analysis'.

2 Week 5 and 6 interval sessions refer to agility runs. What type of agility runs would you include here so that they are suitable to netball, the centre position and the stage of the mesocycle?

3 Give two specific examples of agility exercises you could include in the week 5 or 6 interval sessions.

Features of a good training session

The training session

The training session is the basic building block of all microcycles. The content of each session will depend on the fitness components required by the specific sport, and in which mesocycle and phase the session occurs. However, to gain maximum benefit, all sessions should follow this format:

- the warm-up
- the conditioning phase
- the cool-down.

The warm-up

The **warm-up** is designed to:

- prepare the body for competition or conditioning exercise
- reduce the possibility of joint or muscle injury or soreness.

The warm-up should include exercises that prepare the muscles to be used and activate the energy system required. It should be related specifically to the activity that follows. For instance, sit-ups or push-ups are not useful as a warm-up for a running session. Instead, jogging followed by run-throughs and a carefully planned dynamic stretching program are the best preparation.

A warm-up should incorporate the following activities:

- a continuous activity
- light resistance exercises
- flexibility exercises.

Warm-up is the combination of activities (jogging, dynamic stretching and skills) done at a low intensity to prepare the body for more vigorous exercise.

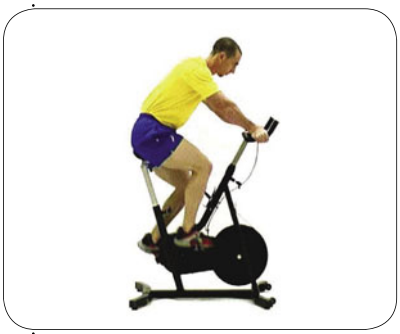


Figure 15.12
Elite teams often have bikes on the sideline to keep players warm while they are on the bench. The bike can also be used as a good method of achieving a general warm-up.

Source: Visualcoaching® Pro software, <www.visualcoaching.com>

A continuous activity

Jogging is often used as a continuous activity that increases blood flow to the muscles and therefore increases muscle temperature. This activity should be kept up until sweating begins, as this is the sign that the internal temperature has increased.

Light resistance exercises

The next part of the warm-up is a series of light resistance exercises that will work the muscles to be used in the conditioning phase of training, e.g. a set of push-ups just before a chest–arm weight-training session.

Flexibility exercises

The final part of the warm-up is a series of flexibility exercises. The aim of these is to increase the range of motion at the joints to be used in the conditioning phase of training. Any dynamic stretching should incorporate exercises that develop in intensity and range of motion as the athlete gets progressively warmer and can utilise more intense movements.

Effects of the warm-up

Warming up produces beneficial physiological changes:

- an increase in the blood flow through the muscle as the small blood vessels dilate, and therefore an increase in the local temperature of the muscle and the oxygen supply
- increases in heart rate and respiratory rate, resulting in mobilisation of the oxidative energy sources, making it easier to switch to aerobic energy production
- reduced viscosity in the muscles, so they can contract and relax more quickly (see figure 15.14), which reduces the risk of injury
- increased speed and force of contraction of the muscles
- increased enzyme activity within the muscle fibres, due to the increase in temperature
- increased extensibility of the fibres and tendons, due to the increase in temperature
- increased alertness of the nervous system, preparing you physiologically and psychologically for the strain to come.

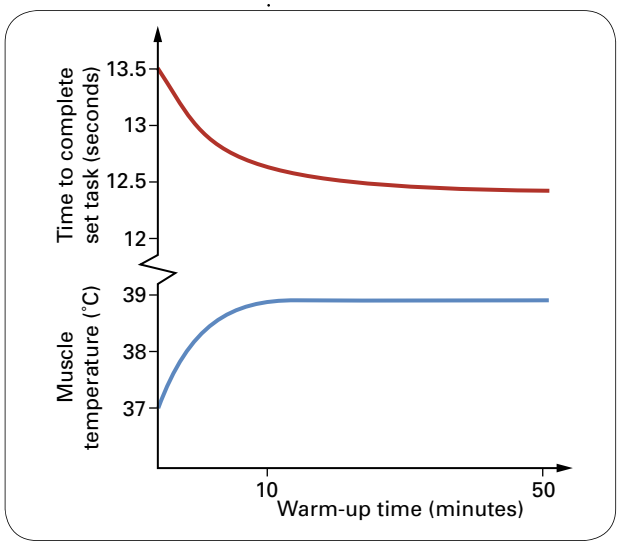


Figure 15.13 Muscle temperature and time taken to complete a task as a function of warm-up time

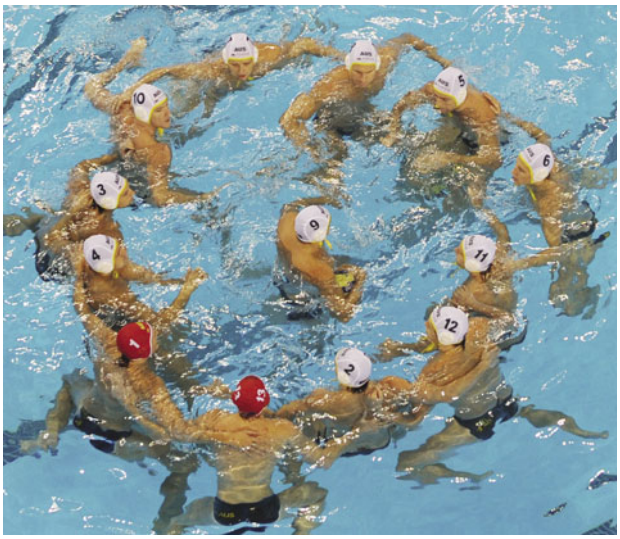


Figure 15.14 A team warm-up

The need to warm up

The muscles torn most frequently if you neglect to warm them up are the antagonists (such as the hamstrings) to the strong contracting muscles (such as the quadriceps). Cold antagonist muscles relax slowly and incompletely when the agonists contract, therefore hampering free movement and accurate coordination. At the same time, the force of the contraction of the agonists and the momentum of the moving part exerts a great strain on the unyielding antagonists. This may lead to the tearing of muscle fibres or tendons.

SNAPSHOT

The 11+—a complete warm up to prevent injuries

Warming up prior to playing and training is a matter of routine for any serious athlete. A smart warm-up not only improves your performance, but also helps to prevent injuries. 'The 11+', the new injury prevention program from FIFA's Medical Assessment and Research Centre (F-MARC), provides a complete, football-specific warm-up and can easily be integrated into a daily training routine.

'The 11+' is divided into three parts: it starts off with running exercises (part I), moves on to six exercises with three levels of increasing difficulty to improve strength, balance, muscle control and core stability (part II), and concludes with further running exercises (part III). The different levels of difficulty increase the program's effectiveness and allow coaches and players to individually adapt the program. 'The 11+' takes approximately 20 minutes to complete and replaces the usual warm-up before training. Prior to playing a match, only the running exercises are performed, for about 10 minutes.

'The 11+' has proven to cut injuries by up to half—if performed correctly and regularly. When it is adopted together with the values of fair play, it enables you, as a player or coach, to protect yourself, your team and your opponents and thus increase everyone's enjoyment of the game.

Figure 15.15
An athlete completes the intermediate hamstring exercise as part of FIFA's 11+ complete warm-up.

Source: FIFA, <www.fifa.com/aboutfifa/developing/medical/the11/index.html> (accessed January 2010)

Learning experience

THE 11+ COMPLETE WARM-UP

Refer to the Snapshot 'The 11+—a complete warm up to prevent injuries' and answer the following questions.

1. What does the 11+ complete warm-up look like? Go to the link at <f-marc.com/11plus/files/poster_e.pdf/> or locate the warm-up on FIFA's website.
2. Why would FIFA's Medical Assessment and Research Centre (F-MARC) spend time and money researching how to prevent football injuries?
3. What is the benefit of injury reduction for professional teams?
4. As well as reducing injuries, the article claims that the 11+ improves performance. Do you believe this would be the case? Why/why not? Give specific examples from the article, exercises or research to justify your decision.
5. Identify:
   - **a** why the exercises in part II are organised into strength, plyometrics and balance in that order (levels 1, 2 and 3)
   - **b** the physical activities to which this type of warm-up would be suited
   - **c** the modifications you would make if you were to adopt this type of warm up for your own sport or the physical activity you are currently studying.
6. Participate in the 11+ as part of preparation for the physical activity you are currently studying. Did you enjoy the warm-up and find it effective in preparing you for the physical activity? Justify your decision with discerning and convincing data.

The conditioning phase

During the conditioning (or fitness) phase, the specific fitness components for a particular sport are developed using the training methods you favour. At all times follow proven training principles, such as the principle of overload.

In a well-planned training program, the following should be stated for each session (see figure 15.16):

- the training phase, macrocycle, mesocycle and microcycle, within which that session falls, e.g. pre-season mesocycle, week (microcycle) 2, session 1
- the type of exercise (training method) to be used
- the intensity (the speed of the work), e.g. continuous running at 75% maximum heart rate
- duration, or length, of the session
- volume, i.e. the amount of work to be performed.

If the workout is one continuous effort, the duration and volume are identical. If the workout has periods of work and rest, the volume is the sum of the work times, e.g.:

4 × 300 m at 85% maximum heart rate
6 × 75 m at 95% maximum heart rate

- rest periods, i.e. the length of time for recovery between work periods. The rest period is related to the length of the work period, so that the work-to-rest ratio (W:R) is specific to your sport, e.g.:

  6 × 75 m in 10 seconds
  Walk back 30 seconds
  W:R = 1:3

- repetitions, i.e. the number of times a specific exercise, routine or event is repeated during the workout.

Within the conditioning phase of each training session, there is an order of priority for the development of fitness components to ensure maximum return:

- Speed work should always be done first, allowing complete recovery between repetitions.
- Power and specific strength work should follow next, while fatigue levels are still low.
- Work on local muscular endurance, followed by aerobic work, should be performed last, since these activities are very fatiguing.

The cool-down

Cool-down is the combination of activities (walking, static stretching) done at reduced intensity to help the body return to pre-exercise state and aid recovery after conditioning phase.

The **cool-down** is the tapering off after completion of the workout. It should be a continuation of the activity at a very reduced intensity (e.g. after running, keep walking).

The cool-down is needed to prevent venous pooling (i.e. pooling of blood in the veins). After strenuous exercise, the heart keeps pumping blood at a rapid rate. If you end your workout abruptly, the muscles are no longer contracting—helping to propel the blood back to the heart—so blood may pool in the veins and tissue.

Venous pooling can result in insufficient venous return, therefore reducing the flow of blood for other vital organs. Less blood is reoxygenated, and waste (lactic acid) is not being removed from the muscles that have just been working. Therefore the cool-down is essential and must be long enough for the heart to recover to between 100 and 120 beats per minute.

All cool-downs should include either static stretching exercises or PNF stretching exercises (see figure 14.41, p. 359) for all muscle groups involved in the fitness phase.

Training diary

Day Sunday **Date** 27/6/10
Phase of training Pre-season macrocycle **Session no.** 3
Climatic conditions Raining
Psychological state Happy
Location Basketball court and football oval

Resting heart rate 56 **Exercise maximum heart rate** 188 **Recovery heart rate** 86

Warm-up
Jog till light sweat
Stretches:
- Calves
- Quads
- Hamstrings
- Gluteals
- Shoulder (front and rear)

Training method 1: interval training
Grid (20 m x 20 m)
1 Walk, jog, sprint, walk
  Jog, sprint, jog, walk
  Sprint, jog, sprint, walk
2 5 x 15 m (different starting positions)
3 3 x 50 m sprint

Training method 2: circuit training (2 laps individual load)
1 Side shuttles
2 Sit-ups
3 Wrist rolls
4 Agility cone run
5 Push-ups
6 Step-ups
7 Medicine ball pass
8 Forward back run
9 Skips
10 Bench jumps

Cool-down
5-minute walk/jog
Stretches as for warm-up

Comments on the session
Hard. Humid conditions. Combining two methods in one session very difficult.

Figure 15.16 Sample page from a training diary

Learning experience

TRAINING DIARY: STRENGTHS AND WEAKNESS

Refer to figure 15.16, the sample page of a training diary.

1. Identify the physical activities to which this training session might be specific.
2. What other information could be included to inform the coach or athlete of:
   - how to implement the session, or
   - how the session went?
3. Redesign the warm-up so it targets the same body parts but becomes dynamic instead of static.
4. Working in groups, implement either training method 1 or 2 and evaluate how effective it was in terms of:
   a. intensity
   b. time.

Learning experience

SPORT-SPECIFIC FITNESS TRAINING

You are currently participating in practical activity sessions as part of your Physical Education course. Complete the following for your activity area.

1. Give the two key fitness components most required for successful performance and an example of where each component is required in this activity.
2. Based on your current knowledge and experience of this activity, plan a 1-week training microcycle of three training sessions, to improve the two key fitness components.
3. Explain how your three sessions adhere to the principles of specificity, intensity and duration.
4. Participate in a class discussion of the difficulties you found in completing parts 1–3.
5. Compare your microcycle with those of your classmates. Using ideas from the class discussion and from your observations of other microcycles, modify your microcycle as you feel appropriate.
6. Implement the 1-week microcycle. Maintain a training diary to record session, intensities and any modifications.

Learning experience

AN ELITE TRAINING SESSION

1. Contact the office of an elite team or a state sporting association to find out where and when the team trains. For example, it could be a state or national league netball team, an NBL basketball team, an NRL rugby team, a state league volleyball team or a representative touch team.
2. Attend a training session and record:
   a. the activities performed in each phase of the session, i.e. warm-up, fitness phase, skill drill phase, team play or game play phase and cool-down
   b. the time taken for each phase in the session.

>>

3 Was the session as demanding as you expected?
4 Was there any evidence that the coach incorporated game-based skill and fitness training? If you answered yes, do you think it effectively targeted skills, fitness or both?
5 Was time given in the session to allow players to rehydrate?
6 Were players given feedback/coaching during the session?
7 What training principles were evident in the session?
8 Prepare a report on your findings and present a 2-minute summary of it to the class.

Learning experience

DEVELOPING A TRAINING PROGRAM

Throughout the year, you have been participating in practical sessions as part of your physical education course. Chances are these will be for a team sport, which is ideal for this research report. To complete this report, you will need to perform the following:

1 In the designated team sport, decide which playing position you wish to focus on in your analysis and training program.
2 Attend a high-level match in your chosen sport. Video, for a minimum of 20 minutes, one person playing in your chosen position. If possible, also record heart rates.
3 Analyse your video and record the following statistical data:
   a work times
   b rest times
   c movement patterns
   d frequency of skill use
   e direction changes
   f jumps, rebounds and leaps
   g stretches and lunges of various body parts
   h contacts, bumps, tackles and collisions in various body parts
   i any other information relevant to fitness components.
   If several students are interested in the same position, the video analysis is most efficiently completed as a group task.
4 Convert your data into tables that indicate:
   a random work and rest intervals
   b total work and total rest, with work to rest ratio
   c movement pattern results/tally sheet
   d heart rates
   e additional involvements, with columns showing
      - each additional involvement
      - frequency
      - fitness component required
      - body part or muscle group involved
      - contraction type.

>>

5 Discuss the following:
   a energy system usage in your sport—support your discussion with references to:
      - the movement pattern
      - the work to rest ratio
      - heart rate.
   b the other fitness components required by your sport (as shown by your additional involvement results—support your discussion with references to your tabulated data).
6 Use the results of the games analysis to:
   a list the components of fitness required for this physical activity
   b state in which body part each component is required.
7 Design or select a suitable test to assess your current fitness level for each fitness component. Arrange your tests into a fitness test battery, allowing for body part exhaustion and the intensity of effort required by different tests.
8 Perform each fitness test and record your pre-test results. Tabulate your results and compile a personal fitness profile.
9 Discuss the implications of your test results for your training microcycle (3–4 sessions over 1 week).
10 Make a short statement on the purpose of your microcycle.
11 Select the training methods you are going to use in your 1-week microcycle and the exercises, work intervals, distances, times, etc. within each training method. Write down a justification of the training methods you selected, in view of your games analysis and pre-test results.
12 Plan your training sessions for each training method, making sure you adhere to all training principles. Discuss how you have applied the training principles throughout the development and implementation of your program microcycle.
13 Implement the microcycle over 1 week and maintain a training journal that identifies any changes you have made, and indicates the intensities and effectiveness of the session in targeting the fitness components, energy systems and physical activity.
14 Identify the strengths and weaknesses of the microcycle.
15 Modify the microcycle to provide solutions for the weaknesses that were identified through implementation and evaluation in the training journal.

Evaluating training programs

As has been discussed previously, the minimum length for a training program to be implemented is 6 weeks. This is sufficient time for the body to make training adaptations, the performer to assess the difficulty and relevance of the program, and the planned sessions to have produced a measurable outcome.

Training programs can be evaluated according to a number of outcomes; however, the first step in this process is to conduct a post-test.

Post-testing

The post-test consists of the same battery of tests conducted in the pre-test. For the post-test to be completely accurate, the tests must be performed in the same order, in the same weather conditions and the same state of health of the performers as for the pre-test.

Once the post-test is completed, the results from each individual test can be compared with the matching pre-test result (see figure 15.17). The results for each test can then be graphed for comparison, along with the percentage change in performance from pre-test to post-test (see figures 15.18 and 15.19). This is essential for accurate evaluation of the program.

Program evaluation

Just as training programs are developed and planned on a step-by-step basis, so too must they be evaluated according to a number of steps.

Step 1: review purpose of the program

Did the program suit the special needs of the individual or team for which it was designed? To answer this question, you need to refer to the post-test results and training diary/journal entries. If the training journal discussion shows the program was not too stressful, if the post-test results are significantly improved and if the individual or team's performance has improved, then the program has achieved its purpose.

Step 2: review games analysis

This step in the evaluation tends to occur at the time of completing the games analysis, but shortcomings of the games analysis may be highlighted by the post-test results or the individual's feelings about their performance. Games analysis is a difficult process that is refined through practice. Errors or difficulties in the original analysis need to be identified in the evaluation so that they can be avoided or solved in any following games analysis. For example, the analysis may have been performed on an elite performer, which resulted in the program being pitched at a level that was too challenging for the individual for whom it was designed. The duration, intensity and specific exercises may therefore need modification.

Step 3: review test selection

The features that need to be considered in this step are the order, number and specificity of the tests. For example, in figure 15.17, perhaps 10 tests were too many in a pre-test battery and led to excessive fatigue before the final couple of tests, which resulted in poor results that did not really reflect the performer's specific fitness in those areas. Or if the tests were performed in the order shown in figure 15.17, then there may need to be some rearrangement so that, for example, the phosphate recovery test is not performed straight after the 3RM leg press.

Figure 15.17 Results of a pre-test and a post-test

Test	Component tested	Pre-test results	Post-test results	Percentage change
VO_2 20 m shuttle	Aerobic capacity	11.0	11.2	1.8
Vertical jump	Leg power	35.8 cm	56.9 cm	58.0
Grip test	Hand/forearm strength	30.5 kg	40 kg	31.0
3RM bench press	Chest/arm strength	40 lb (18.2 kg)	40 lb (18.2 kg)	0.0
3RM leg press	Leg/hip strength	120 lb (54.5 kg)	140 lb (63.6 kg)	16.0
Phosphate recovery test	Anaerobic capacity	3	8	166.0
Sit-ups	Abdominal endurance	41/min	57/min	39.0
Sit and reach	Hip/lower back flexibility	14 cm	18 cm	28.0
Illinois agility test	Agility	17.79 s	17.30 s	2.7
Shoulder hyperextension	Shoulder flexibility	41 cm	50 cm	21.0

Learning experience

TEST ORDER

Refer to figure 15.17 and list the ideal order for completing the battery of tests. Use your understanding of training and energy production to explain why you ordered the tests in this way.

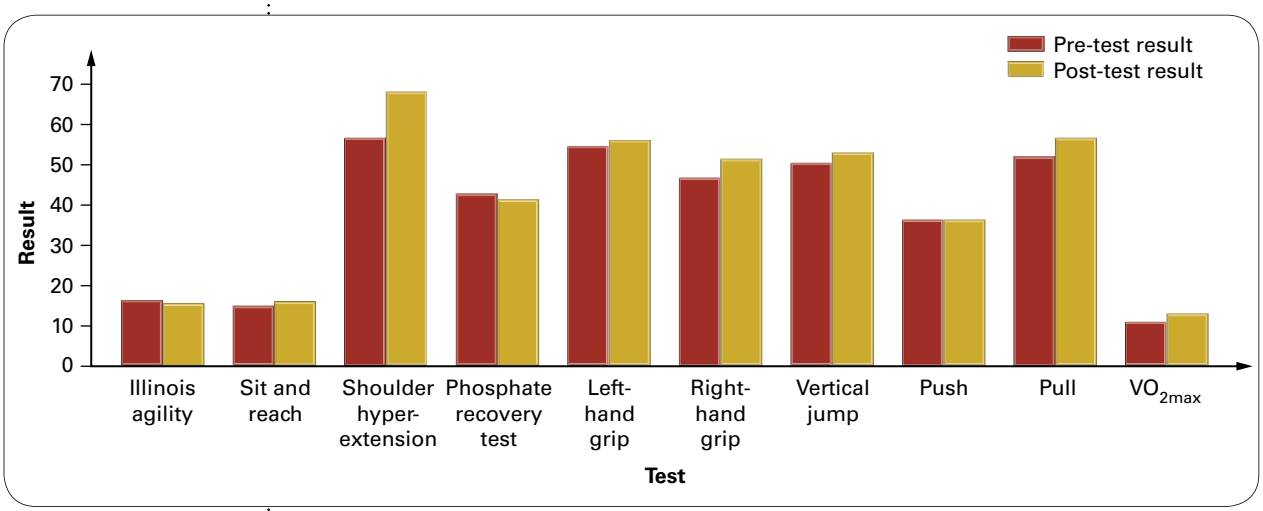


Figure 15.18 Graphed comparison of results of a pre-test and a post-test

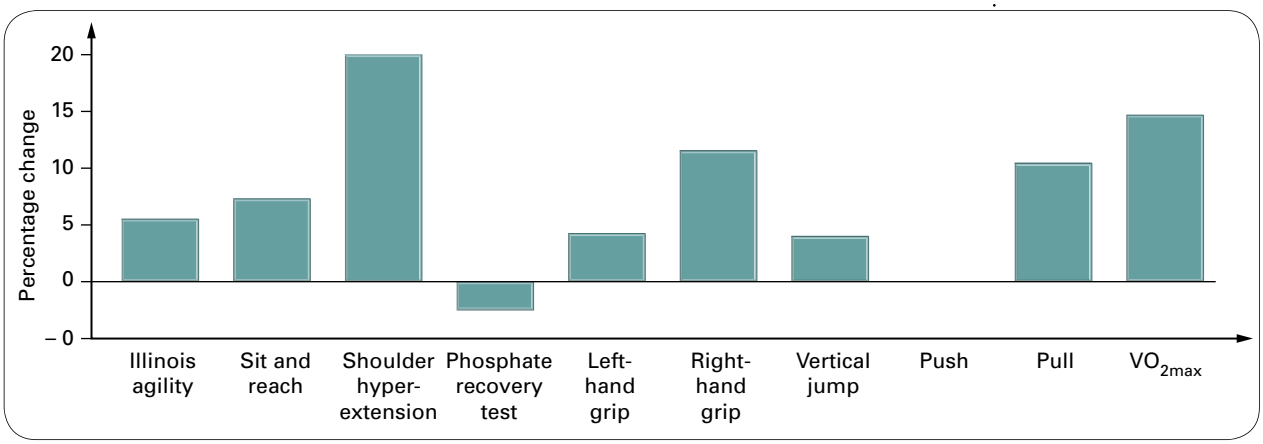


Figure 15.19 Percentage performance changes from pre-test to post-test insert

In the second part of the test review, the specificity and relevance of each test should be considered. For example, the Illinois agility test may have been used to assess agility, but on reflection the 5-0-5 agility test would have been more specific to the movements analysed for that sport. As a result, the pre-test battery would need to be modified.

Learning experience

WHAT WOULD YOU SUGGEST?

Based on the results of the pre- and post-tests and the analysis of improvement (refer to figures 15.17–15.19), select one component of fitness that has not improved significantly and is related to the physical activity you are currently studying.

1. Using the appropriate methods of training, design a microcycle of 3 training sessions that targets:
   - **a** this component of fitness and the relevant energy system/s
   - **b** the physical activity you are currently studying.
2. Implement one of the sessions of the microcycle and evaluate how effective it was in terms of:
   - **a** training method selected
   - **b** specificity to the component of fitness, relevant energy system/s and the physical activity you are currently studying.
3. Modify the session/s where appropriate.
4. Write a report on the solutions you applied to make the implemented training session more effective through the principles of specificity and intensity.

Step 4: review training methods

To successfully complete this step, you need to consider training diary or journal entries, subjective performance assessments and post-test results. For example, the training journal may show that trying to combine weight training and a continuous run in one session is too stressful. Or a poor post-test result on the 20 m shuttle test (see figure 15.17) may indicate the need to include more continuous training in any future program, as there was clearly no significant development of aerobic training effects during the 6-week period.

Learning experience

WHAT WOULD YOU RECOMMEND?

1 Conduct some research into training to improve aerobic capacity and recommend some specific training sessions that the athlete could implement to improve shuttle test results and VO_{2max}. Post your suggestions onto your school's online network as part of a forum. (Your teacher will set this up if it is appropriate.)

2 Comment on the effectiveness of other classmates training session recommendations to improve VO_{2max}.

Step 5: review training sessions and timetable

For the most part, this step should focus on individual needs. For example, did the days of the week scheduled for training suit the performer's lifestyle? Were the sessions spaced well throughout the week to allow sufficient recovery between sessions? Was each session too complex or difficult? Would it have been better planning to have more sessions, each of less complexity? All these factors need to be considered in a full evaluation before planning the next 6-week program. Usually this is achieved through maintaining a training journal.

Learning experience

TRAINING JOURNAL DESIGN

Design a template that you could use to evaluate individual training sessions to ensure they are effective in meeting your training needs and monitor modifications. You may wish to use internet or other research to inform your decisions.

Consider including information about:

- date, time and place
- training method/s used
- exact details of what was done
- intensity, e.g. heart rate: target, before, during and after
- any modifications, e.g. increase of reps to achieve target heart rate
- how training felt
- anything else you consider relevant.

Figure 15.20
This athlete shows the benefits of a well-planned flexibility program.

Step 6: review training principles

To develop a successful training program, it is essential to apply training principles, so any evaluation must consider the impact of these principles during the 6-week training period. For example, did the training diary indicate that the planned overloads were manageable or too stressful? Do the post-test results indicate that the specific training methods chosen produced the improvement wanted? Did the training journal indicate that the planned variety was sufficient to maintain motivation, or did the program suffer from lack of variety and hence performer boredom? Do the post-test results show

that the intensity chosen for each session was effective in developing the specific training effects desired, or could future programs include more intense sessions? All these factors must be considered in a complete evaluation.

Program modification

Once the program evaluation is complete, it is essential to go back and modify the process that led to the development of the program, as well as modifying the program itself. Areas that may require modification include:

- *purpose of the program*—e.g. the new program may need to be designed for in-season training rather than pre-season
- *games analysis*—e.g. additional assistance may be required to gain more accurate movement pattern information, or the subject of the video analysis may need to be at a level more appropriate to the individual or team for whom the new program is being developed
- *test selection*—e.g. more reliable or specific tests may need to be substituted for those tests that were evaluated as poor, and the order in which the tests are performed may need to be shuffled to prevent excessive fatigue
- *training methods*—e.g. additional training methods may need to be added to the program, or specific training methods may require greater emphasis in the new program
- *training sessions and timetables*—e.g. the spacing between sessions in the new program may need to be altered to allow more recovery between very physically demanding sessions, or the type of cool-down activity may need to be changed to encourage more rapid recovery post-exercise
- *training principles*—e.g. the principle of variety may need greater emphasis in the new program to prevent boredom, or the principle of specificity may need to be applied more carefully in choosing interval training distances and repetition numbers.

All this information can then be used to plan and develop a more accurate and specific program that better suits the individual or team for whom it was developed. This process of development, implementation and evaluation is ongoing and allows sportspeople and those interested in health-related fitness to steadily improve as efficiently as possible.

Effects of training

Training effects are the physiological changes your body makes in response to the demands of the exercise you perform. There are two kinds of responses:

- immediate responses that last only for the duration of the exercise and the recovery period (these will be explained in detail)
- long-term responses, which are adaptations over time and take about 6 weeks of training to develop.

The summation of the long-term responses is known as ‘the training effect’.

All circulorespiratory (heart, blood, blood vessel and lung) responses to exercise are the body’s way of trying to deliver more oxygen, more quickly and efficiently, to the working muscles in order to produce aerobic energy.

Cardiorespiratory fitness plays a large role in oxygen consumption and delivery, and training helps to increase the efficiency of this system. Therefore this section will also explain the factors that affect oxygen consumption and delivery and the impact of this on the body during exercise.

Figure 15.21 provides a summary of the immediate and long-term effects of training on the heart, blood, blood vessels and lungs.

Figure 15.21 Summary of the circulorespiratory responses to exercise

Immediate responses	Long-term training effects
Blood flow to working muscles increases Blood plasma volume decreases Heart rate increases Stroke volume increases Cardiac output increases a–v0_2 diff. increases Systolic blood pressure increases Respiration rate increases Tidal volume increases Ventilation increases Oxygen uptake (VO_2) increases Lung diffusion increases	Size of the left ventricle increases Number of blood vessels increases Blood volume increases Haemoglobin and oxygen-carrying capacity increases Resting heart rate decreases Recovery rate increases Stroke volume increases Maximum cardiac output increases a–v0_2 diff. increases slightly Risk of high blood pressure (hypertension) decreases Efficiency of breathing mechanism increases Lung diffusion increases Maximum ventilation increases Lactate threshold 2 (anaerobic) increases VO_{2max} increases

Immediate effects of training

Immediate cardiovascular (circulatory system) responses to exercise

Acute responses of the cardiovascular system to exercise include:

- increased heart rate
- increased stroke volume
- increased cardiac output
- increased blood lactate concentrations
- increased blood pressure
- increased blood flow
- increased arteriovenous oxygen difference
- decreased blood plasma volume.

Increased heart rate

Your resting heart rate is the number of beats your heart makes in one minute. Your resting heart rate, taken upon waking in the morning, is often used to indicate your level of aerobic fitness. It is determined by how much training you have been doing and by your genetic inheritance.

The average resting heart rate is about 70–72 beats per minute. Resting heart rates taken during a normal day can vary enormously because stress, excitement, eating, smoking and your body position can all increase your heart rate.

When you begin to exercise, your heart rate increases to increase the supply of oxygen to your working muscles (see figure 15.22). If you exercise at a constant, comfortable (submaximal) pace, your heart rate will level off and

remain constant until you change pace or stop. This is called a 'steady state' and indicates that the muscles are receiving enough blood and oxygen to keep working at that pace; that is, the athlete is working between lactate threshold 1 and lactate threshold 2.

Your heart rate increases linearly with increases in exercise intensity (see figure 15.22) until you reach maximum heart rate. On average, maximum heart rate is calculated by using the following formula: Maximum HR = 220 – age (years). So for a 17-year-old person:

$$\begin{aligned}\text{Maximum HR} &= 220 - 17\\ &= 203\end{aligned}$$

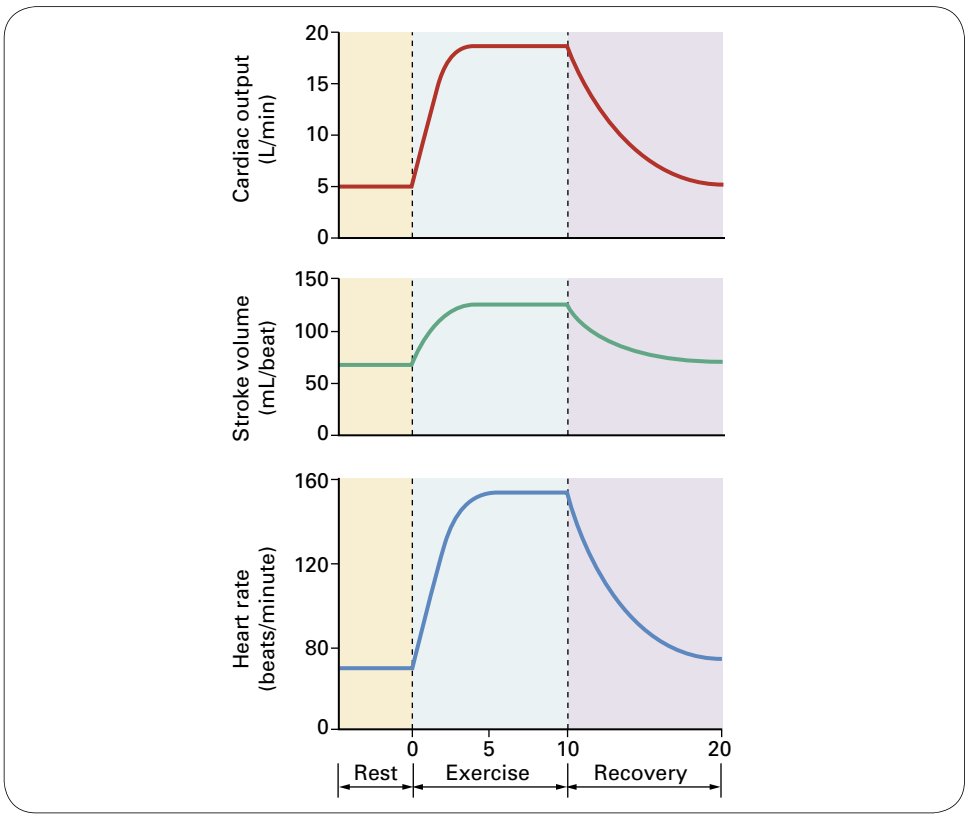


Figure 15.22 Pattern of change in cardiac output (top), stroke volume (middle) and heart rate (bottom) during short-term (5–10 minutes) submaximal exercise. There is a sharp rise at the onset of exercise, followed by a steady state, then a sharp decline as exercise stops.

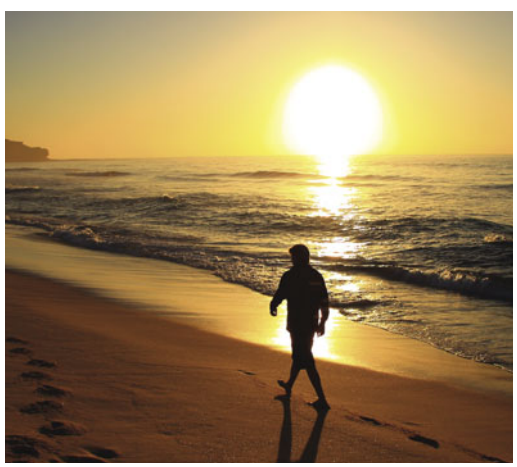


Figure 15.23 Heart rate increases in direct proportion to the workload on the body.

Increased stroke volume

Stroke volume is the volume of blood ejected by a ventricle of the heart during systole, the period of a single cardiac contraction.

Stroke volume is the amount of blood pumped out of the left ventricle with each heart beat (contraction). Your stroke volume depends on the size of your left ventricle, which is determined by a combination of genetics and training.

At rest, the average stroke volume is 60–80 mL of blood ejected per beat. However, when you begin to exercise, your heart muscle contracts more forcefully to increase blood (and hence oxygen) supply to your muscles. This causes a more complete emptying of your ventricles, so your stroke volume increases. Maximum stroke volume, on average, is about 90–120 mL per beat and is reached during submaximal exercise (see figure 15.22).

Increased cardiac output (*Q*)

Cardiac output (*Q*) is the volume of blood pumped from a ventricle of the heart per unit of time. It is the product of heart rate and stroke volume.

Cardiac output is the amount of blood pumped out of the heart's left ventricle in one minute. It is calculated by using the following formula:

$$Q = \text{stroke volume} \times \text{heart rate}$$

For example:

$$Q = 80\,\text{mL per beat} \times 70\,\text{beats/min}$$
$$= 5.6\,\text{L/min}$$

At rest, the average person has a cardiac output of 4–6 L pumped out per minute.

When you begin to exercise, your cardiac output increases in an effort to increase the blood supply (and hence oxygen delivery) to your working muscles. If you exercise at a constant submaximal pace, your cardiac output will eventually level out (i.e. reach a steady state). However, if you keep increasing the pace, cardiac output will increase linearly up to the point of exhaustion.

During maximal exercise, the cardiac output can on average reach 20–30 L per minute because of the doubling of the stroke volume and tripling of the heart rate (see figure 15.22), e.g.:

$$Q = \text{stroke volume} \times \text{heart rate}$$
$$= 120\,\text{mL} \times 202$$
$$= 24.4\,\text{L/min}$$

Learning experience

HEART RATE AND EXERCISE

Figure 15.24 shows results obtained during a laboratory exercise test performed by a Year 11 student wearing a heart-rate monitor.

a What happened at the 2-minute point?
b What is this student's resting heart rate?
c What is the term used for the plateau at points A and B?
d Why does this student's heart rate plateau at point A?
e Does this student reach their maximum heart rate?

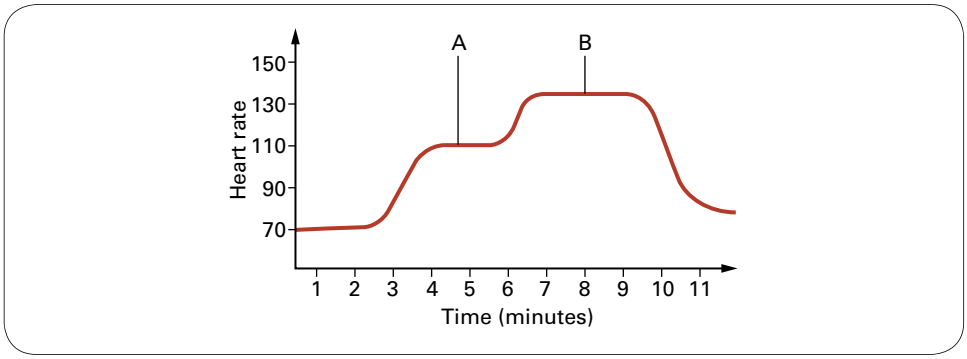


Figure 15.24
Results of a laboratory exercise test by a Year 11 student wearing a heart-rate monitor

Increased blood lactate concentrations

Despite popular belief **blood lactate** is a useful form of potential energy as long as it does not accumulate above a certain level in the blood. Lactate continuously forms during rest and exercise. The amount of blood lactate accumulation depends on the exercise intensity and the ability of the cardiorespiratory system to deliver enough oxygen to the muscles, to clear the lactate as it is produced.

Blood lactate measures the concentration of lactate in the blood formed from the salts of lactic acid

A sustained increase of blood lactate concentrations above 2 mmol/L (usually during submaximal exercise) is referred to as the blood lactate threshold 1 (LT1). During moderate aerobic conditions lactate removal matches lactate accumulation and blood lactate level remains stable. When clearance of blood lactate does not match production, there is an increase in blood lactate concentration. As exercise intensity increases so does blood lactate production and accumulation. The muscle cells cannot meet the energy demand aerobically or clear lactate at its rate of production. This point is referred to as the lactate threshold 2 (LT2). It is the upper limit of equilibrium between lactate production and clearance. This process is similar for trained and untrained individuals. However, LT2 occurs at a higher percentage of aerobic capacity for the trained individual, approximately 80% or higher. This means that the trained individual can work harder for longer before blood lactate concentrations increase to the point where it interferes with muscular contractions due to acidosis (see figure 15.25).

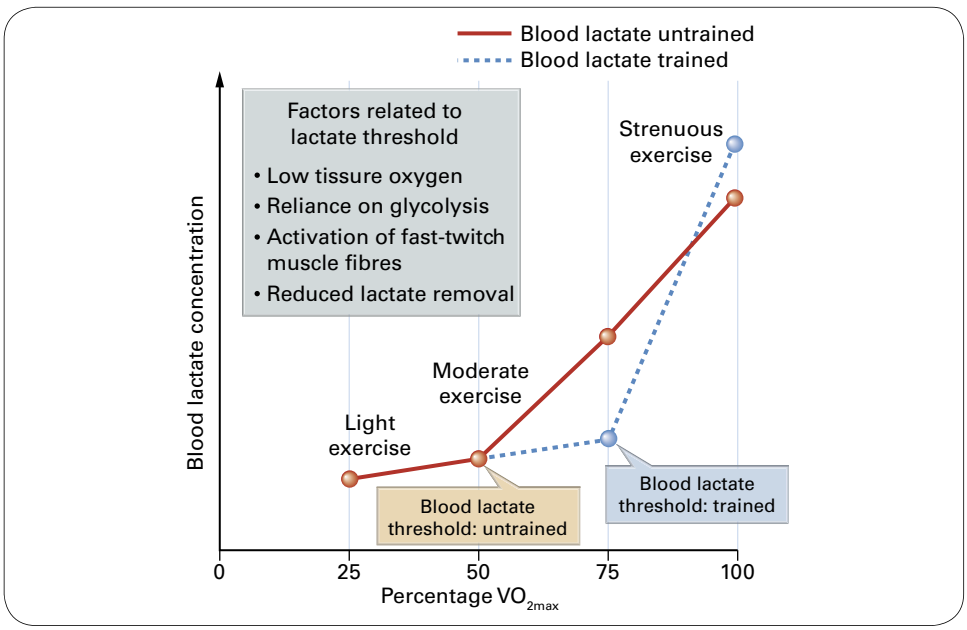


Figure 15.25
Blood lactate concentration for trained and untrained subjects at different levels of exercise expressed as a percentage of maximal oxygen consumption (VO_{2max})

Blood pressure is the pressure of the blood in the arteries.

Increased blood pressure

Blood pressure is a measure of the pressure produced by the blood being pumped into the arteries. Systolic blood pressure is the pressure as the left ventricle ejects the blood into the aorta during heart contraction, and diastolic blood pressure is the pressure in the arteries during relaxation of the heart. Normal blood pressure is about 120/80.

During exercise, because stroke volume, heart rate and cardiac output increase, more blood is pumped into the arteries more quickly. This causes the systolic blood pressure to rise as high as 180, while diastolic blood pressure remains fairly constant.

Increased blood flow

During exercise, blood flow to the working muscles and skin increases because of increased cardiac output (Q) and a greater distribution of blood away from non-working areas to active muscles. This is called 'redistribution' and is managed as follows:

- About 80–85% of the cardiac output goes to the working muscles, because the muscle capillaries dilate to allow more blood to flow to the muscles (this is called 'vasodilation').
- Blood flow to the kidneys, stomach and intestines decreases because the capillaries constrict (this is called 'vasoconstriction').
- Blood flow to the lungs increases, as the right ventricle increases its activity during exercise.
- There is a fivefold increase in the coronary blood flow during strenuous exercise to supply oxygen to meet the increased demands of the cardiac muscle.

To allow for this increased blood flow to the muscles, there must be an accompanying increase in venous return. Venous return is increased as a result of the increased muscular activity, which forces the blood back to the heart along the veins.

Increased arteriovenous oxygen difference (a–vO_2 diff.)

The arteriovenous oxygen difference (a–vO_2 diff.) is the difference between the oxygen concentration in the arteries and the oxygen concentration in the veins.

The a–vO_2 diff. shows how much oxygen is being absorbed into your muscles and used to produce aerobic energy (see figure 15.26). For example, when the body is at rest, the arterial oxygen concentration could be 19 mL of oxygen per 100 mL of blood, and the venous oxygen concentration could be 13 mL of oxygen per 100 mL of blood. Therefore the muscles are using 6 mL of oxygen per 100 mL of blood:

$$\text{a–v}O_2 \text{ diff.} = 6\,\text{mL}/100\,\text{mL}$$

When you begin to exercise, more oxygen is extracted from the blood as it passes through the muscle because it is needed to produce energy to keep the muscle contracting. As a result, the venous oxygen concentration could drop to 4 mL of oxygen per 100 mL of blood, and the exercising arteriovenous oxygen difference would be:

$$\begin{aligned}\text{a–v}O_2 \text{ diff.} &= 19\,\text{mL}/100\,\text{mL} - 4\,\text{mL}/100\,\text{mL} \\ &= 15\,\text{mL}/100\,\text{mL}\end{aligned}$$

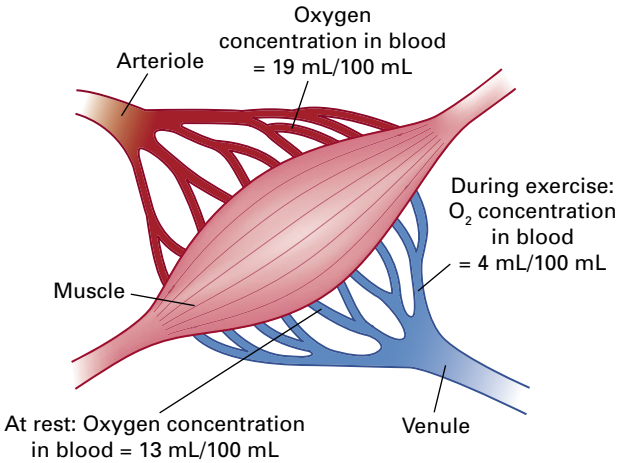


Figure 15.26
The arteriovenous oxygen difference during exercise and during rest

Decreased blood plasma volume

Because of increased sweating, the blood plasma volume usually decreases during strenuous exercise, especially in hot weather. This can lead to dehydration and heatstroke if the athlete does not attempt to rehydrate during and immediately after the event.

A fluid loss of 2% of your body weight because of sweating can cause your performance to deteriorate. It is possible to lose 8% of your body weight during a marathon or triathlon if you do not rehydrate during the event. Australian Rules football players have recorded fluid losses of up 3.6 L per game, particularly early in the season when temperatures are higher.

Immediate respiratory responses to exercise

During exercise and recovery, more oxygen must be delivered from the lungs to the working muscles, and excess carbon dioxide must be removed from the muscles. Acute responses of the cardiovascular system to exercise include:

- increased respiratory rate
- increased tidal volume
- increased ventilation
- increased lung diffusion
- increased oxygen uptake, or volume of oxygen consumed (VO_2).

Increased respiratory rate

Respiratory rate is the number of breaths taken in one minute. At rest, you breathe about 12–15 times each minute. When you begin to exercise, the carbon dioxide (CO_2) level in the blood increases, because CO_2 is a waste product of energy production. This triggers the respiratory centre in your brain and you breathe faster.

During races such as an 800 m run, your respiratory rate can be as high as 45–50 breaths per minute, as your body tries to take in oxygen and blow out carbon dioxide.

Figure 15.27
The start of a triathlon rapidly stimulates a series of acute cardiorespiratory responses

Increased tidal volume

Tidal volume is the volume of air breathed in or out with each breath.

Tidal volume is the size of each breath taken. At rest, the average tidal volume is about 0.5 L, which is enough to supply the body with oxygen. However, during heavy exercise, tidal volume can increase to 2.5 L per breath as the body tries to increase the oxygen supply to the blood.

Increased ventilation

Ventilation is the movement of air in and out of the lungs.

Ventilation is the amount of air breathed in 1 minute. Therefore ventilation depends on two factors:

- the number of breaths per minute (respiratory rate)
- the size of each breath (tidal volume).

It is calculated by using the following formula:

$$\text{Ventilation } (V) = \text{tidal volume} \times \text{respiratory rate}$$

During exercise, ventilation increases, with more vigorous exercise requiring greater ventilation. For example, ventilation at rest might be:

$$V = 0.5\,\text{L} \times 12\ \text{breaths/min} = 6\,\text{L/min}$$

During exercise, it could rise to:

$$V = 2.5\,\text{L} \times 45\ \text{breaths/min} = 112.5\,\text{L}$$

During maximal exercise, ventilation can reach 130 L/min for females and 180 L/min for males.

Increased lung diffusion

Diffusion is the net movement of chemicals such as oxygen, carbon dioxide and sodium from an area of high concentration to an area of lower concentration.

During strenuous exercise, there is a threefold increase in oxygen **diffusion** from the alveoli to the blood because of a massive increase in blood flow to the lungs, and dilation of the capillaries surrounding the alveoli. Similarly, more carbon dioxide diffuses from the blood into the alveoli, and is then breathed out.

Increased oxygen uptake or volume of oxygen consumed (VO_2)

Oxygen uptake (VO_2) is the amount of oxygen taken up and used by the body to produce energy. It reflects the total amount of work being done by the body.

During rest, the average VO_2 is about 0.25 L of oxygen per minute, but this varies greatly depending on body size (the larger the body, the larger the resting VO_2).

When you begin to exercise, your VO_2 increases as your body absorbs more oxygen and uses it to produce more aerobic energy. If you exercise at a constant submaximal (comfortable) pace, your VO_2 will level off (i.e. reach a steady state) and remain constant until you change pace or stop.

A **steady state** in VO_2 during submaximal exercise shows that all the energy needed to maintain that pace is being supplied aerobically. As the pace (intensity) of the exercise increases, so too does the VO_2, because you need more oxygen to exercise at a faster pace.

Steady state is the point reached after the first 3–4 minutes of exercise, when oxygen uptake meets the oxygen demand of the tissue, and heart rate, cardiac output and pulmonary ventilation have reached fairly constant levels.

During maximal aerobic exercise (which usually lasts for 5–10 minutes), you reach maximum oxygen consumption (e.g. 2–3 L/min), called the 'VO_{2max}'. This is the maximum amount of oxygen that can be taken in, transported to and consumed by the working muscles to produce energy.

Maximum oxygen uptake (VO_{2max}) is used as the most accurate measure of a person's aerobic fitness. A higher VO_{2max} reflects the increased ability of:

- the heart to pump blood (i.e. increased cardiac output)
- the lungs to ventilate large volumes of air
- the muscles to take up oxygen (a–vO_2 diff.) and remove carbon dioxide.

Learning experience

VO_{2MAX} AND a–vO_2 DIFF.

The following table gives the VO_2 and a–vO_2 diff. at rest and during maximal exercise for a trained and an untrained subject and an endurance athlete:

Subject	VO_2 (mL/min)	a–vO_2 diff. (mL/L)
X Rest	300	48.8
Max. exercise	3100	138.0
Y Rest	300	49.3
Max. exercise	3440	140.5
Z Rest	300	49.3
Max. exercise	5570	155.0

a Which of X, Y or Z is the endurance athlete? Give reasons for your choice.

b Define the term 'VO_{2max}'.

c Name one test used to measure or predict VO_{2max}.

d Which component of fitness does VO_{2max} best measure?

e Some tests used to predict VO_{2max} rely on an important relationship between heart rate and oxygen consumption. What is the relationship?

Learning experience

OXYGEN DEBT

The graph in figure 15.28 represents the oxygen uptake (VO_2) and blood lactic acid responses of a subject exercising for 10 minutes on a bicycle ergometer. During the recovery period the subject sat quietly on the bicycle ergometer.

a What was the oxygen uptake at rest?

b List three immediate physiological responses that had to occur in order for O_2 consumption to increase.

c Define 'lactate threshold 2'.

d Discuss lactate threshold 2 in relation to the subject's 10-minute exercise period.

e Explain why lactic acid (blood lactate) does not accumulate during steady-state work.

f Which energy system or systems are used between minutes 2.5 and 7.5 of the exercise period?

g Explain why this subject, after the 10-minute exercise period, should continue some activity at a reduced intensity.

h What is the predominant fuel being used to produce the energy during the steady-state exercise period?

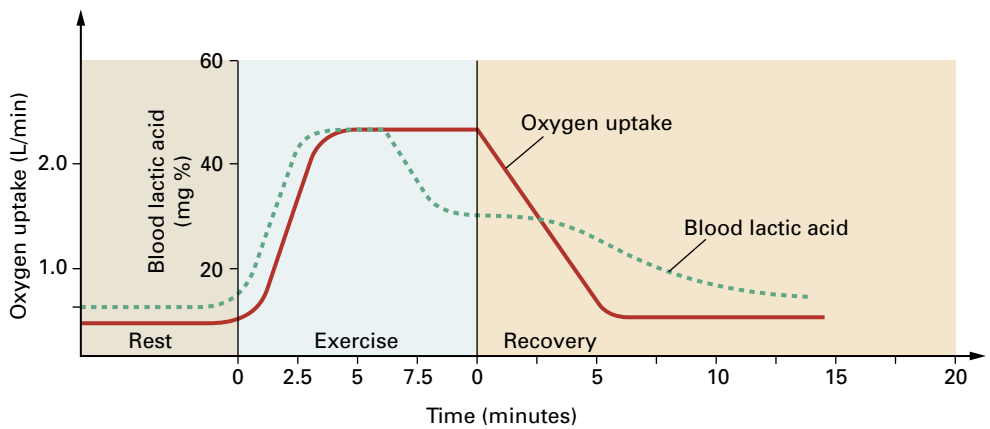


Figure 15.28 VO_2 and blood lactic acid of a subject exercising for 10 minutes on a bicycle ergometer

Immediate muscular responses to exercise

The immediate changes that occur in muscles during exercise depend very much on the type, duration and intensity of the exercise. However, a summary of changes includes:

- an increased number of muscular contractions to propel the body
- increased motor-unit activation, so that more fibres are fired to contract and the muscles make more forceful contractions

- increased recruitment of muscle fibres in a motor unit to produce more force
- increased muscle temperature because of increased blood flow and heat released from energy production
- depletion of ATP–CP stores, as creatine phosphate is used to produce energy for contractions
- depletion of muscle glycogen and triglyceride stores, as those fuels are used to make energy through the lactic acid and aerobic energy systems
- increased blood flow to working muscles as muscle capillaries dilate
- increased oxygen extraction at the muscle as myoglobin delivers more oxygen to the working muscles
- increased enzyme activity, as enzymes are involved in all the chemical reactions that produce energy.

Immediate responses to exercise—oxygen consumption and delivery

Aerobic power, aerobic fitness and aerobic capacity are all terms that refer to the same thing—the ability of the body to utilise oxygen to perform work or to exercise.

Aerobic fitness depends on the efficiency and development of the cardiovascular and respiratory systems, and therefore is sometimes called cardiorespiratory fitness.

Although the responses the body makes to increase oxygen consumption and delivery during exercise are immediate, the efficiency of oxygen consumption and delivery is also a goal of training and therefore a long-term effect.

Oxygen delivery

The major factor limiting performance in aerobic activities is oxygen delivery to the mitochondria in the muscles. Oxygen delivery depends on:

- the ability of the lungs to take in large volumes of air
- the ability of the blood to take up oxygen as it passes through the lungs
- the ability of the heart to pump large volumes of blood to the muscles
- the ability of the muscles to extract the oxygen from the blood
- the ability of the muscles to convert oxygen and fuels into ATP (adenosine triphosphate).

Oxygen uptake

Your ability to consume oxygen for energy production is called your oxygen uptake (VO_2). This depends on:

- your genetically inherited body structure, such as lung capacity and distribution of red (slow-twitch) muscle fibres
- how well developed your cardiorespiratory system is (whether as a result of an active or a sedentary lifestyle)
- the type of exercise you are performing
- your age
- your gender.

Aerobic steady state

As you begin to exercise, your ventilation (respiratory rate and tidal volume) and cardiac output (stroke volume and heart rate) increase to deliver more oxygen to your muscles (see figure 15.29).

While your oxygen uptake is building up gradually, ATP is being produced by the anaerobic energy systems. If you exercise submaximally, after 2 or 3 minutes (but certainly by 5 minutes), your oxygen uptake will have increased sufficiently for all the required ATP to be produced aerobically. At this point your oxygen uptake levels off (see figure 15.30) and you have reached an aerobic steady state.

A steady state occurs when all the ATP required to maintain the current pace is being supplied aerobically, so there is no need for further increases in oxygen uptake.

However, if the pace increases, the demand for ATP and oxygen increases. Again, during the short delay before oxygen uptake increases, the anaerobic system (this time the lactic acid system alone) supplies the extra ATP. As the oxygen uptake increases to the required level, a second aerobic steady state is reached.

Figure 15.29 Metabolic and circulatory measures in a club level athlete and an elite athlete: at rest, during submaximal exercise and during maximal exercise

Measure	Rest		Submaximal exercise		Maximal exercise	
	Club level athlete (80 kg)	Elite athlete (75 kg)	Club level athlete (80 kg)	Elite athlete (75 kg)	Club level athlete (80 kg)	Elite athlete (75 kg)
Heart rate (bpm)	60	50	128	128	180	175
Stroke volume (mL)	70	88	140	172	140	172
Cardiac output (L/min)	4.2	4.4	17.9	22	25.2	30.1
Haemoglobin (g/L)	149	157	153	164	153	164
Arterial O_2 (mL/L)	200	210	205	220	205	220
Venous O_2 (mL/L)	120	125	93	97	46	41
a–vO_2 (mL/L)	80	85	112	123	159	179
Oxygen uptake (L/min) (mL/kg/min) (%VO_{2max})	 0.35 4.3 8	 0.37 4.9 7	 2 25 50	 2.7 36 50	 4 50 100	 5.40 72 100
Blood lactic acid (mmol/L)	1	1	4	3	9	16
Respiratory exchange ratio	0.8	0.8	0.99	0.94	1.10	1.17

VO_{2max} (maximum oxygen consumption)

The process of increasing oxygen uptake and reaching a new steady state (see figure 15.31) can continue until eventually you reach a pace that is so demanding that a new aerobic steady state cannot be reached. At this stage, the lactic acid system supplies much of the extra energy you require to keep going. As the lactic acid builds up in muscles, it will eventually cause you to fatigue and stop.

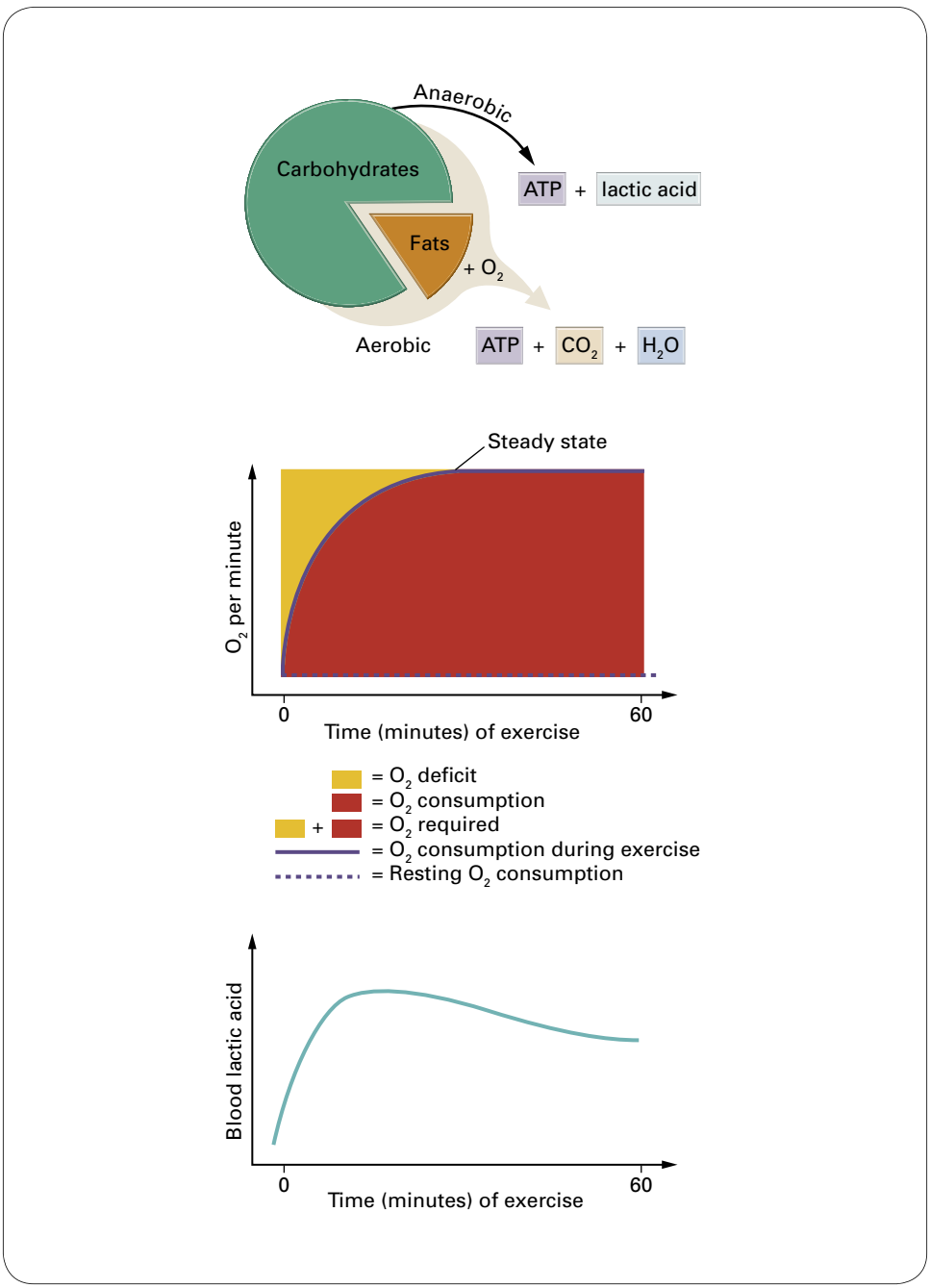
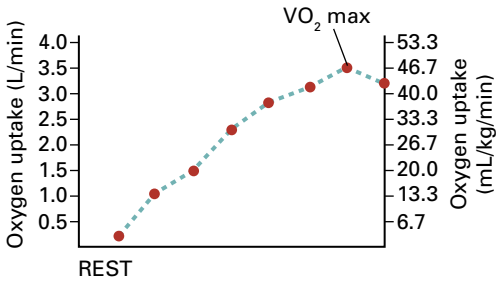


Figure 15.30
ATP production, oxygen consumption and lactic acid production during prolonged submaximal exercise. The major source of ATP is the aerobic system. The creatine phosphate system and the lactic acid system also contribute at the beginning, before oxygen consumption reaches a steady state. Lactic acid accumulates during the oxygen deficit period and then remains fairly constant.

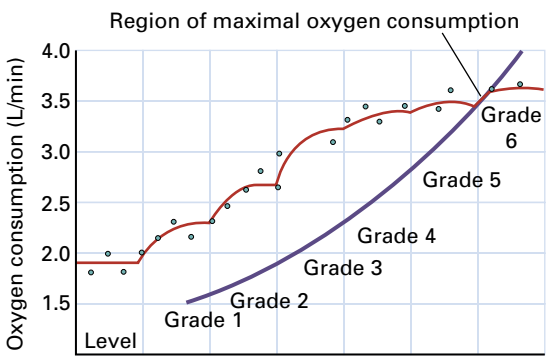
The intensity of exercise at which lactic acid starts to accumulate in your muscles is called your 'lactate threshold 2 (LT2)' or 'anaerobic threshold'. Shortly after you cross your LT2, and if the pace continues to increase, you will reach your highest possible oxygen intake, your VO_{2max}.

Lactate accumulates rapidly once you cross your LT2. In addition, ventilation rises sharply as your body tries to get rid of carbon dioxide, the production of which also rises sharply (see figure 15.31). In an untrained person, the LT2 may be reached at 50% of VO_{2max}. However, in an endurance athlete it may not be reached until 85% of VO_{2max}. This means that the endurance athlete can perform at a faster pace and clear the lactate that accumulates in the muscles and blood efficiently.



Speed (km/h)	4.8	8.0	11.2	11.2	11.2	11.2	11.2
Treadmill grade (%)	0	5.5	7.5	9.5	11.5	13.5	15.5
Time (min)	0–2	2–4	4–6	6–8	8–10	10–12	12–14

Exercise on the treadmill



Hills of increasing grade

Figure 15.31
Oxygen uptake and oxygen consumption during measurement of VO_{2max}, using gradually increasing steepness on a treadmill

Maximal aerobic exercise usually lasts for 5–10 minutes, and your VO_{2max}, which is measured during the final stages of exercise (exhaustion), represents the maximum amount of oxygen able to be taken in, transported to and consumed by the working muscles to produce energy. VO_{2max} is the most accurate measure of aerobic fitness.

Factors affecting VO_{2max}

Aerobic fitness

The level of aerobic training and the development of chronic training effects affect VO_{2max}. If you are aerobically active, you develop an efficient cardiorespiratory system that can deliver extra oxygen more quickly to your muscles. Your cardiorespiratory system will have a greater cardiac output, stroke volume and a–vO_2 difference. At the muscular level, you will also develop changes that result in better oxygen extraction from the blood and production of ATP. All these factors result in a higher VO_{2max}.

Body size

Oxygen uptake is expressed in litres per minute. For example, a person may have a resting VO_2 of 0.25 L/min, which may rise to 3 L/min during exercise. But oxygen uptake is related to body size, so a large person would naturally have a larger VO_2 than a small person.

To account for these body size variations, VO_{2max} is expressed in millilitres of oxygen consumed per kilogram of body weight per minute. Therefore, VO_{2max} values can be used to compare the aerobic fitness of individuals, irrespective of body size, as the more aerobically fit person can consume more oxygen for each kilogram of body weight.

For example, a sedentary male of 80 kg, whose peak oxygen consumption is 3 L (3000 mL) per minute, has the following VO_{2max}:

$$\frac{3000}{80} = 37.5 \text{ mL/kg/min}$$

However, an elite marathon runner of 70 kg, whose peak oxygen consumption is 6000 mL/min, has the following VO_{2max}:

$$\frac{6000}{70} = 85.7 \text{ mL/kg/min}$$

Gender

Females tend to have lower VO_{2max} values than males of similar training status. This seems largely attributable to the fact that women have more body fat and less muscle mass than men. Since body fat is essentially dead weight and, unlike muscle, is not involved in aerobic energy production, women score lower on bodyweight-corrected VO_{2max} scores (see figures 15.33 and 15.34).

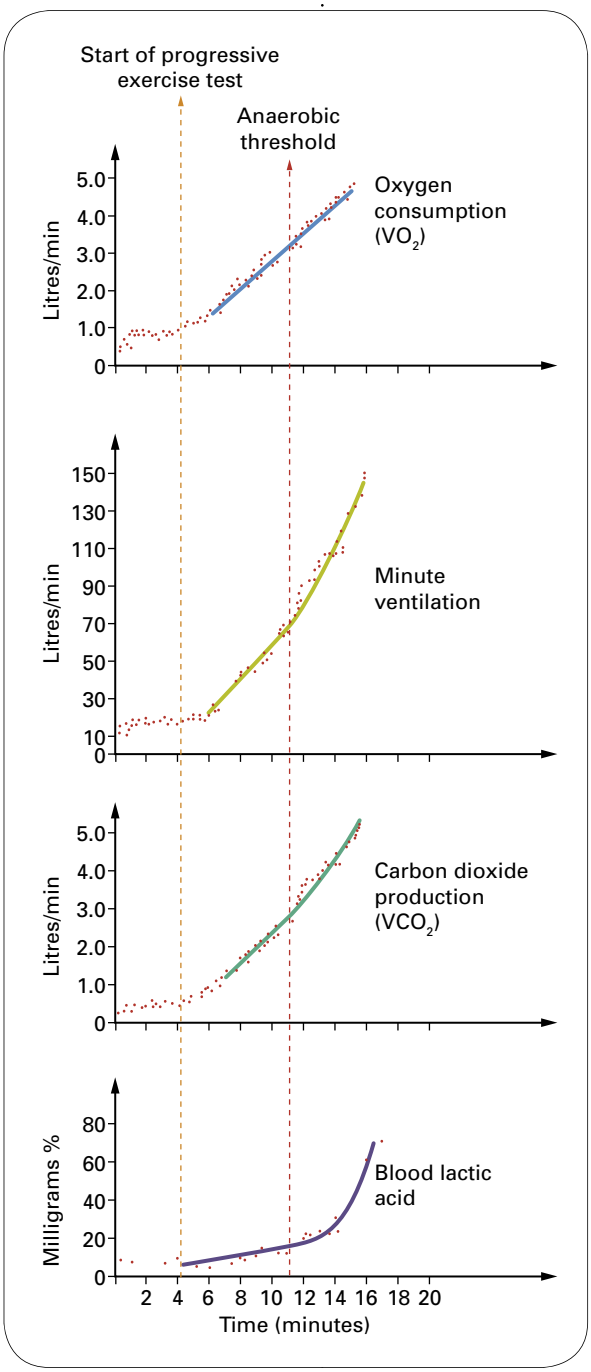


Figure 15.32
Relationship of minute ventilation (the amount of ventilation in 1 minute) to the anaerobic threshold. Minute ventilation and carbon dioxide production (VCO_2) start to rise sharply at the anaerobic threshold, coinciding with the steep rise in blood lactic acid.

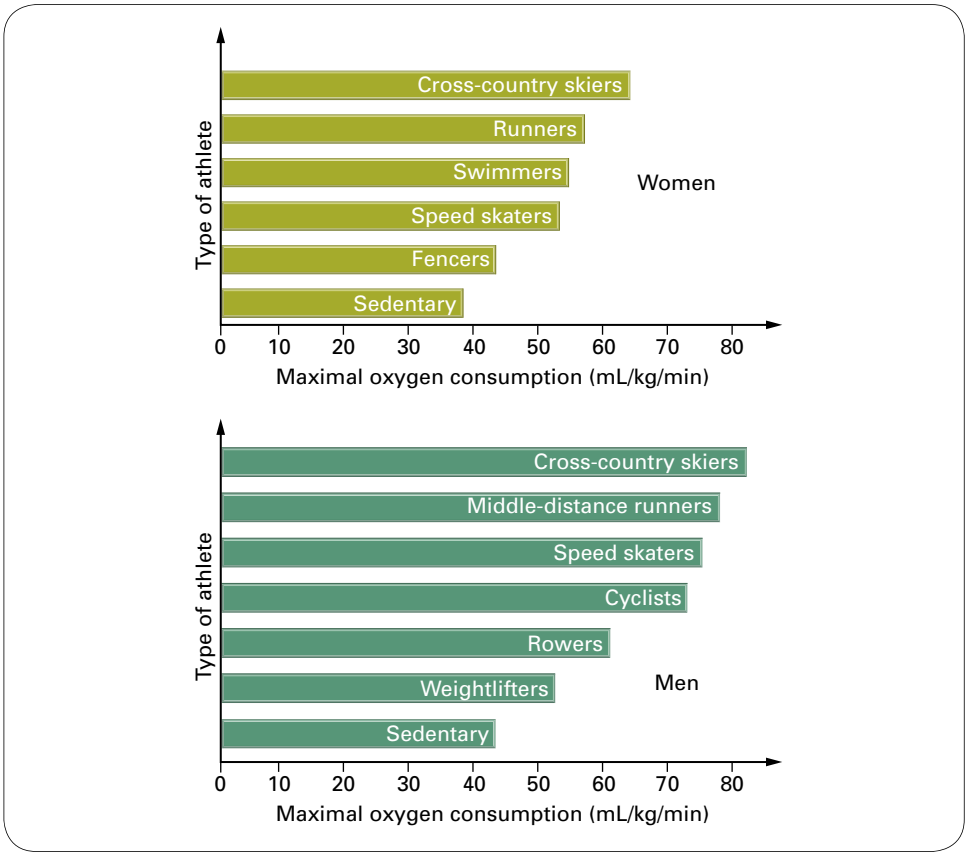


Figure 15.33
Maximal oxygen uptake values for athletes in different sports

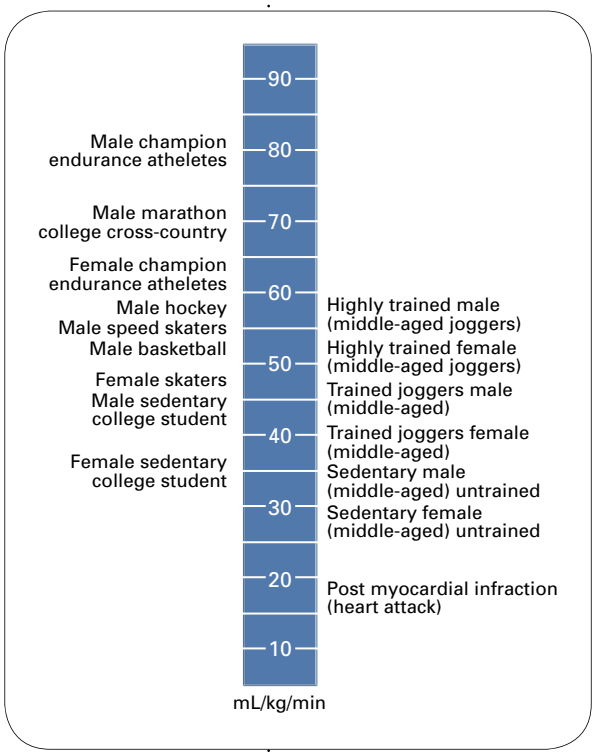


Figure 15.34
Maximal oxygen uptake values for selected activity groups

Heredity

Although there is no doubt that aerobic training improves your VO_{2max}, there is significant evidence that your VO_{2max} potential is genetically determined. In other words, everyone can improve, but there is a genetic limit to how much improvement can be made.

Some people can make significant changes to their cardiorespiratory systems through training. When these changes are combined with high proportions of red (slow-twitch) muscle fibres, the result is a high VO_{2max}.

Age

Unfortunately, after peaking at about 10 years for girls and 16 years for boys, your VO_{2max} (aerobic capacity) declines with age unless you maintain your aerobic fitness through to early adulthood. After early adulthood, VO_{2max} declines because of a decrease in cardiorespiratory efficiency and an increase in body fat.

However, VO_{2max} is always higher in active people, and the rate of decline is slower in active people than in inactive people.

Oxygen deficit and debt

To re-introduce the concepts of oxygen deficit and oxygen debt, we will look at the contribution of the three energy systems to the running of three events: the 100 m sprint, the 400 m race and the 5000 m race. Keep in mind that the body always wants to produce its energy aerobically, although this is sometimes not possible.

100 m sprint

For elite runners, the 100 m is a 10-second event:

- As the race begins, there is an extremely rapid increase in ATP demand to keep the muscles contracting rapidly.
- The cardiorespiratory system tries to supply oxygen rapidly, but the race requires 8 L of oxygen.
- Because the athlete can at best deliver 3–5 L in 60 seconds, the race is over before the oxygen supply can be increased.
- This creates an oxygen deficit or shortfall, because the creatine phosphate system supplies the necessary ATP, and the runner pays back the oxygen debt by panting after crossing the finish line.

400 m race

For elite runners, the 400 m is a 45-second event:

- As the race begins, there is a rapid increase in ATP demand to keep the muscles contracting rapidly. The cardiorespiratory system tries to increase the oxygen supply rapidly, but has no hope, as it would take 2–3 minutes to increase the oxygen supply to produce enough ATP aerobically. At this stage there is an oxygen deficit, i.e. insufficient oxygen to complete the task aerobically.
- The creatine phosphate system supplies the initial 10 seconds worth of ATP, after that the lactic acid system begins to take over. The lactic acid system supplies most of the ATP, with a minimal aerobic contribution towards the finish.
- As the runner crosses the finish line, they pant furiously in an effort to recover. This panting is a sign of 'oxygen debt', i.e. the extra oxygen that, during recovery, the runner needs to consume in addition to the amount that would ordinarily have been consumed at rest in the same time (see figure 15.36).

5000 m race

For elite runners, the 5000 m is a 14-minute event:

- As the race begins, the demand for ATP increases. Because it takes about 3 minutes to increase oxygen consumption, the two anaerobic systems (creatine phosphate and lactic acid) provide the required ATP. This creates an oxygen deficit.
- After about 3 minutes, the oxygen consumption has increased so that the ATP required to maintain this pace can be supplied aerobically—a steady state has been achieved. This situation continues until the final laps.

Figure 15.35
Sprinting starts rely on the creatine phosphate system to provide energy.

- As the pace increases during the final laps, a runner reaches a point where, despite increased oxygen consumption, they cannot meet the high ATP demand through aerobic means alone. At this point the runner has crossed their lactate threshold 2 (anaerobic threshold) and begins using the lactic acid system to produce the extra ATP. This creates an extra oxygen deficit.
- As the runner sprints the last 200 m and crosses the line, they pant vigorously to recover and repay the oxygen debt.

Paying back the oxygen debt

An oxygen deficit occurs during exercise when either all or some of the ATP required is produced anaerobically. Anaerobic energy production leaves creatine phosphate (CP) stores depleted and lactic acid accumulates in the muscles and bloodstream.

To replenish our CP stores and oxidise lactic acid, we need extra oxygen. Therefore, the respiratory rate and heart rate remain high after exercise so we can consume extra oxygen and pay back the oxygen debt (see figure 15.36).

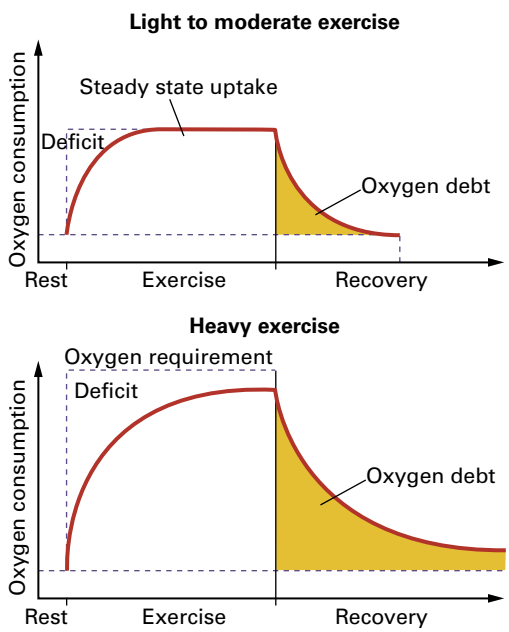


Figure 15.36 Oxygen consumption during exercise and in recovery. Top, light to moderate steady-state exercise, where energy is mainly obtained from the aerobic system; bottom, heavy exercise of short duration, where energy is mainly obtained from the lactic system and results in the build-up of lactic acid

Excess post-exercise oxygen consumption (EPOC) is the total amount of oxygen required during recovery process after exercise, to replace ATP, restore CP, remove lactic acid in the working tissue and return all body systems back to pre-exercise resting state. It is also referred to as oxygen debt.

Research has redefined oxygen debt. You may also see it referred to as **excess post-exercise oxygen consumption (EPOC)** and as the name suggests relates to the increased amounts of oxygen that are consumed after exercise to aid recovery. (Refer to the snapshot on page 408 for more detail about EPOC.)

Types of oxygen debt

Oxygen debt is the extra oxygen consumed during recovery after exercise, over and above the amount that ordinarily would have been consumed at rest in the same time.

The amount of extra oxygen consumed depends on the size of the oxygen deficit incurred during exercise. When large amounts of creatine phosphate are depleted and lactic acid accumulated, the oxygen debt may be very large. Put simply, the longer the duration and the higher the intensity of the exercise, the greater and therefore the longer the recovery.

There are two parts to this oxygen debt:

- *alactacid debt*, which supplies the oxygen needed to replenish stores of creatine phosphate
- *lactacid debt*, which supplies oxygen needed for the removal and breakdown of lactic acid from muscles and blood.

Alactacid debt

Alactacid debt or 'fast component' of the oxygen debt occurs when oxygen is consumed in early recovery and used to replenish ATP and CP stores. It takes about 30 seconds to replenish 50% of the total amount, and 3 minutes to replenish 100% (i.e. for 100% recovery). (See figures 15.37 and 15.38.)

Alactacid debt is the oxygen debt for which there is no noticeable increase in the lactic acid levels in the muscles or the bloodstream. It is about the first 2.5 L of the oxygen debt and is rapidly repaid at the end of exercise.

Alactacid debt is the amount of oxygen needed to replenish creatine phosphate and ATP stores in tissue cells during the recovery process after exercise.

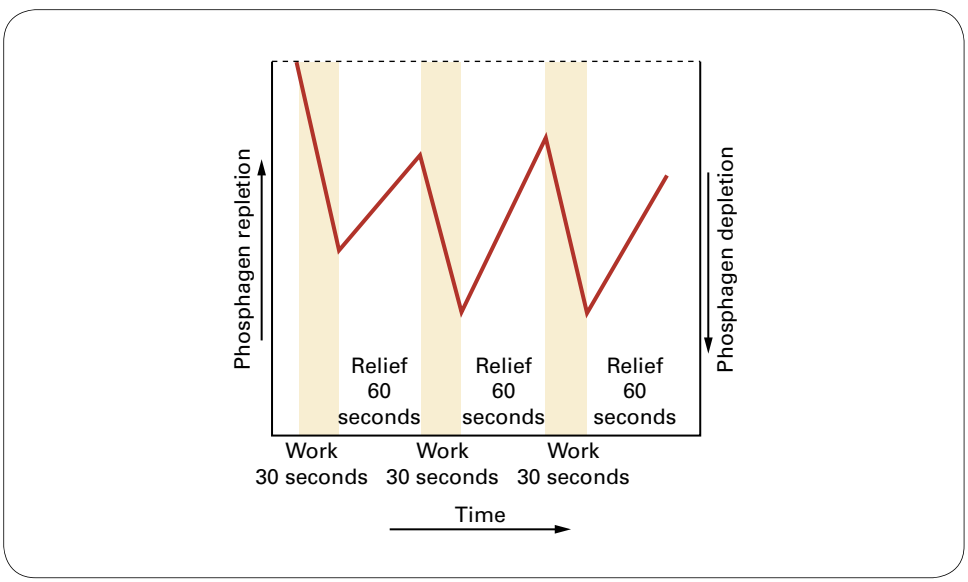
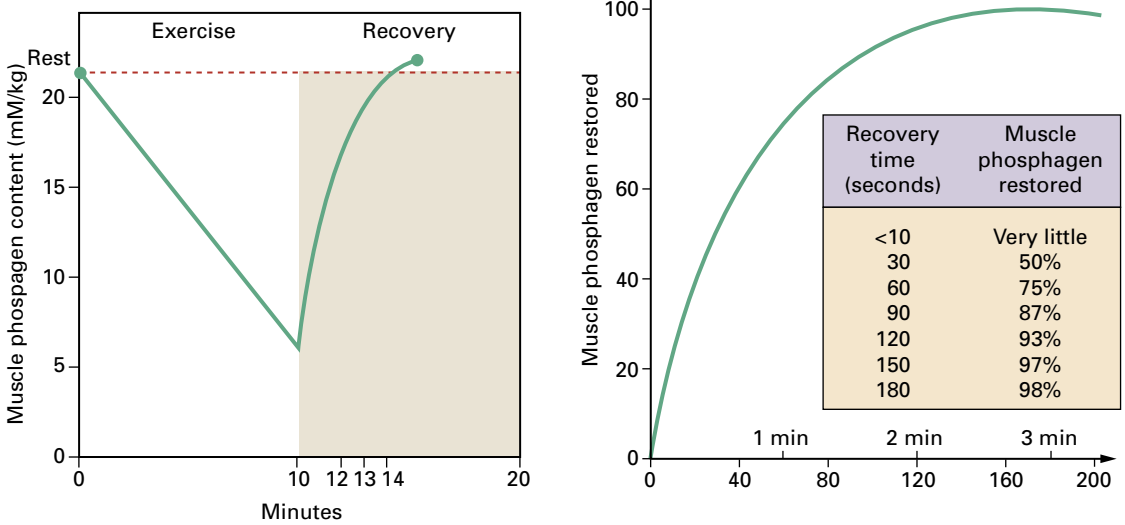


Figure 15.37
The pattern of creatine phosphate depletion and repletion during intermittent exercise (in this case, cycling). The work intervals were 30 seconds long and the relief or rest intervals were 60 seconds long.



Recovery time (seconds)	Muscle phosphagen restored
<10	Very little
30	50%
60	75%
90	87%
120	93%
150	97%
180	98%

Figure 15.38
After exercise, replenishment of the phosphate stores is rapid. Most of the ATP and creatine phosphate used during exercise is restored to the muscles within 2–3 minutes. The half-time for phosphate replenishment ranges between 20 and 30 seconds.

Lactacid debt is the amount of oxygen needed during recovery after intense exercise to remove lactic acid that has accumulated in muscle tissue and blood during the exercise period.

Lactacid debt

Lactacid debt is the second part or 'slow component' of the oxygen debt and refers to the extra oxygen needed to break down and remove the lactic acid that has accumulated in the muscles and bloodstream during exercise. The oxygen is used mainly to convert lactic acid into carbon dioxide and water, either in the muscles or in the liver. Oxygen is also used to convert small amounts of lactic acid into glucose in the liver.

Lactacid debt takes about one hour to be repaid (see figure 15.39). However, lactic acid removal and breakdown is more rapid if you perform light exercise during the recovery period (see figure 15.40). During recovery accompanied by light exercise, lactic acid is more quickly removed from the muscles and transported to the liver for breakdown, while the muscles that are still working use the lactic acid as a fuel.

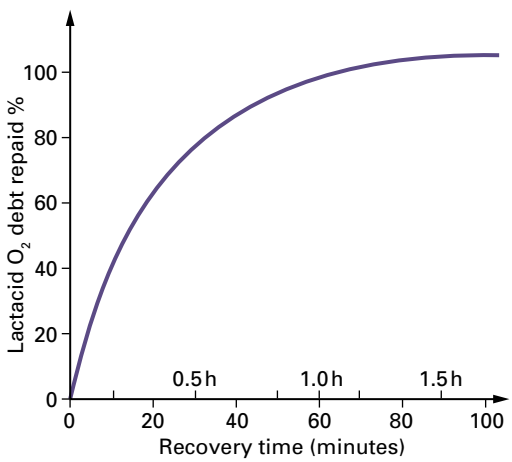


Figure 15.39
The rate of repayment of the lactacid debt following exhaustive exercise. The half-time for repayment is about 15 minutes. This means that 50% of the debt will be repaid in 15 minutes, 75% repaid in 30 minutes, and 95% in 1 hour.

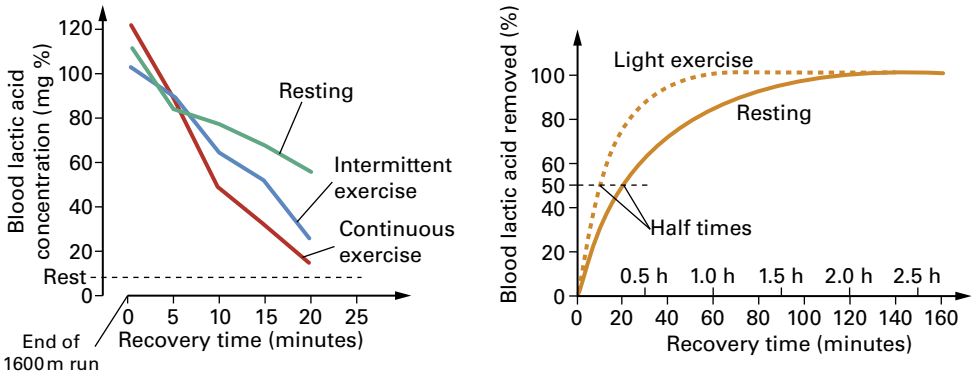


Figure 15.40
Removal of lactic acid from the blood during recovery from exhaustive exercise. Left, decrease in blood lactic acid concentration during recovery under conditions of rest, intermittent light exercise and continuous light exercise. Lowering of the lactic acid level is more rapid if light exercise is taken during the recovery period rather than resting. Right, the rate of lactic acid removal. The time it takes for one-half of the total accumulated lactic acid to be removed during rest–recovery is twice as long as that during exercise–recovery.

Learning experience

OXYGEN DEBT

Rank, in order from 1 to 5, the activities listed in the table below in terms of the lactacid oxygen debt they would produce (1 being most and 5 being least).

Activity*	Rank
Athletics 100 m sprint	
Athletics 10 000 m run	
Athletics 400 m run	
Athletics triple jump	
Athletics shotput	

*All activities are performed at an elite level.

Recovery, oxygen debt and aerobic capacity

If, during exercise, only 2 L of oxygen debt accumulates, this amounts to only an alactacid debt, so lactic acid levels remain low. Alactacid debt is repaid 30 times faster than lactacid debt, so recovery will be fast.

However, if after a hard run you accumulate 5 L of oxygen debt, only the first 2.5 L (alactacid debt) will be repaid quickly, while the other 2.5 L (lactacid debt) will take a long time to be repaid (see figures 15.39 and 15.40).

The speed of recovery after high-intensity, anaerobic exercise is determined by the efficiency of the body in removing oxygen from the air, absorbing it into the body, transporting it to the muscles and using it to repay the debt. Therefore a well-developed aerobic capacity is required for rapid recovery, which is why aerobic training forms the basis of all team sport training. Although individual efforts might be short and anaerobic, aerobic capacity is essential for rapid recovery.

Figure 15.41
The 200 m butterfly is an event that involves a huge oxygen debt

SNAPSHOT

Excess post-exercise oxygen consumption (EPOC)

After cardiovascular exercise or weight training, the body continues to need oxygen at a higher rate than before the exercise began. This sustained oxygen consumption is known as excess post-exercise oxygen consumption (EPOC). Originally referred to as an oxygen debt, this post-exercise state was first hypothesised by AV Hill and H Lupton in 1922. Hill and Lupton theorised that the body needs to replace the oxygen used by working muscles during mild to intense bouts of exercise. More recently, researchers have used the term EPOC to describe the several different events that occur as the body restores itself to homeostasis, or rest.

During EPOC the body is restoring itself to its pre-exercise state, and thus is consuming oxygen at an elevated rate. This means that energy is also being expended at an elevated rate. The following occurs during EPOC:

1. Replenishment of energy resources
   - Replenishment of immediate energy stores, creatine phosphate and ATP (known as alactacid debt)
   - Conversion of lactate to pyruvate for fuel utilisation (known as lactacid debt)
   - Restoration of muscle glycogen (a stored form of glucose) that has been used during the exercise bout
2. Re-oxygenation of blood and restoration of circulatory hormones
3. Decrease in body temperature
4. Return to normal ventilation and heart rate

Because the body continues to expend energy after exercise, EPOC plays a supplemental role to an exercise program in weight management. The evidence suggests that interval and resistance training have a more pronounced effect on EPOC than aerobic exercise.

Figure 15.42 Resistance training requires a larger energy requirement than aerobic exercise to restore the body's systems to normal and thus results in a higher EPOC.

Source: cited from Reynolds, JM & Krvavitz, L, 'Resistance training and EPOC', <www.drlenkravitz.com/Articles/epoc.html>, accessed 17 January 2010

Learning experience

ANALYSIS OF A CONTINUOUS ACTIVITY

Take part in a continuous activity, such as cycling, running 1500 m or swimming 400 m and, if possible, identify periods of EPOC, deficit and steady-state. Give reasons for your choices. You might like to wear a heart-rate monitor to assist you.

Learning experience

ENERGY SYSTEMS USED IN DIFFERENT PHYSICAL ACTIVITIES

1 From textbooks, magazines, CD-ROMs or the internet (e.g. <www.sportingimages.com.au>), collect photographs of 5 very diverse physical activities and arrange them as a collage on a poster.
2 State which energy systems are used during the activity shown in each photograph.
3 **a** State whether performance of the activity shown in each photograph will result in an oxygen deficit during the activity.
b State what type of oxygen debt, if any, would need to be repaid after the activity.
4 State the ideal form of recovery after each activity.
5 Present your findings to the class in an oral report. Include your poster, as well as a table showing data about the activities as shown below.

Activity/sport	Energy system	O_2 debt yes/no	O_2 deficit yes/no	Type of O_2 debt	Recovery strategy

Learning experience

LABORATORY: ENERGY AND RECOVERY

Below is an interval program for an intermittent sport.

Work phase	Rest phase
12 × 30 m sprints Each sprint completed in 6 seconds	60 seconds rest between each sprint (the athlete walked during this phase)

a Which is the main energy system used during the work phase of this program?
b Is 60 seconds rest between each sprint long enough to recover? Explain your answer.
c If this athlete were to jog during the rest phase rather than walk, what effect would this have on their recovery time?
d In pairs, implement the training session, with one person doing a walk recovery and the other doing a jog recovery. Compare your observations. (Wear a heart-rate monitor to assist you with this.)

Learning experience

LABORATORY: EXERCISE AND THE AEROBIC SYSTEM

Aim

To monitor the effects of exercise of varying intensities on a range of cardiorespiratory responses.

Equipment

- ergometer (cycle)
- digital sphygmomanometer (blood-pressure monitor)
- heart-rate monitor
- stopwatch
- stethoscope.

Subjects

Work in groups of four for tasks 1, 2 and 4 and complete the other tasks individually.

Procedure

Task 1

1 Measure each subject's heart rate 2 minutes and 1 minute before exercise. Record them in the table.
2 Subjects pedal the ergometer for 5 minutes at the following workloads: males—600, females—450.
3 Measure and record each subject's heart rate and respiratory rate at the end of each minute.
4 During the first 5 minutes of the recovery period after the exercise, measure each subject's heart rate and respiratory rate at the end of each minute. Record them in the table.

Times	Subject 1		Subject 2	
	Heart rate	Respiratory rate	Heart rate	Respiratory rate
Pre-exercise				
1 minute				
2 minutes				
Exercise				
1 minute				
2 minutes				
3 minutes				
4 minutes				
5 minutes				
Recovery				
1 minute				
2 minutes				
3 minutes				
4 minutes				
5 minutes				

>>

Results and questions

1 Graph the heart rates and respiratory rates recorded for each subject on a graph like the one below.

2 Why do the heart rate and respiratory rate change during exercise?

3 Discuss steady-state oxygen consumption in relation to each subject.

Task 2

1 Measure the subjects' heart rates just before exercise. Record them in the table below.

2 Each subject will pedal the ergometer as far as possible in 2 minutes, competing against each other.

3 Measure the heart rate and respiratory rate at the end of each 30 seconds. Record them in the table.

4 During the first 5 minutes of the recovery period after the exercise, measure each subject's heart rate and respiratory rate at the end of each minute. Record them in the table.

Times	Subject 1		Subject 2	
	Heart rate	Respiratory rate	Heart rate	Respiratory rate
Pre-exercise				
Exercise				
30 seconds				
1 minute				
1 minute				
30 seconds				
2 minutes				
Recovery				
1 minute				
2 minutes				
3 minutes				
4 minutes				
5 minutes				

Results and questions

1 Graph the heart rates and respiratory rates for each subject on a graph with axes like those in the diagram above.

2 Why does neither subject achieve steady-state oxygen consumption?

>>

3 What factors caused the subjects' fatigue?
4 What was happening during the recovery period?
5 Why did recovery take longer than in task 1?

Task 3

1 Record your pulse rate when you get up in the morning.
2 Record your pulse rate again while sitting in class during the day.

Question

Explain any difference between the two rates.

Task 4

1 Using a digital sphygmomanometer (blood-pressure monitor), measure and record your blood pressure while resting.
2 Measure and record your blood pressure after 3 minutes of rapid bench-stepping.

Question

What is the effect of exercise on blood pressure?

Task 5

1 Record your pulse rate after each of the activities, in a table like the one below.

Activity	Pulse rate
Resting	
Walking 100 m	
Jogging 100 m	
Sprinting 100 m	
Hop skipping 1 min	
Jump skipping 1 min	

Question

What is the relationship between heart rate and exercise intensity?

Task 6

1 Using a stethoscope, monitor and record your heart rate when your body is in the different positions set out in the table below.

Position	Pulse rate
Standing	
Sitting	
Lying down	

2 Using a stethoscope, monitor your heart rate:
   a during inspiration
   b during expiration.

Questions

1 Does body position have any effect on the heart rate? If so, why?
2 Does breathing have any effect on the heart rate? If so, why?

>>

3 How many sounds make up each heartbeat? What causes these sounds?

Task 7

1 Locate your pulse at the following points and record it:

- **a** carotid
- **b** femoral
- **c** radial
- **d** temporal.

Long-term training effects

Long-term training effects (or adaptations) are achieved only after training for weeks or months. Once achieved, these adaptations are retained, unless training ceases. If you stop training, your body will gradually revert to its past condition (this is called 'detraining').

Long-term training effects are specific to:

- the training methods you use
- the duration, frequency and intensity of the training methods
- the capacity of the individual athlete.

These training effects result in the desired improvements in performance and justify the hours of hard work needed to achieve them.

Long-term cardiorespiratory training effects lead to more efficient delivery of larger amounts of oxygen to the working muscles which, in turn, improves performance of aerobic tasks. These cardiorespiratory training effects are best developed by continuous, circuit and interval training.

Long-term circulorespiratory training effects

Long-term training effects in the circulorespiratory system include:

- cardiac **hypertrophy**
- increased stroke volume
- decreased heart rate
- increased cardiac output
- increased vascularisation
- increased arteriovenous oxygen difference
- increased blood volume and haemoglobin levels
- lower blood pressure
- respiratory changes
- increased VO_{2max}
- increased anaerobic threshold and decreased lactic acid production
- glycogen sparing
- blood flow changes.

Hypertrophy is an increase in cell size leading to an increase in tissue size.

See figure 15.21 on page 388 for a summary of the long-term training effects on the circulorespiratory system compared to the immediate circulorespiratory responses to exercise.

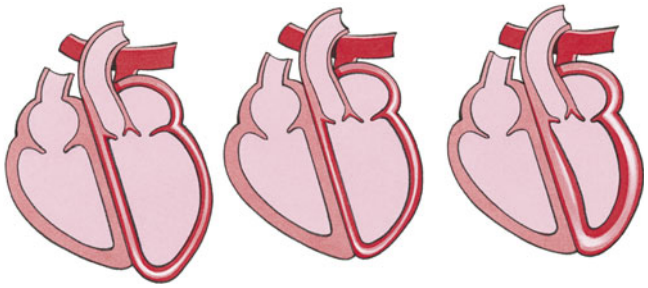


Figure 15.43
Cardiac hypertrophy in athletes. In endurance athletes, the ventricular cavities, particularly the left, become larger. There is no increase in the thickness of the heart's walls. In non-endurance athletes, the thickness of the ventricular wall increases, particularly in the left ventricle. There is no increase in the size of the cavity.

Learning experience

CARDIAC HYPERTROPHY

Refer to figure 15.43.

1 Why is it an advantage that there is hypertrophy of the left ventricle, in particular?
2 Why does the heart respond differently to the training for endurance and non-endurance?
3 What advantage is this to the athletes?

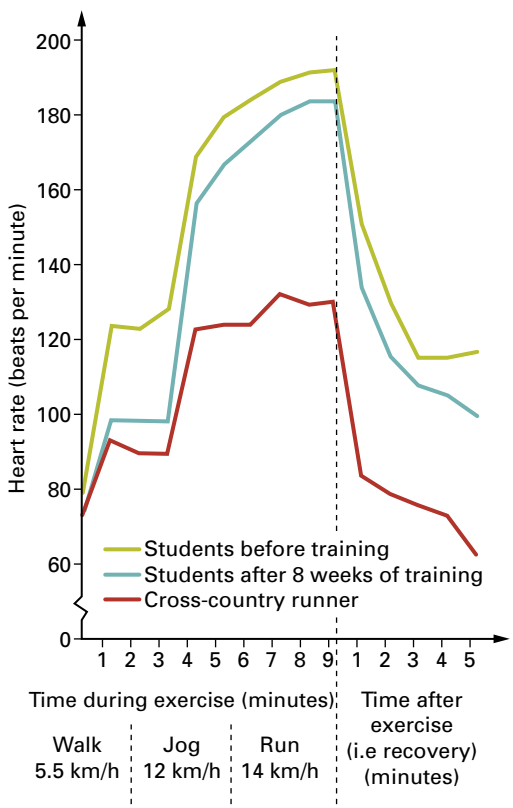


Figure 15.44
Heart rate response during exercise (a standardised walk–jog treadmill test) and recovery

Learning experience

HEART RATE RESPONSES

Refer to figure 15.44.

1 What are some of the main differences between the heart rate of the cross-country runner that of the students (before and after training)?
2 Is the O_2 deficit at the beginning or end of exercise? Explain what this means.
3 Why did the heart rate of the untrained students go up after exercise?
4 Explain why the cross-country runner's heart rate dropped to below pre-exercise levels only after approximately 3 minutes of recovery?
5 Explain the impact of 8 weeks of training on exercise heart rate and recovery.

SNAPSHOT

Lance Armstrong—a super human

Why is Lance Armstrong such a successful long-distance cyclist? He has won one of the most arduous races in the world, the Tour de France, many times. Yes, he has a great training program, a great coach, and great equipment. However, his genetics for an endurance athlete are nothing short of astounding. His VO_{2max} is twice that of the average person (85 mL/kg/min) and the combination of great training, will, desire, and unbelievable genetic makeup has ensured he has been at the top of his sport for many years. Genetics plus training have had the following long-term effects on his body:

1 lungs—two times the capacity of the average person
2 muscle—accumulates less lactic acid and is more efficient at removing it
3 heart—is about one-third larger with a resting heart rate of 32 beats per minute, and peaks around 200 beats per minute
4 body fat—4–5% before the Tour starts, while an average person has 15–20%.

Source: <EzineArticles.com/?expert=Jim_O'Connor>, accessed 8 January 2010

Figure 15.45 Lance Armstrong understands the impact of years of training on performance and the body.

Figure 15.46 VO_{2max} values for a range of Australian sportspeople

Type of athlete	VO_{2max} (mL/kg/min)
Males	
Inactive men	42.0
Active young men	50.8
National level Australian Rules footballers	53.9
International level soccer footballers	56.0
National level volleyball players	56.4
National level squash players	59.0
International level field hockey players	61.4
National level middle-distance runners	67.0
National level long-distance runners	73.5

(continued)

Type of athlete	VO_{2max}. (mL/kg/min)
Females	
Inactive women	38.0
Active young women	45.4
National level volleyball players	46.8
National level field hockey players	50.1
National level squash players	51.5
National level middle-distance runners	62.1

Learning experience

YOUR VO_{2MAX} VALUES

1. Based on the results from your aerobic capacity fitness tests (beep test or 12 minute run) work out your approximate VO_{2max}.
2. According to your gender, are your VO_{2max} values similar to those of any of the Australian sportspeople listed in figure 15.46?
3. What type of training can you do to increase your VO_{2max}? Are you involved in that type of training now? Give some specific examples.

Other long-term changes

Long-term training results in a number of other changes.

- Changes in body composition due to extended training result in a decrease in total body fat and an increase in lean body weight.
- There is a decrease in LDL cholesterol levels and an increase in levels of HDL, lowering the risk of heart disease.
- There is an increased ability to cope with the heat.
- There are skeletal muscle changes that are dependent on the type of training (endurance or non-endurance).

Endurance training effects on skeletal muscle

Chronic endurance training effects in muscle are produced by high-repetition resistance training or continuous training.

These adaptations increase aerobic energy production through:

- increased fuel stores of glucose and triglycerides
- increased oxygen extraction by increased concentrations of myoglobin
- increased oxygen delivery through increased vascularisation, i.e. increased numbers of capillaries in the muscles
- increased numbers of energy production sites in increased numbers of larger mitochondria
- improved ATP production by the aerobic system, because of vastly increased levels of oxidative enzymes
- increased oxidation of fat, because of vastly increased levels of enzymes associated with fat metabolism and increased storage of triglycerides; this means that glycogen stores are not used early in an exercise session.

Non-endurance training effects on skeletal muscle

Non-endurance training effects are best developed through weight, callisthenic and sprint training, in which the aim is to increase speed, anaerobic power and strength.

These changes include:

- increased capacity of the ATP–CP system because of increased muscle stores of ATP and creatine phosphate, and increased levels of enzymes needed to synthesise and break down ATP (see figure 15.48)
- increased glycolytic capacity resulting from increased muscle glucose stores and increased levels of glycolytic enzymes; this means that the lactic acid system can produce ATP more rapidly
- increased speed of muscle contraction
- increased speed of nerve impulse transmission
- muscle hypertrophy (mostly of the fast-twitch fibres) as a result of
  - increased cross-sectional area of fibres and therefore increased muscle force
  - increased number and size of myofibrils per fibre
  - increased amounts of myosin and actin
- increased numbers of muscle capillaries
- increased strength and amounts of connective tissue, including tendons and ligaments
- increased ability to recruit motor units to produce more forceful contractions
- increased lean body weight and decreased percentage of body fat
- flexibility training effects
  - increased resting length of muscles, tendons and ligaments
  - increased range of joint movement
  - decreased resistance to joint movement.

Figure 15.47
Elite swimmers show the changes in body composition achieved through intensive training.

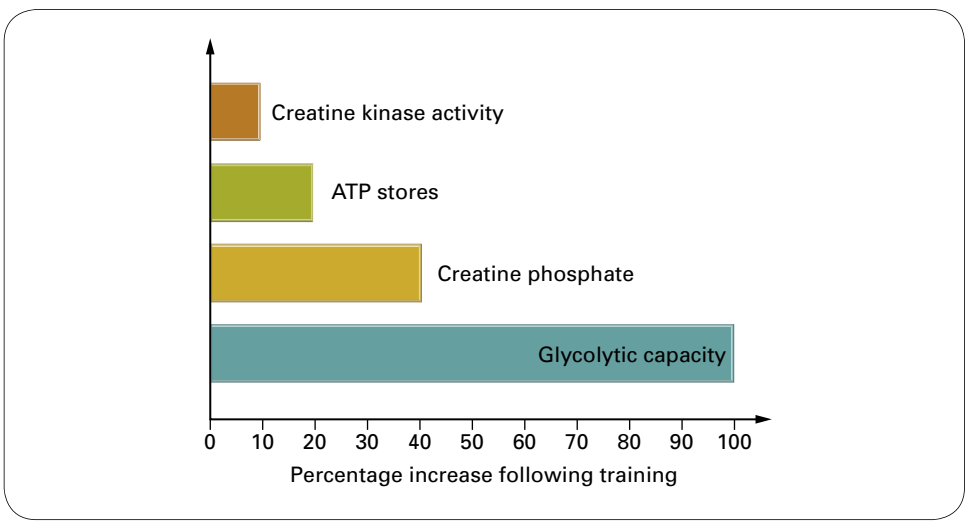


Figure 15.48
The effects of training on the anaerobic potential of skeletal muscle include increases in anaerobic enzyme activity, muscular stores of ATP and creatine phosphate, and in glycolytic capacity.

Learning experience

THE TRAINING EFFECT

'When an athlete trains over a long period (3 months or more), their body changes, both internally and externally. These changes are called the training effect.'

1 What evidence can you find to support this statement? You may wish to use before-and-after pictures, photographs of athletes and/or research data from textbooks, magazines or the internet.

2 List three different training methods and, for each, state the possible internal and external changes that can occur after 3 months of training.

Learning experience

LABORATORY: MEASURING TRAINING EFFECTS

Procedure

Perform the following tasks using class members as subjects:

1 a Measure and record the resting pulse rate of a class member who is currently a distance runner.
  b Measure and record the resting pulse rate of a class member who has no background in distance running or other endurance sport.
  c Discuss the reasons for the variation in the pulse rate of the two subjects.

2 a Measure and record the hip flexion of a class member who is involved in gymnastics or callisthenics.
  b Measure and record the hip flexion of a distance runner.
  c Discuss the reasons for any variation in the hip flexion of the two subjects.

3 a Measure and record the arm girth of a class member who trains with weights.
  b Measure and record the arm girth of a class member (of the same gender) who has never trained with weights.
  c Discuss the reasons for any variation in the measurements.

4 a Measure and record the upper arm girth of five class members and calculate the average.
  b Have each of these people perform 3 × 10 RM biceps curls.
  c Measure their arm girth again and record the results. Recalculate the average.
  d Explain any variation in the measurements.

5 a Measure and record the resting pulse rates of five class members.
  b Measure and record the pulse rates of the same people immediately after 5 minutes of submaximal work at the same pace.
  c Measure and record the pulse of the same five people 3 minutes after the exercise in part b.
  d Explain the variations and trends you discover.

Learning experience

'Warming up is of no value—it doesn't improve performance.' Discuss this statement and provide discerning and convincing justifications for your decision.

Chapter review

Training program design, evaluation and modification

Know

1 Compile a list of useful websites that have relevant, current and reliable information on training program:
   - planning and design
   - evaluation
   - effects (training)

   Load these on to the class forum using the school's online network.

2 Visit some other websites recommend by your classmates. Do you agree that they are useful? Why/Why not?

Comprehend

3 What have been the most difficult aspects of planning, designing and evaluating your own training programs specific to the physical activity you are currently studying?

Apply

4 If possible interview an elite athlete who is (or has) been involved with implementing a training program to improve their performance and work towards a goal or high level performance (periodised training).

   Ask them to tell you about their experiences. Choose a method of recording the interview, such as video recording or written. (Ensure you get permission from the athlete to video or record them.)

   1 What is the most intense session they have ever done?
   2 How did they cope with that session and keep going?
   3 Have they achieved their goals? Why/why not? Did it have anything to do with the design or implementation of the training program?
   4 What are their performance weaknesses? How do they address these, e.g. types of training, increased intensity, skill practice, psychological tools?
   5 If they have a coach, what is the relationship like between coach and athlete? How much say do they have in their training? What sort of feedback does the coach give and when, e.g. fitness test results, verbal, written, technical (skills), fitness related.
   6 How do they stay motivated to keep going with their training?

Analyse
Evaluate
Synthesise

5 Compile the interview and share it with a small group. Based on the elite athlete interviews, were there any common themes or elements that emerged from the variety of athletes interviewed. Why/why not?

6 How do the three quotes below reflect the concepts of training program design covered in this chapter (planning and designing, evaluation and effects of training)?

> *For me, winning isn't something that happens suddenly on the field when the whistle blows and the crowds roar. Winning is something that builds physically and mentally every day that you train and every night that you dream.*
>
> Emmitt Smith, American football player

> *So you wish to conquer in the Olympic games, my friend? And I too, by the Gods, and a fine thing it would be. But first mark the conditions and the consequences, and then set to work. You will have to put yourself under discipline; to eat by rule, to avoid cakes and sweetmeats; to take exercise at the appointed hour whether you like it or no, in cold and heat; to abstain from cold drinks and from wine at your will; in a word, to give yourself over to the trainer as to a physician. Then in the conflict itself you are likely enough to dislocate your wrist or twist your ankle, to swallow a great deal of dust, or to be severely thrashed, and, after all these things, to be defeated.*
>
> Epictetus, Greek Stoic philosopher

> *I hated every minute of the training, but I said, 'Don't quit. Suffer now and live the rest of your life as a champion.*
>
> Muhammad Ali

Training limitations

Chapter 16

Training can be limited by a variety of factors from the short-term physiological responses related to fatigue and recovery to long-term issues related to overtraining, injury or illness. Training and therefore performance can also be limited by factors relating to time, motivation, cost or the environment, such as air temperature or pollution.

Fatigue

Fatigue is defined as a state of discomfort and decreased efficiency resulting from prolonged or excessive exertion. However, fatigue affects different people at different rates and is specific to the type of exercise being performed. Sedentary people are more prone to fatigue and have far less tolerance of it than active people. This lower tolerance is often called a 'low pain threshold'. The type of activity, the intensity of effort and your level of fitness determine the type of fatigue.

Whether you exercise for fun or train for a specific sport, you place a stress on your body. This stress is the pressure on your body to perform an activity to which it is not accustomed.

Exercise-induced stress is generally a positive stress. However, while the body is under any stress it is not used to, it experiences fatigue, discomfort and even pain.

Pain is registered in your brain when pain receptors (sensory nerves) around your body send signals up your spinal cord to tell you that some physiological changes occurring in your body are causing discomfort. When you exercise, unless you actually damage your body (e.g. by pulling a muscle or tearing a ligament), pain is caused by fatigue.

Fatigue is the diminished capacity for work as a result of prolonged or excessive exertion.

Adaptation to stress

Over a period of weeks of regular activity, your body adapts to the stress of the activity by making physiological changes. These changes allow the body to perform better than it did at the beginning, so that the current exercise no longer stresses you, and you no longer feel fatigued.

If you then increase the intensity or duration of the exercise, your body will also eventually adapt to this new stress.

Causes of fatigue

The following factors can contribute to causing fatigue:

- blood lactate accumulation
- type of muscle fibre
- restricted blood flow
- depletion of energy stores
- dehydration
- rising body temperature
- central nervous system inhibition
- psychological factors.

Figure 16.1
An exhausted rugby league player will need to ensure he follows appropriate recovery protocols at the end of the game.

Recovery (regeneration)

Recovery is the overcoming of the effects of fatigue induced by an activity program.

Recovery after exercise is often called 'regeneration'. It is defined as the overcoming of the effects of fatigue induced by an activity program, and the restoration of the body to its full performing potential.

If recovery between successive training sessions is inadequate, fatigue will accumulate. As a result, training benefits will be delayed, performance will deteriorate, and the risk of injury, illness or overtraining will increase.

To recover as quickly and completely as possible, include all of the following in your recovery period:

Exercise recovery is a combination of active recovery and post-exercise stretching.

- **exercise recovery** (active recovery 'cool down', post-exercise stretching)
- nutritional replenishment (glycogen and protein stores)
- rehydration (electrolytes)
- rest days
- regenerative techniques.

Exercise recovery

Exercise recovery is composed of **active recovery** or the 'cool-down', which is the tapering off of activity after completion of a workout, and post-exercise stretching. It should be a continuation of the activity at a much reduced intensity, e.g. after running, keep walking. Various studies have shown that active exercise during recovery can accelerate blood lactate removal and prevent venous pooling (pooling of blood in the veins).

Active recovery involves cooling down the body after exercise, reducing the intensity of the activity but remaining active submaximally.

Figure 16.2
Yoga is an effective way of increasing flexibility as well as speeding up recovery through post-exercise activity.

After strenuous exercise, the heart keeps pumping blood at a rapid rate. If you end your workout abruptly, the muscles are no longer contracting and helping to propel the blood back to the heart, and so blood may pool in the veins and tissues. This can result in insufficient venous return, therefore reducing the flow of blood to other vital organs. Less blood is reoxygenated, and waste (blood lactate) is not being removed from the muscles that have just been working. To prevent venous pooling, the cool-down is essential and must be long enough for the heart to recover to between 100 and 120 beats per minute.

To assist recovery, take part in low-intensity exercise during the 24 hours following an exhaustive training session or competition. This exercise should use the same muscle groups as the training or competition, to speed recovery.

Gentle exercise during recovery increases blood flow to the muscles and removes muscle wastes. This exercise should be non-jarring, e.g. swimming or pool-running, cycling or walking.

To maintain flexibility, all exercise-recovery protocols should include either static or PNF stretching exercises for all muscle groups involved in the activity session.

Learning experience

ALTERNATIVE RECOVERY STRATEGIES

Procedure

For this learning experience, the class is to be randomly divided into three groups, with each group performing one of the allotted tasks.

Group 1

1 Perform three 400 m runs, each at 85% of your maximum pace. Rest for 3 minutes between each run by walking slowly another 400 m.
2 Shower and change immediately after your third recovery walk.

Group 2

1 Perform three 400 m runs, each at 85% of your maximum pace. Recover for 3 minutes between each run by slowly walking or jogging another 400 m.
2 After your last run, recover by slowly walking or jogging for 8 minutes; then perform the following static flexibility exercises:
   - **a** seated toe touch
   - **b** calf stretch
   - **c** quadriceps stretch
   - **d** groin stretch.

   Hold each stretch for 30 seconds and then repeat.

Group 3

1 Perform three 400 m runs, each at 85% of your maximum pace. Rest for 3 minutes between each run by lying down.
2 After your final 400 m run, lie down until you feel better; then shower and change.

Results and discussion

Complete the following tasks.

1 Each subject, irrespective of group, should keep the following subjective record of how their legs felt:
   - **a** during the second and third runs
   - **b** 1 hour after the runs
   - **c** 6 hours after the runs
   - **d** 24 hours after the runs
   - **e** 48 hours after the runs.
2 In turn, each member of group 1 will relate their subjective feelings during a class seminar. Each member of group 2 will follow, and finally each member of group 3 will relate their feelings. What patterns, if any, emerge within or between groups?
3 Discuss which group had the better recovery regime.
4 Is there a relationship between recovery regime and perceived leg soreness?
5 What is the cause of leg soreness in the following situations:
   - **a** during the third repetition?
   - **b** 48 hours later?

Nutritional replenishment

The goal of nutritional replenishment is to restore liver and muscle glycogen stores, replace fluids and electrolytes lost in sweat and protein to rebuild stressed muscle.

Replenishment of fluids

After tiring exercise, the greatest need is for fluid. In extended exercise, fluid losses can be up to 4–6 L, or the equivalent of 3–4 kg of body weight.

Complete fluid replacement may take up to 24–48 hours. You may need to drink whether you feel thirsty or not.

Dehydration can be assessed by checking the colour of the urine. If the urine is clear and almost colourless, fluid replacement has probably occurred. If the urine is yellow, it may still be a concentrated solution of metabolic wastes and thus indicate a degree of dehydration. It may be necessary to drink more fluid to alleviate dehydration.

Water is perhaps the best fluid replacement drink. According to research, it is best absorbed when taken cool. In winter, fluid losses can still be considerable, and the exerciser will still need to drink plenty of fluids although this might not feel necessary.

Despite what some people say, alcoholic drinks are not beneficial in replacing fluid or electrolytes after exercise. In fact they can increase dehydration by causing further fluid loss.

Replenishment of electrolytes

As well as water, the body loses some **electrolytes** (salts/minerals) during exercise. Some sports drinks contain electrolytes, but often in quantities that exceed those lost through sweat.

An **electrolyte** is a substance that dissociates into positively and negatively charged ions in water and conducts electricity. It aids in a number of vital bodily process, e.g. muscle control, absorption of fluids.

Potassium losses can easily be recovered by drinking a glass of fruit juice, e.g. orange juice. Sodium is generally replenished through the normal diet. High-sodium supplements, such as salt tablets, are both unnecessary and potentially dangerous.

Learning experience

HOW MUCH SHOULD I DRINK?

Because thirst is not a good indicator of dehydration and fluid needs, it is essential to have a rehydration plan. Fluid losses occur not only during exercise but also post-exercise as a result of sweating as the body tries to return to its pre-exercise state. Therefore it is important that the athlete continues to replace fluids after exercise has ceased.

To know how much fluid is required, the athlete can work out their fluid deficit. A simple way to do this is to weigh themself before and after exercise. The weight that is lost multiplied by 1.5 is the volume of fluid that should be consumed over the next hour.

Note: 1 kg is equal to 1 L; therefore, if an athlete loses 1 kg as a result of lost fluid, then they should drink at least 1.5 L of fluid (sports drink and water would be ideal) over the next hour.

1 Conduct this process on a day you know you will be exercising or training and it will be convenient to weigh yourself before and after, to work out your fluid deficit.

Weight before exercise
Weight after exercise
Weight lost in kg × 1.5 = ____ L

2 Did you consume the right amount of fluid post-exercise?

3 What did this process show you about your rehydration post-exercise?

Replenishment of glycogen and protein stores

As discussed previously, glucose is the major fuel for energy during exercise. After long training sessions or competition, particularly those involving aerobic activities, glycogen stores can be significantly depleted. Therefore, competitive athletes should not only eat complex carbohydrates as a significant part of their regular diet, but during recovery they should also concentrate on boosting their complex carbohydrate intake to 70% of their dietary intake (see figure 16.3).

The **glycemic index (GI)** is a way of ranking carbohydrates according to their effect on blood glucose levels. Foods with a high GI cause a greater increase in blood glucose and insulin levels.

It is important that the types of carbohydrates consumed during recovery are those that best aid glycogen replenishment. Research suggests that food with a high **glycemic index** (foods that quickly release glucose) should be consumed immediately following activity, preferably in liquid form. Within 20 minutes, 1 g/kg of body mass (BM) of carbohydrate should be ingested. The athlete needs to continue to consume high glycemic index foods at this rate over the next 2 hours, as the glycogen replenishment rate is maximised at 7–8% per hour. Examples of convenient, high glycemic index foods include fruit juices, white bread sandwiches or rice cakes with honey or jam, jelly beans and watermelon.

After 4 hours the rate of glycogen replenishment reduces to about 5% per hour, regardless of the glycemic index of the food. Any fats consumed during the recovery process will result in a decreased rate of glycogen replenishment. It can take 48 hours to restock glycogen stores after exhaustive aerobic exercise.

Sports bars and gels contain high concentrations of carbohydrates that are easily consumed and quickly digested. They are compact and easy to carry and are particularly useful for athletes who need to refuel during an endurance event (longer than 90 minutes). Athletes involved in a multi-event competition and who find post-exercise eating difficult may also benefit. Due to their high cost, it is important not to use them as a general snack but as a high-energy fuel to provide a substantial nutritional boost when consumed during or after exercise.

Sports bars also contain protein which, when consumed with carbohydrates, enhances glycogen storage. Proteins are needed post-exercise as they contain amino acids that are necessary to rebuild damaged muscle tissue. Sports bars are advantageous as they are prepared with carbohydrates and proteins in the right proportions (4:1) as well as being low in fat.

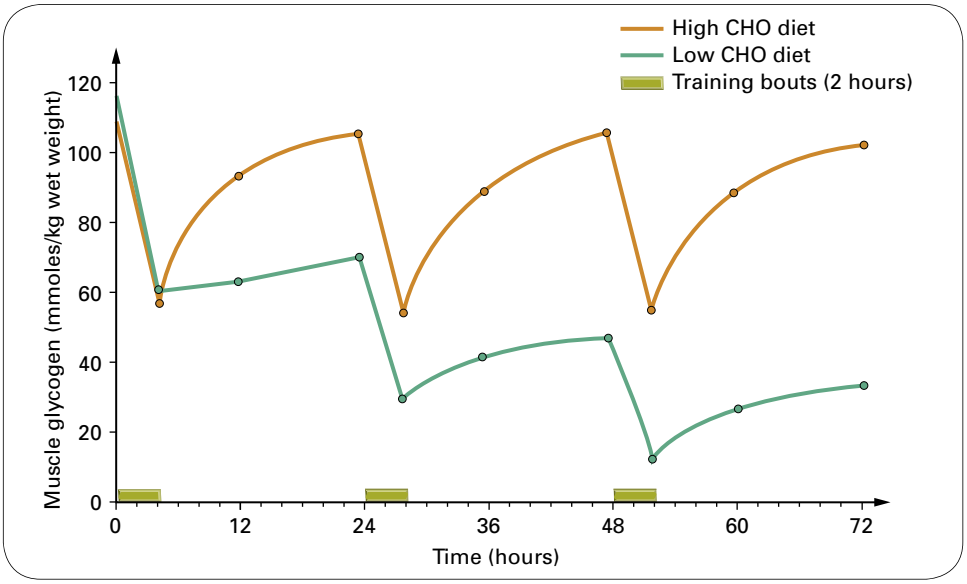


Figure 16.3
Muscle glycogen content of the vastus lateralis (thigh) during 3 successive days of heavy training on diets whose kilojoule compositions were 40% carbohydrate (low CHO) and 70% carbohydrate (high CHO).

Rest days

For the average person interested in health-related fitness, exercising every second day is sufficient to develop fitness and excellent for recovery. However, for the highly competitive athlete who trains and competes all week, there should be 1 day per week for almost complete rest, as well as low-intensity sessions spread throughout the week, to allow the body to recover completely.

Rest days are so important that they should be considered a method of training, and not having enough rest to allow the body and mind to recover from the rigors of training can lead to overtraining and even injury.

Sports drinks fight back

Once sports drinks were thought to be little better than water, but changes in formulation and a reorientation of the product have led to a rethink on fluid replacement drinks.

Increased interest in endurance activities in recent years has led to the development of a variety of fluid replacement drinks (e.g. Staminade, Gatorade).

The theory behind these was that electrolytes, like sodium, are lost in sweat and therefore need to be replaced to maintain endurance performance. Early drink formulations were high in sodium (salt) and advertised as 'electrolyte replacement' drinks.

Research by exercise physiologists in the mid-1980s, however, questioned the value of electrolyte replacement, as sweat contains proportionately more water and less sodium and potassium than blood plasma. As endurance exercise proceeds, there is also an adaptation by the kidneys and relatively fewer electrolytes are lost.

Thus exercise and heat exposure often cause an increased concentration of electrolytes in the blood. Replacement with high-sodium drinks was thought to be counter-effective as it was believed this would increase the electrolyte content of the blood even more. Plain water was therefore regarded as better.

Replacement rethink

Stung by the effect on their market, sports drink manufacturers responded with a different approach. Changes in formulation to take account of the scientific criticisms and a reorientation in promotion appear to have answered the critics. Drinks are now sold as 'carbohydrate replenishment', and for this the evidence is a little more convincing. It's believed that endurance athletes in particular benefit from ingestion of quickly absorbed carbohydrates (glucose, maltodextrin or sucrose) because this maintains blood glucose levels at a time when muscle glycogen stores are diminished.

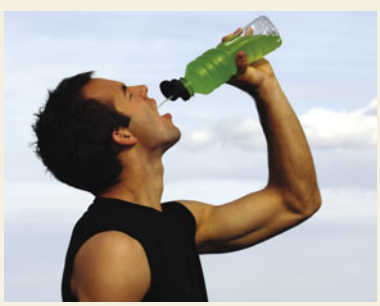


Figure 16.4
An athlete rehydrating with a sports drink

Again, early research indicated that gastric emptying (absorption) was delayed if the ingested drink contained more than 2.5% carbohydrate, as many sports drinks do. However, that figure has now been revised to 10% for some distance events.

It's doubtful whether drinks containing less than 5% carbohydrate can provide enough energy to enhance performance in long-term events. Drink manufacturers have therefore concentrated on providing a level of around 6–8% carbohydrate, which appears to satisfy requirements of gastric emptying speed (equal to cool water), fluid replacement, energy replacement and pleasant taste.

Some manufacturers have also added a complex form of glucose called glucose polymers, which facilitate the fast absorption of fluids and electrolytes without causing a glucose 'peak' followed by a 'let-down'.

Electrolyte changes

Manufacturers have also generally decreased electrolyte levels, particularly sodium, to avoid the possibility of increased concentrations of sodium in the blood (hypernatremia), which could enhance rather than decrease the chances of dehydration. The continuation of a certain level of sodium replacement is thought desirable because research suggests this helps retain water in the intracellular space without inhibiting thirst.

Plain water may decrease the desire to keep drinking; hence blood volume wouldn't be properly restored.

Another advantage of sports drinks is their taste, which is often preferred to water. And since the drinking (although not over-consuming) of cool fluids should be a goal for anyone performing extended exercise (e.g. more than 20 minutes) and/or in the heat, taste serves an important purpose.

What's wrong with water?

Given improved sports drinks, the question now is 'What's wrong with water?' The answer is 'Nothing'. Fluid replacement is still the first objective in any endurance event, and water does this well, particularly in shorter events (less than an hour).

In events longer than an hour, increasing amounts of carbohydrate replacement may be needed and hence replacement drinks become more valuable.

Sports drinks such as Exceed, Staminade and Gatorade now appear to provide palatability with improved performance properties.

Tips for using replacement fluids during exercise

- Drink at regular intervals (e.g. every 20 minutes), particularly when an activity is conducted in a hot environment.
- Don't just drink when thirsty, as thirst is an unreliable indicator of fluid needs.
- Drink at the rate of around 500 mL/h during endurance exercise.
- If the exercise is intense, this may need to be increased to 800 mL/h.
- Water is adequate for short events, but for events that last more than an hour, carbohydrate replacement drinks are preferable.
- In hot weather, drinks should contain a small amount of sodium, such as is contained in fluid replacement drinks.
- Keep the drink cool, as cool fluids are absorbed more quickly through the intestinal wall than warm or cold fluids.

Source: *Choice Health Reader*, vol. 3, no. 2, 1991, pp. 385–386

Learning experience

THE VALUE OF SPORTS DRINKS

Read the article 'Sport drinks fight back' and answer the following questions:

1. Why was the effectiveness of electrolyte drinks questioned by physiologists in the 1980s?
2. Why do current sports drinks contain about 6–8% carbohydrate?
3. What are the advantages of sports drinks over water?
4. What are the advantages of water over sports drinks?
5. Athletes competing in which type of events benefit most from sports drinks?
6. Given the knowledge you have gained from this article, how would you modify your fluid-intake practices during activity in future?

   The websites for popular sports drinks contain a range of recovery information and tools to assess your training and recovery. They might be interesting to look at.

Regenerative techniques

Techniques such as yoga, massage, flotation, sauna and spa hydrotherapy can help both physical and psychological recovery. Research shows that correct and regular use of these procedures increases the rate of recovery to three times that of unassisted recovery. There are also a variety of products available, for example compression garments, which can enhance recovery from the effects of exercise.

Massage

The following extract outlines ways in which massage can benefit athletes' performance and recovery.

Sports massage

Massage is now commonly used as a recovery technique for all levels of athlete. While the health-driven participant may use massage as a response to severe soreness, the elite performer incorporates massage as an integral part of their training regime. There is evidence emerging which indicates that massage provides benefits as a result of increasing the rate of blood flow through the muscles, thereby delivering greater levels of oxygen and nutrients and removing any accumulated waste products. Massage has been shown to reduce muscle tightness, assist in regaining pre-activity muscle length, improving joint movement and decreasing the impact of Delayed Onset Muscle Soreness (DOMS).

Source: Wayne Clews, 'Sports massage in Australia today', *Sport*

Hydrotherapy

There are several types of hydrotherapy that can be used as part of the warm-up to prepare athletes for competition or to stimulate rapid physical and mental recovery post-exercise (see figure 16.5). The technique described is known as contrast water therapy (CTWT). Athletes are exposed alternately to hot then cold water, which is believed to increase blood flow and speed

up recovery. Another form of hydrotherapy, cold water immersion (CWI), is common practice for many elite team sports, particularly before significant competitions or after intense workouts. The external application of cold has been shown to reduce swelling, muscle spasm and pain and is a common treatment for soft-tissue injuries.

Figure 16.5 Guidelines for contrast water therapy

How to use

- Rehydrate before, during and after the session.
- Clean skin with soap and shower off beforehand.
- Alternate: Hot (35–38°C) Cold (10–16°C)
- Shower: 1–2 min 1–30 s (repeat × 3) or
- Spa/bath: 3–4 min 30–60 s (repeat × 3)
- Shower and rehydrate to finish.

When to use

- Showers can be used any time before, during or after a session.
- Spas and baths are best left until the end of the day.

Note: Do not use if the athlete has a virus or cold or recent soft-tissue injury.

Learning experience

RECOVERY METHODS

Four methods of recovery have been discussed including, active recovery, massage, cold-water immersion (CWI) and contrast water therapy (CTWT).

1 Conduct research and decide what are the advantages and disadvantages of each method of recovery.

Method of recovery	Advantages	Disadvantages
Active recovery		
CWT		
CTWT		
Massage		

2 Design an active recovery (cool-down) program that you could implement for all your exercise recoveries.

SNAPSHOT

Compression garments

We are very aware what the manufacturers say about the benefits of wearing compression garments during and post-exercise. Compression garments have been worn as part of medical treatment for poor circulation for many years. However, what do the sports scientists say?

Davies and colleagues (2009) carried out a limited study of 11 trained netball players who completed plyometrics training and then wore compression tights for 48 hours as part of recovery. One week before the training, the athletes had been tested for speed, agility and power. The athletes were retested 48 hours after training to ascertain what effect the compression tights had on recovery of speed, agility and power.

Davies et al:

> *… did not find evidence that wearing compression tights during 48 hours of recovery after plyometric exercise has a beneficial effect upon significantly reducing bloodborne markers (creatine kinase and lactate) of muscle damage or improving sprint, agility or jumping performance. However, it is important to note the subjects reported more comfort and less pain while wearing the compression tights. In fact a number of subjects began to use compression garments as a recovery method after participating in the experiment.*

Source: Davies, V, Thompson, K and Cooper, SM, 2009, 'The effects of compression garments on recovery', *Journal of Strength and Conditioning Research*, 23(6), pp. 1786–1794

An earlier study of track athletes specialising in sprint and jump events and wearing compression tights while being tested was carried out by Doan and colleagues (2003), who found that the garments did not

> *… appear to improve speed over 60 m, but did increase skin temperature during warm-up protocol, muscle oscillation decreased significantly during vertical jump landings and countermovement vertical jump height increased when the garment was worn. The elasticity of the garment increased flexion and extension torque at the end range and hip joint range of motion decreased slightly during the 60 m sprint. Through various mechanisms these findings may translate into an effect on athletic performance (increased vertical jump height) and a reduction in injuries.*

Source: Doan, BK, et al, 2003, 'Evaluation of a lower-body compression garment', *Journal of Sports Sciences*, 21, 601–610

It can be said that compression garments appear to be a safe recovery method that is relatively inexpensive and easy to implement. It can also be said that wearing compression garments during athletic performance can have some benefits. However, care must be taken when selecting the garment as it needs to reflect the requirements of your sport and provide enough pressure to promote venous return of blood and support of joints and muscles.

Learning experience

COMPRESSION GARMENTS

1 What do the manufacturers say? (Despite what these two studies revealed, compression garments have become part of our recovery and training routines.)

2 There are now so many options on the market it is often difficult to make a decision. Conduct some research of your own and recommend which compression garments, if any, you would use as part of your training, performance or recovery. Provide discerning and convincing justifications.

You could use a decision-making matrix to assist you in analysing the information and making a decision.

Muscle soreness

Most of us have at some stage experienced sore muscles in the days following vigorous exercise. The causes of this are summarised in the article 'Delayed onset muscle soreness (DOMS)'.

Delayed onset muscle soreness (DOMS)

Anyone who has exercised has felt muscle soreness. One type (immediate) occurs after intense anaerobic work and is associated with the buildup of lactic acid in the muscle.

A second type, delayed onset muscle soreness (DOMS), is less well understood. It occurs up to 48 hours after exercise (particularly if you are unaccustomed to the exercise) and seems to be lessened by more of the exercise that caused the soreness in the first place.

The causes aren't yet known. But researchers are starting to narrow down the possibilities.

Muscles involved

Not all muscles, it seems, suffer DOMS. Most commonly it occurs in the flexor and extensor muscles of the major joints.

DOMS is most common following high-velocity or high-force exercise, particularly if the exercise involves eccentric (working while lengthening) muscle contractions, such as running downhill or lowering in the squat. DOMS seems to occur at the ends of the muscle close to the musculotendinous junction. There's no evidence, though, that any long-term structural damage is caused to the muscle.

Causes of DOMS

All this has given scientists some clues to the mechanisms underlying DOMS. To date, there are four main theories:

- The muscle is damaged by increased tension.
- Metabolic waste products accumulate in the muscle.
- Muscle tissue is damaged by increased temperature.
- Spasms are caused by altered neural control of the muscle.

No one theory adequately explains the phenomena. Hence, Oklahoma physiologist Dr Robert Armstrong has come up with a new model to try to explain the disparities. Armstrong's model, in simple form, suggests that:

- High mechanical forces during exercise cause a disruption of the proteins in muscle fibre and connective tissue. (This is particularly so in eccentric exercise because the work is more concentrated and fewer motor units are called on to do more work.)
- Through a complicated process, this structural damage causes an influx of calcium into the muscle cell. Abnormally high calcium concentrations have been shown to degrade certain of the protein elements in muscle fibre.
- This in turn causes the release of other substances, which act on nerve endings in the muscle and cause the sensation of pain.

Experiments using drugs to decrease the level of calcium in muscle cells tend to support the theory by reducing soreness in patients with DOMS. Still, much more research needs to be done before it's known just how well the theory fits.

It does seem clear, though, that the popular belief that 'lactic acid buildup' explains delayed muscle soreness is no longer viable.

Meanwhile, for sufferers of DOMS, Armstrong points out that it is best decreased by regular, specific training. When it does occur, light exercise—particularly non-weight-bearing, such as swimming—that uses the sore muscles, and massage of the skin surface, reduce the pain.

Source: *Fitness Reader*, vol. 2, no. 77

Overtraining (burnout)

Overtraining is often called 'burnout'. It is the staleness that athletes or regular exercisers can encounter after particularly long and intense training, and leads to a serious drop-off in physical and mental performance. Overtraining is the result of an imbalance between training and recovery.

Causes and symptoms of overtraining

There are many symptoms of burnout, both physiological and psychological (see figure 16.6).

The symptoms of burnout tend to be caused by one or more of the following:

- a large volume of training, such as two sessions a day, 7 days a week
- intense overloading in a training program, i.e. too much too soon
- too much high-intensity work with insufficient recovery time between sessions (often associated with the outdated 'no pain, no gain' approach to training)
- training while suffering an illness or infection
- inadequate carbohydrate or vitamin and mineral intake
- outside stress, such as academic work, family problems, social problems or work commitments during an intense training period.

Athletes and regular exercisers need to be aware of these causes of burnout and plan carefully to avoid them, or modify training plans if problems arise.

Self-monitoring

One method of checking the level of stress the athlete is experiencing is to teach them to self-monitor. This involves a process in which physical and psychological parameters are recorded by the athlete on a daily basis so that any changes are quickly identified (see figure 16.7).

Indicators for evaluating overtraining

There is no foolproof method of evaluating overtraining, and using a number of the following indicators is probably the best way to discover if you or someone else is overtrained:

- presence of a substantial number of the symptoms of overtraining (see figure 16.6)
- resting pulse rate
- red blood cell count
- observations made by other people.

Figure 16.6 The symptoms of overtraining, or burnout

Physiological symptoms of overtraining			
At rest	**During submaximal exercise at a given workload**	**During maximal exercise**	**After exercise**
Increased heart rate	Increased oxygen uptake	Decreased capacity for maximal performance	Abnormal fatigue
Lower body weight	Increased ventilation	Decreased lactate	Slumped posture
Lower skinfolds	Increased heart rate		Slower return of blood pressure to normal after exercise
Increased resting blood pressure	Increased lactate		Slower return of heart rate to normal after exercise
Abnormal heart beat			Chronic muscle soreness
Increased blood lactate			Injury, including stress fractures
			Increased incidence of infections

Psychological symptoms of overtraining

- Insomnia or other disturbances in sleep patterns
- Anorexia (i.e. loss of appetite)
- Depression
- Feeling run-down
- Decreased motivation
- Irritability
- Lack of enjoyment of training and competition
- Feelings, such as that:
  - the season is never going to finish
  - recovery is incomplete
  - training is heavier
  - training is more stressful
  - the desire for training and competition have disappeared.

Prevention and treatment of burnout

To prevent burnout, eliminate the potential causes. Regular exercisers should therefore follow these guidelines:

- Limit high-intensity anaerobic sessions to 2 or 3 per week.
- Plan weekly rest days to allow body restoration.
- Overload gradually.
- Cease training during illness.
- Eat a balanced, high-carbohydrate diet.

- Cut back training during times of stress, e.g. if you have work or family problems.

If the symptoms of overtraining appear, the treatment is simple:

- Reduce training demands.
- Increase rest periods.

The length of recovery depends on how badly overtrained a person is. It could take weeks or months. Perhaps the best sign of cure is when genuine motivation returns and your body really feels like training.

It must be stressed that burnout is more common in athletes involved in the development of sport-related fitness. Burnout is rarely seen in people who exercise regularly to develop health-related fitness.

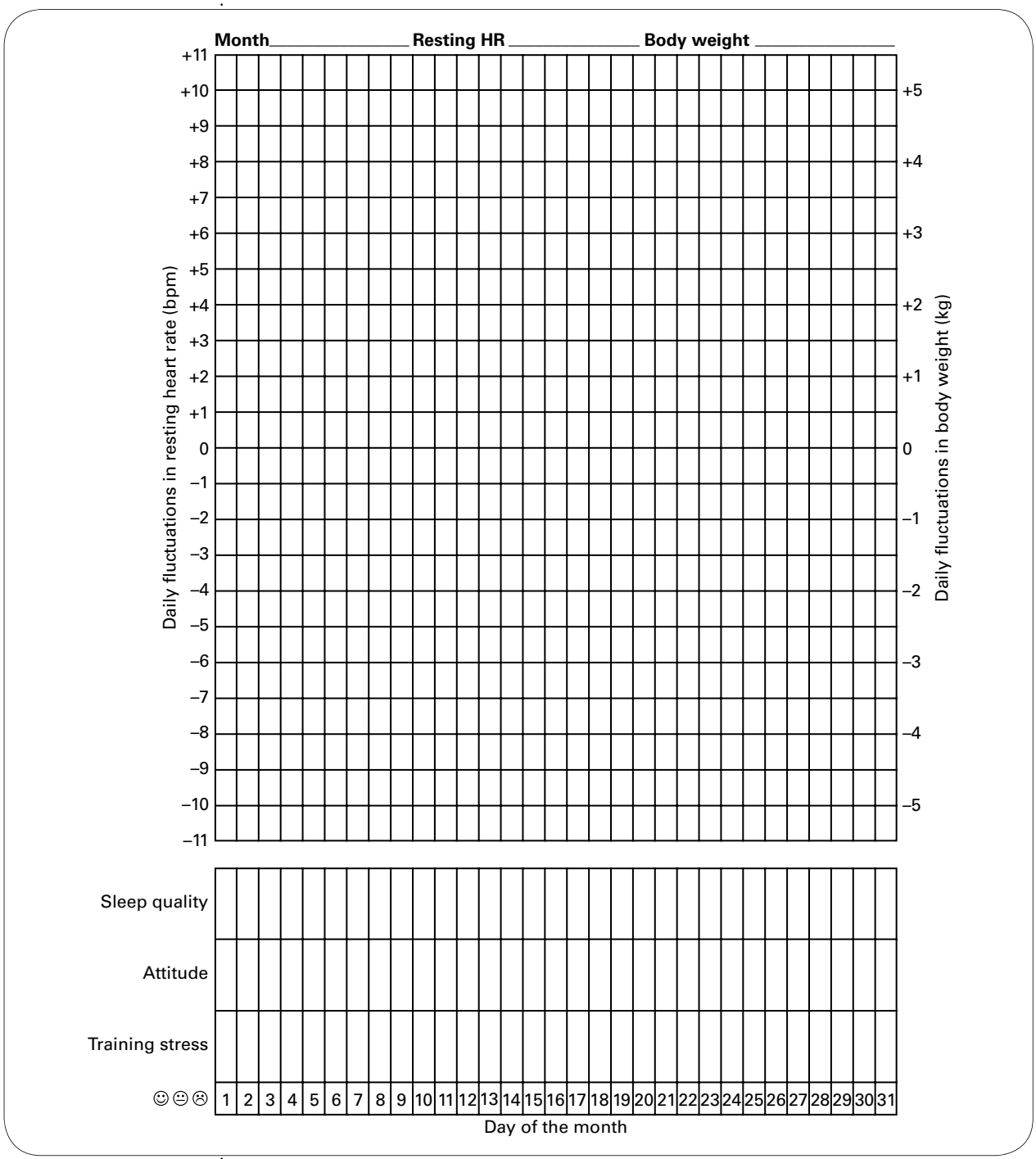


Figure 16.7 Athlete self-monitoring sheet

Learning experience

FATIGUE IN SPORT

Watch a live or televised sporting event and then present a 2-minute oral report to a small group that answers the following questions:

1 What event or type of competition are you investigating?
2 a Did any of the athletes seem to be suffering from fatigue?
  b If so, choose one of them and say what evidence there is that this person is suffering from fatigue.
  c Did the athlete's face or body give you any clues about their fatigue?
3 Taking into account the sport in which the athlete is involved, what do you think has caused this fatigue?
4 Outline the physiological factors that may have caused the fatigue.
5 Outline the psychological factors that may have caused the fatigue.
6 Taking into account your athlete's sport, outline the way in which the athlete could achieve adequate recovery from fatigue.

Learning experience

SIMPLE STEPS FOR RECOVERY AND REGENERATION

It is clear that recovery is important and these are some simple steps you can take:

1 Rest.
2 Stretch.
3 Cool down.
4 Eat properly.
5 Replace fluids.
6 Try active recovery.
7 Alternate hot and cold showers/baths.
8 Get lots of sleep.
9 Have a massage.
10 Avoid overtraining.

From the list decide which:

a you do well as part of your recovery
b you need to know more about
c you would be interested in trying.

Learning experience

A SPORTS-SPECIFIC RECOVERY PROTOCOL

Design an effective recovery protocol for you and your sport, including rehydration, replenishment of energy stores and methods of recovery, based on your understanding of fatigue and recovery or regeneration process.

The aim of the recovery protocol is to ensure recovery becomes another training method that you use to enhance your performances.

Using information in this book, your own knowledge, library research and informal interviews with coaches or Physical Education teachers, complete the following tasks.

1. List all the different physical activities or training methods, both in and out of school, in which you participated this year.
2. For each activity discuss:
   - **a** the fatigue you experienced during or after the activity (the site of the fatigue, its severity, its possible cause)
   - **b** any soreness experienced during or after the activity (the site of the soreness, its severity, its possible cause)
   - **c** recovery (length of the recovery period, efforts to speed up recovery).
3. Research the range of recovery methods and how to implement them effectively to help develop your protocols.
4. Share your recovery protocols with a small group and modify them, if necessary, based on the feedback received.

Sports injuries as a training limitation

Sports injuries are another limiting factor on training and performance and can range from minor to very serious requiring extensive rehabilitation and or surgery. Elite sport generates a lot of revenue for clubs, sponsors, cities, governments and individuals. Therefore sports injuries for professional players are treated very seriously and with the most up-to-date technology. Having a star player out of the game and training can cost a club in terms of premiership points and money. It is in their best interest to get the athlete back to full fitness as quickly and as safely as possible. Australians take their sport seriously and there is even a website <injuryupdate.com.au> devoted to monitoring the injuries for national leagues in a variety of sports. The website has information about players, clubs and the injuries that have been suffered.

Prevention of sports injuries

You have probably heard the expression ‘Prevention is the best cure’. If you can avoid injury, you can save yourself a lot of pain, discomfort, wasted time and, often, wasted money.

Unfortunately, injury of some sort is almost unavoidable in sport, particularly team games.

One million Australians are injured each year playing sport or undertaking recreational activities. Most of these injuries are preventable through basic injury-prevention strategies. However, this 12-point plan should help you minimise the risk of injury to yourself and others.

1 Warming up

Warming up is essential. A good warm-up includes light continuous exercise for 5 to 10 minutes, followed by stretching exercises. By increasing muscle temperature and resting-muscle length, you can greatly decrease the risk of injury.

2 Pre-season fitness testing

Undergo pre-season fitness testing to identify physical deficiencies. During pre-season training, you need to improve specific weaknesses so that you are fully prepared physically for your sport.

3 Training

Always do your pre- and in-season training. At training you develop the specific skills and fitness for your sport that you need both to be a good player and to avoid injury.

4 Protective equipment and safety gear

Wear the protective equipment and safety gear designed for your sport. Many sportspeople tend to be either optimists or heroes and think they will never get hurt. It is better to be safe than sorry.

Examples of protective equipment and safety gear are:

- *padding and helmets:* Mouthguards, shin pads, helmets, knee pads and goggles are all designed to save pain, give you confidence and improve your performance.
- *dangerous bodily obstructions:* Wearing rings, sleepers, worn stops or long fingernails is hazardous to the safety of everyone playing sport with you.
- *strapping:* Strapping or taping joints such as your ankles is an excellent way of preventing new injuries and the aggravation of old injuries.
- *correct clothing:* Always wear the correct clothing for a sport. For example, if you enter a fun run in hot weather while wearing football shorts and jumper, you are asking for dehydration.
- *special shoes:* Each sport has its own special shoes, so wear the type that suits your sport. For example, distance runners should wear shoes that provide:
  - a good arch support
  - a firm heel counter
  - a flexible mid-sole
  - a slightly flared heel
  - a firm saddle
  - an Achilles support.

Figure 16.8
Cricketers wear a range of protective equipment whether batting or fielding.

Warning: Running shoes with their high heel wedge are dangerous for activities that involve rapid direction changes. These sports require flatter, broader shoes to give extra ankle stability. High-top basketball boots give extra ankle support to prevent ligament damage when a player lands on another player's foot.

5 Playing area

Always make a comprehensive check of your playing area for stones, glass, slippery patches, potholes or uncovered sprinklers. These hazards can quickly cause injury and pain. Ensure appropriate padding is in place and follow regulations, e.g. goal posts covered to a minimum height of 2.5 m and a thickness of 35 mm.

6 Environmental conditions

Allow for environmental conditions at the time you are playing sport:

- In cold conditions, you might need to train in leg warmers or a tracksuit, gloves and a waterproof jacket.
- In hot conditions, especially during high humidity, you must drink:
  - two glasses of water 20 minutes before heavy exercise
  - one glass of water every 20 minutes during exercise
  - two glasses of water every 20 minutes for 2 hours after exercise.

If you don't follow this pattern, you run the risk of dehydration, which causes fatigue, cramp and possibly collapse. Environmental effects are discussed in more detail later in the chapter.

Figure 16.9 Which of these two skateboarders is running less risk of injury?

7 Overtraining

Never overtrain. If you want to push yourself hard at training, that is fine. However, if your parents or coach are asking you to go beyond what you think is your sensible limit, stand up for yourself.

Typical signs of overtraining are constant tiredness and a general loss of interest in most aspects of life (see figure 16.6 on page 433).

8 Diet

Always eat a balanced diet high in carbohydrates, to be sure that your body receives the nutrition it needs to recover rapidly and ward off injury and illness.

9 Umpiring (refereeing)

Good umpiring or refereeing is needed to enforce the rules of a game, therefore ensuring each player is protected during play. Good umpires prevent injuries by creating a safe environment for sport.

10 Balanced competition

A balanced competition means that players of all sizes can play without fear of injury. Examples include:

- modified rules for juniors in some sports, e.g. no contact
- gradings for height and weight, not for age, to stop early maturers dominating and physically intimidating smaller opponents.

11 Intelligent coaching

Intelligent coaches can:

- emphasise winning by the rules
- make sure players are well trained, i.e. have the skill and fitness to avoid injury
- make sure players are aware of the rules
- make sure injured players do not play, and apply rigid post-injury fitness tests to players before they return to the field.

12 Play with commitment

A half-baked, unenthusiastic mental approach usually results in errors and injury. Bored players usually make silly mistakes or fail to anticipate a potentially risky situation.

Learning experience

SMARTPLAY

With so many sport-related injuries occurring, and with rising insurance costs for clubs and the cost to the healthcare system, it is important that governments are proactive in providing support to ensure clubs, coaches and officials understand the importance of injury prevention and what they need to do to be effective.

Refer to the Smartplay website <smartplay.com.au> and research the recommendations for your sport or the sport you are currently studying.

1 How do the recommendations compare with the practices in your club?

2 Create a series of recommendations that would improve the safety for your club, players, spectators and officials.

Figure 16.10
Rugby league is well known for its violent clashes between players.

Major causes of sports injury

External violence (direct injuries)

This includes contact injuries, such as a corked thigh and a broken nose. These injuries are usually caused by collisions between players (e.g. a rugby tackle) or collisions between a player and equipment (e.g. being hit by a hockey stick).

Internal violence

These injuries include sprains, strains and tears, usually of soft tissues. Internal injuries may be of several types:

- **Acute injuries** occur immediately and spontaneously. They are usually very painful and require rapid treatment, e.g. torn hamstrings, damaged ankle ligaments, strained back.
- **Chronic injuries** reappear at regular intervals because they have become a continuing weakness. Chronic injuries are usually the result of poor treatment and little or no rehabilitation, so that the weakened body part is liable to further damage.
- **Overuse injuries** are caused by excessive use, and the symptoms are pain and inflammation. Overuse injuries usually take a long time to develop and, once present, are difficult to treat and slow to mend. Achilles tendonitis, shin splints and runner's knee are common overuse injuries.

Injury assessment and diagnosis

Injury examination

Picture the following scenes:

- You are surfing with friends. One of them gets pounded by the shore break and staggers from the surf clutching their shoulder. What do you do?
- You are playing netball and your best friend lands awkwardly and rolls over clutching an ankle. What do you do?

Examination precedes treatment—SALTAPS

When dealing with injuries, one fear in your mind might be of making things worse by interfering without understanding. When the patient is conscious, proceed in the following way to minimise harm from sports injury.

All you have to do is remember the letters SALTAPS, and do what they represent in the correct sequence (see figure 16.11).

S—Stop

As soon as an injury occurs, stop. Whether you or another person has been injured, make an on-the-spot examination of the injury. In most cases, if this is done immediately, the injury will be less severe than it would have been otherwise, because rapid treatment can be organised.

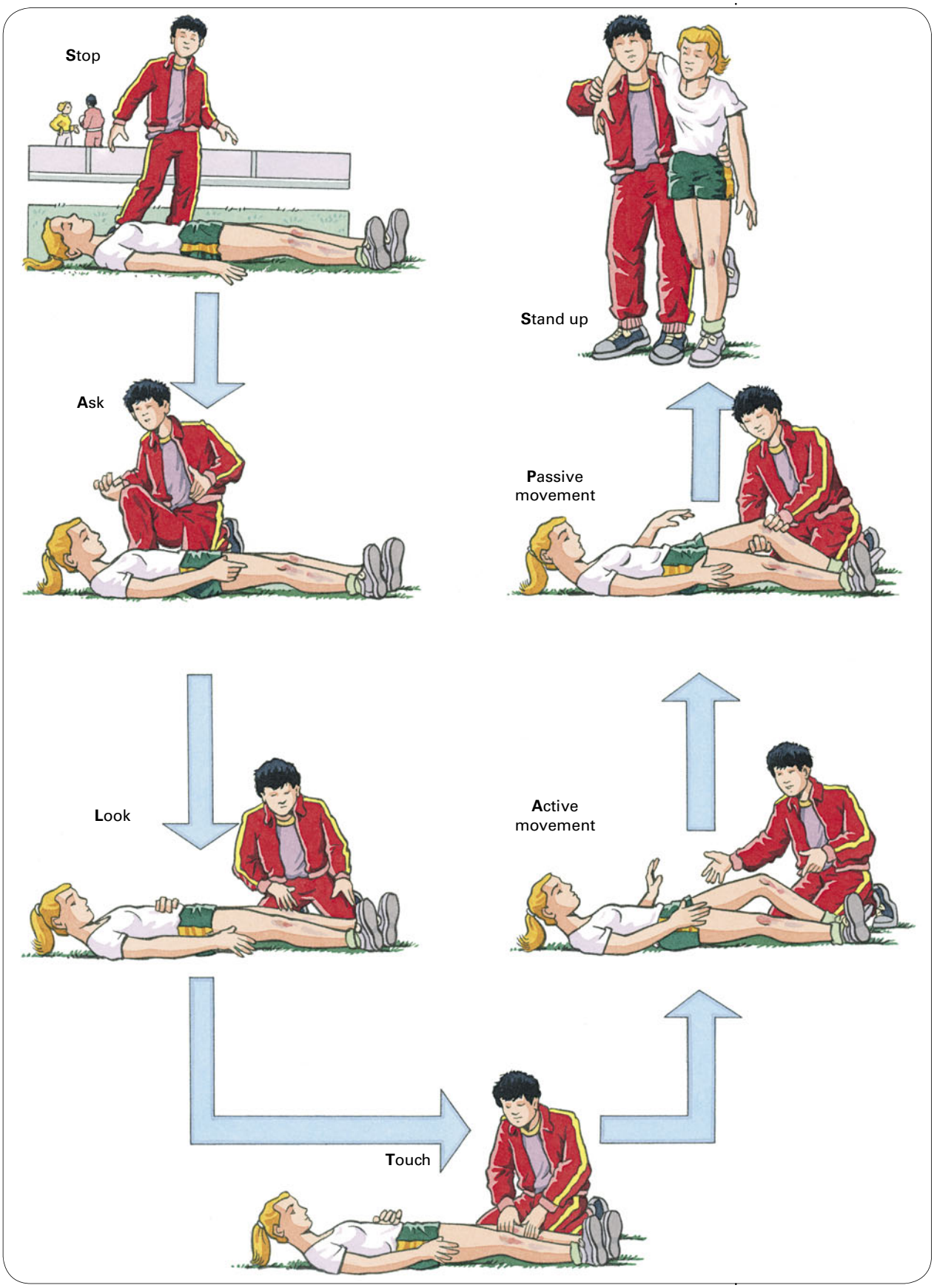


Figure 16.11 SALTAPS procedures

A—Ask

Ask the person what happened, how, when and why. Get this information while it is fresh in their mind and make a note of it. This takes their mind off the pain and assists a doctor to diagnose the injury. Ask questions such as:

- What actually happened?
- How did it happen?
- Were you hit or not?
- If you were, where and from which direction?
- Could you stand, move etc.?
- Did you play on?
- What does the pain feel like?
  - A throbbing pain usually means that the blood circulation has been affected.
  - A burning pain means that the injury is neural (nerve-based).
  - A stabbing pain means that it has affected the muscles or ligaments.
  - A gnawing pain usually shows that it is an aggravated old injury.

Then add some reassurance. People need comfort and support when they are injured, and saying something like 'Don't worry' can help to provide this.

Remember:

- **If the patient is unconscious,** NEVER pick them up in case they have spinal damage. Follow the DRABCD formula (Danger, Response, Airways, Breathing, Compressions, Defibrillation). If the patient is breathing and has a pulse, put them in the recovery position.
- **If the patient is conscious but paralysed**, do NOT move them. Clear the area around the patient and ring for an ambulance immediately.

L—Look

Now look at the injury very carefully before touching it. Carefully observe the injured area for change in colour, shape, size and resting position, and compare it with the opposite limb or part of the body.

- For a recent injury, paleness or blanching may indicate arterial damage; blueness can indicate obstruction to the veins draining the injured area.
- Redness in an old injury means inflammation.
- Obvious change in shape or resting position can be indicate a fracture or dislocation or both.
- An increase in size occurring very suddenly or immediately after the injury indicates rapid bleeding under the surface.
- With joints, sudden swelling almost certainly indicates haemorrhage, whereas swelling that comes on after 2 to 4 hours will probably be from an increase in joint fluid.

T—Touch

Look thoroughly at the injured area and its opposite limb or equivalent. Begin by feeling the appropriate area on the opposite side of the body, taking particular note of the bone shapes, contours and landmarks, looking for obvious differences that indicate a bone injury.

Next feel for variations in the amount and distribution of tissue over the bones and around the joints, checking any difference in tissue thickness,

joint contents, lumps, bumps or collections of fluid under the surface. Difference in temperature may indicate inflammation of infection, or internal bleeding.

A—Active movement

With acute injuries, the next step is critical. Can the person move the injured body part? (Not *you* moving it.) If the patient cannot move the area around the injured part, do not try to do so for them. Test for a full range of movement in the limb as a whole and the joints above and below the injury. With old injuries, restriction of range of movement is important.

Feel the injured area during movement through the full range for clicking, grating or creaking, and the alteration in tension of both soft tissue and joints.

P—Passive movement

Only when you have established the degree and extent to which active movement is possible can you gently move the part through its range of movement without forcing movement in any way. This will give you the final information before proceeding to the next step.

S—Stand up

Can the injured person stand? Can they bear weight on the injured leg or hold an arm against pressure? Can they walk? Can they run?

In cases of head injury or suspected concussion, check that the person knows what is going on and what to do next.

If you learn this procedure, you will save either yourself or someone else pain and damage, and you will never be in the helpless position of looking and wondering what to do next. Remember that with this formula:

- if you cannot complete any of these steps, do not proceed with the next—instead get the patient seen by a doctor straight away
- if the patient is bleeding, control this before using the formula
- if the patient is unconscious, you must use the DRABCD formula.

Management of acute sports injuries

Your main concerns

As a sports first aider, your primary concerns must be to:

- keep your patient alive
- prevent your patient's condition from worsening
- get help
- keep yourself and others safe.

To do this, you must have a plan to follow. You must practise this plan many times until carrying it out becomes automatic.

Treatment of soft-tissue injuries—RICER

Soft-tissue injuries include bruises, 'corkies', cartilage damage, tendonitis, sprains to joints, and strained or torn muscles. All these injuries are very common, but must be treated carefully to allow a quick recovery.

When you damage soft tissue, you damage the blood vessels as well as your soft tissues. As a result, your blood vessels leak and swelling occurs. The more blood that collects in an injury, the longer it takes to heal.

To treat soft-tissue injuries, it is important to control this internal bleeding. The method of doing this is called the **RICER** formula (see figure 16.12).

Figure 16.12
An athlete applying the first 2 stages of the RICER formula on the knee

R—Rest

Rest is essential. If you stay active while injured, you make it worse by increasing the internal bleeding and swelling.

I—Ice

Never rub, massage or heat an injury when it happens. You must:

- apply ice or an ice pack wrapped in a thin towel to the injury (never apply cold directly to the skin)
- hold the ice onto the injury for 15 to 20 minutes once every hour
- repeat as often as you can for 48–72 hours (2–3 days).

Ice makes your capillaries contract and therefore reduces internal bleeding and muscle spasm. Never take a hot bath, shower, sauna or spa in the first 2–3 days after an injury.

C—Compression

Apply pressure around the injury with tape or a bandage. This helps to stop the internal bleeding and limits the swelling.

E—Elevation

Raise your injured body part so that the blood must travel uphill to reach the injury. This will reduce the blood flow to the area.

R—Referral

Seek the advice of a qualified medical practitioner for an accurate diagnosis and ongoing treatment. This will ensure a fuller and faster recovery.

NO HARM

Following the NO HARM method will ensure your actions support recovery and promote healing. Follow the NO HARM method for the next 48–72 hours or until a medical professional tells you otherwise.

- NO Heat—Applying heat to an injury increases bleeding. Avoid hot showers or baths, saunas, spas, hot water bottles, hot liniment or heat packs.
- NO Alcohol—Alcohol increases bleeding and swelling, which delays healing. It can also mask pain and severity.
- NO Running—Running or exercise increases blood flow to the injured site. This can make the injury worse and delay healing.
- NO Massage—Massage or the use of heat rubs increases swelling and bleeding.

Rehabilitation: recovery from injuries

What is rehabilitation?

You have probably had many injuries in your lifetime, and you have probably treated most of them in the correct way. However, like most people you would not have undergone any rehabilitation apart from the usual remedy—rest. As a result, you probably have a number of weaknesses in your joints or muscles—weaknesses left by past injuries that did not heal completely.

Rehabilitation is not just resting until the pain goes away. Real rehabilitation is improving your body so that you are not injured again.

What should happen during rehabilitation?

The person in charge of rehabilitation should be a physiotherapist, who speeds up your recovery through special treatment and exercise.

Let's imagine that you have suffered a soft-tissue injury and have applied the RICER formula for 48 hours. This is what should happen during rehabilitation:

- From 48 to 72 hours after your injury, you should apply hot and cold alternately to the area, e.g. a hot towel for 5 minutes, followed by ice in a towel for 5 minutes. Repeat.
- From 72 hours onwards, apply heat only, in the form of massage, baths, ultrasound or diathermy. However, if the injury begins to swell again, go back to the RICER formula.

The rehabilitation sequence

The principle of rehabilitation is to gradually increase muscle–joint activity up to the pain threshold. The best sequence to follow is:

- **static (isometric) activities without a load:** In these exercises the muscles and joints are worked in a fixed position that minimises aggravation of the injury.
- **static (isometric) exercises with a light load:** Muscles are resisted at various joint angles using rubber bands, towels, weights or a partner.

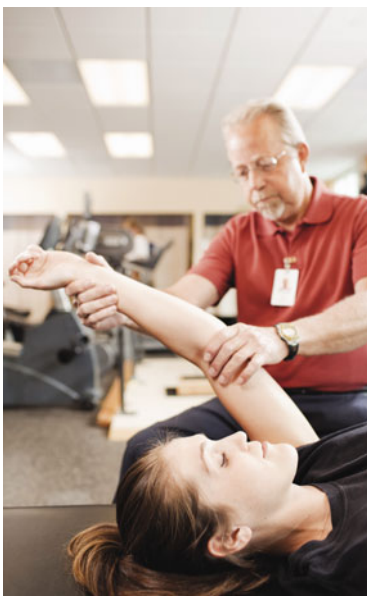


Figure 16.13
A female athlete works through her rehabilitation with a physiotherapist.

- **dynamic exercises:** These exercises are performed over the range of movement allowed by the pain threshold. As strength returns, the load should gradually be increased.
- **stretching exercises:** Stretching exercises improve the range of movement. These must be either static or PNF stretches within your pain tolerance.
- **coordination and balance exercises:** After you have been injured, coordination between nerves, muscles and joints is usually impaired. Coordination exercises are designed to re-teach correct functioning between joint receptors. Using a wobble board or skateboard to practise balance is ideal coordination work.
- **sport-specific training:** As recovery progresses, gradually move back into the specific strength and flexibility work required by your sport and then eventually to full training.

Maintaining fitness in other body parts

Throughout your injury period you must maintain your aerobic fitness and the specific fitness in your other body parts:

- If your leg is injured, you might need to substitute swimming training for your usual training to maintain fitness.
- Bike ergometer work can be used when a shoulder injury eliminates running and swimming.
- If a hand injury eliminates barbell training exercises, substitute dumbbell exercises for the uninjured arm.

Remember, do not let 95% of your body lose fitness because you have injured 5% of it.

Knee-jerk reaction

BY JASON FRENKEL AND KATIE PEART

As Shaun Rehn ran into the ruck contest, his left leg slipped on the disc in the centre of the ground, causing the leg to over-extend, thereby rupturing the anterior cruciate ligament.

Surgery

Reconstructive knee surgery is a routine procedure for experienced surgeons.

Using substitute tissue from the hamstring tendon or patella tendon, the damaged ligament is reconstructed in an operation lasting approximately 1½ hours.

This can take longer depending on the extent of damage to surrounding cartilage and joints. Patients are discharged from hospital within a few days of the procedure.

Cruciate ligaments

Either of two ligaments in the knee joint which cross each other from the femur bone to the tibia bone.

1 Anterior ligament limits extension and rotation.
2 Posterior ligament prevents dislocation in a forward direction.

As the ligament which takes the most pressure, the anterior is more commonly injured.

Anterior ligament

Acts as a stabilising joint in the knee. Can be torn by excessive or sharp twisting, pivoting and turning actions, or immediate and hard stopping. Can also be torn by over-extending the knee.

Posterior ligament

Thought to be twice as strong as the anterior cruciate ligament, and thus harder to damage. Posterior cruciate damage is less common in Australian football and netball than anterior cruciate damage. Can be damaged by a blow to the lower leg, forcing it backwards and causing the knee to buckle, or by over-extending the knee.

The road to recovery

First month

Surgery. Reduce pain and swelling by rest, icing, compression and elevation. Begin gentle bending and straightening of the knee. Walking within 1–2 weeks depending on patient's progress. Begin

>>

gentle hamstring, calf and quadriceps exercises and stretching. Daily physio visits (for full-time athlete) for the first month.

Second month
Off crutches. More aggressive bending and straightening of the knee. Start gentle work on exercise bike. Start swimming program, resistance work.

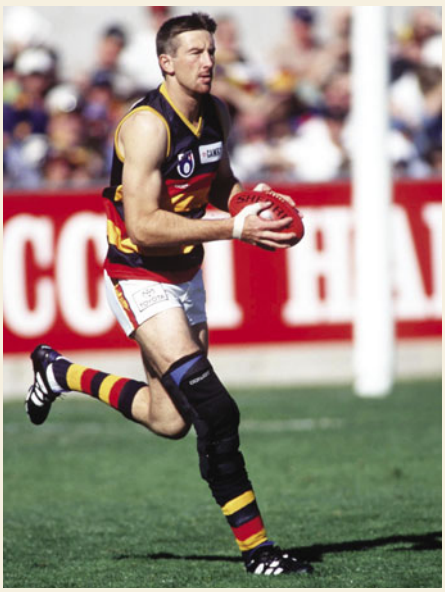
Third month
Focus on strengthening major muscle groups—quadriceps, hamstring, calf etc. Gym sessions three times a week, including weights and bike work. Balancing exercises. Twice weekly physio visits.

Fourth month
Start a running program, including water running and progressing to grass or soft sand running. Working up to 2–3 km, three times a week. Begin interval, sprint work end of this month. See physio once a week, barring complications.

Fifth month
Upgrade running and decreasing gym work. Focus on specific football exercises, e.g. running drills, quick feet drills, hopping and bounding exercises.

Sixth month
Return to full-time training with team. Monthly visits to physio to upgrade the program.

12 months
Return to competitive football if treatment successful.



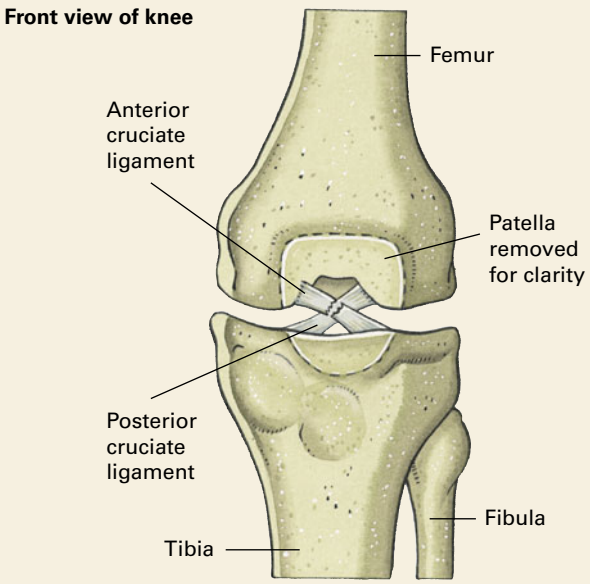


Figure 16.14 Shaun Rehn suffered a serious injury when he ruptured his anterior cruciate ligament.

Source: *Herald Sun*, 23 February 1999

Physiotherapy

Throughout the rehabilitation process your physiotherapist may use a range of treatments to promote rapid healing and recovery.

Massage

Massage is used to break down adhesions and soften the scar tissue that forms between muscle fibres as a result of internal bleeding. This improves the extensibility of the muscle. Massage should not be used for 3–5 days after injury.

Electrotherapy

Electrotherapy is a universal term used to describe a range of injury treatments using some form of electrical stimulation. These treatments include:

- *ultrasound*: In this injury treatment, a fluid gel is spread over the injury site and a metal sound head (shaped like a hammer) is used to pass high-frequency sound waves through the site deep into the soft tissue. The sound waves break up clots and adhesions, soften scar tissue and enhance circulation.
- *interferential therapy*: In this method of injury treatment, suction cups connected via leads to an electrotherapy unit are placed around the injury site. Currents are then run between opposite cups through the injury site. This stimulates circulation to promote more rapid healing.
- *transcutaneous electrical nerve stimulation (TENS)*: This method of injury treatment is basically a less intense version of interferential therapy. Electrodes are placed around the injury, and the current fed from the electrodes is designed to reduce the pain associated with the injury by dampening the messages sent from the pain receptors.

Learning experience

INJURY PREVENTION, ALL YOU NEED TO KNOW

Sports injuries in all age groups are a major burden to the health sector and the community. As a result there is a huge amount of information about sporting injuries, their treatment and prevention.

Go to the website link <www.healthinsite.gov.au/topics/Sports_Injuries> and explore one common sports injury that you have suffered or are interested in. More information can be found through a search of common sports injuries on the internet.

Research

Complete a KWHL to get further information on the injury you have selected and help you organise the information you find.

To do a KWHL you have to:

- Think about what you already know about the selected injury.
- Think about what you want to know about the selected injury (what it is, what it looks like in the body, signs and symptoms, treatment and prevention).
- How you will find out this information.
- What you have learned?

What I know	What I want to know	How will I find out	What I have learnt

Other factors limiting training

There are many factors that can affect performance by imposing limits on training. This final section explores a number of these limitations:

- lack of time
- injuries
- motivation
- environmental conditions
- genetics
- initial fitness
- age
- gender
- equipment and facilities
- illness
- training obsession
- air.

Lack of time

The amount of time devoted to training depends on the priority given to training compared to other parts of your life. Everyone has time to train. The question is whether you want to make that time by shifting another activity down your list of priorities.

Time available for training depends on a balance between work and school demands, social and passive leisure demands, family commitments, and sport and active leisure demands.

If your aim is elite sporting performance, all other aspects of life tend to be curtailed because of huge training demands. If your aim is health-related fitness or sport-related fitness at club level, you need only shift the balance of activities away from passive leisure pursuits to create enough training time.

Injuries

Perhaps the greatest frustration for the active person is to have training interrupted by injury. To ensure this does not happen—or if it does, that the interruption is minimal—follow these guidelines.

Avoiding injury

To avoid injury:

- always warm up before training
- always attend training so that you develop the fitness you need in the appropriate body parts
- always wear the correct protective equipment
- make allowances for the current weather conditions.

What to do if you are injured

If you are injured during training or competition, follow these procedures:

- Use the SALTAPS formula to diagnose the injury and prevent further damage. (SALTAPS stands for Stop, Ask, Look, Touch, Active movements, Passive movements, Stand up. See earlier section for further details of this procedure.)
- If the injury is severe, seek medical treatment. However, if it is a soft tissue injury, follow the RICER formula to treat it. (RICER stands for Rest, Ice, Compression, Elevation, Referral. See earlier section for further details of this procedure.)
- Do not resume playing until the injury is fully rehabilitated. However, while you are injured, maintain fitness in the uninjured parts of your body by altering your training.

Motivation

Motivation is a key factor in training. Lack of motivation means irregular or poor-quality training, whereas over-motivation causes overtraining.

It is an unfortunate fact that, of those who begin a training program, two-thirds drop out within the first 6 weeks. Anyone who begins a fitness program needs to realise that there are three stages of fitness (see figure 16.15):

- the discomfort stage
- the physical stage
- the psychological stage.

Within each stage the motivation to continue the program differs.

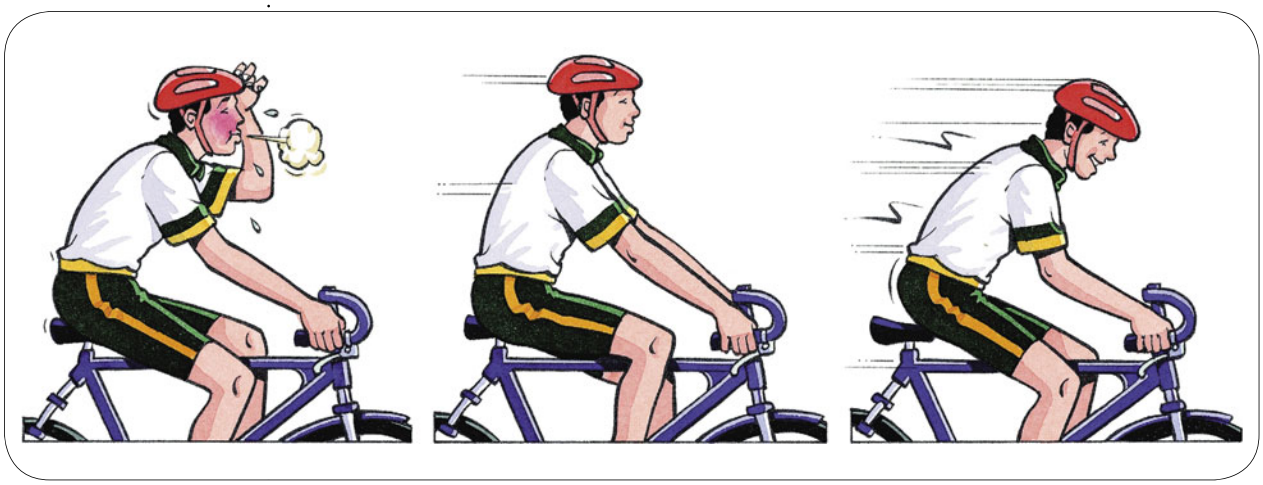


Figure 16.15 The three stages of fitness training in relation to motivation

The discomfort stage

The discomfort stage can last 2–10 weeks, depending on how long it is since you last completed a fitness program. During this stage, training is a pain, and you constantly want to stop. Two out of every three people who start a fitness program drop out during this stage. To make it to the second stage, follow these motivation techniques:

- Train with someone else so that you can take your mind off what you are doing.
- Take the training gradually. Do not punish your body.
- Always keep a record of your training sessions.

- Set yourself both long-term and short-term goals, e.g.
  - short-term goal—able to jog for 10 minutes non-stop
  - long-term goal—able to complete the local 5 km fun run.
- Give yourself a pat on the back after every session.
- Plan your training in advance so that you are committed and cannot get out of it.
- Train in a variety of ways and in pleasant surroundings.
- Mentally rehearse what you are going to do before you do it physically.

The physical stage

When you reach the physical stage, the exercise stops hurting, and even begins to feel good, especially after each session. You start to notice beneficial changes in your body, you feel good, and you look better—so you come back for more. Training is still difficult, but now you know it's worth it.

However, you still need to follow the motivational techniques recommended for the discomfort stage.

The psychological stage

Few people make it to the psychological stage. This is the 'addiction' stage in which the person gets a mental 'high' out of exercise. It takes years to reach this stage, and you don't need to reach it to be able to keep training.

Maintaining consistent motivation

The key to maintaining consistent motivation, and therefore consistent training, is to follow these guidelines:

- Listen to your body.
- Train, don't punish.
- Vary your program regularly.
- Periodise all training.

Learning experience

MOTIVATION

1 How would you describe the stage of fitness motivation you are at right now? Give specific examples of how you know you are in this stage.
'Think, Pair and Share' might be a good tool to approach this task:
   - Think (personal reflection and research)
   - Pair (discuss with a partner)
   - Share (discuss with another pair).

   What did you notice about the range of responses in your group?

2 Collect a series of images and identify the stage of fitness motivation each image would fit into.

Cost

Cost can be a limiting factor in your selection of a suitable sport or the level of training you can reach. For example, sports such as surfing, skiing, motorcycle racing and horse riding are expensive choices; the equipment is expensive, and you need some form of independent transport to be able to participate in training

or competition. Team sports tend to be a cheaper alternative because most require little equipment and can be played in your local area.

As your standard of performance rises, the level of training required for improvement to continue also rises. This can increase costs by requiring you to hire or buy better equipment, better coaching and better training facilities. Some people may find that these increasing costs, combined with the extra time commitments, place a limit on the degree of training they can undertake and hence on the level of performance they can achieve.

Learning experience

COST OF YOUR SPORT

Consider all the sports and physical activities you participate in. Calculate the cost of these activities over a year. You may have to talk to your parents about this. The results may surprise you.

Environmental conditions

Tragedy of the athlete who 'melted'

Mark Dorrity was not your average weekend jogger.

When he graduated from the University of NSW, he took with him a prestigious Blue for athletics.

And when he moved from Sydney to work in Melbourne as a wool buyer, he found the Botanical Gardens a perfect place for his daily 4 km run.

Mark also used to swim a kilometre three times a week ... but that was five months ago, before 28-year-old Mark from Albert Park and his mates decided to enter an 8 km fun run in Wagga, in southern NSW.

The official run was cancelled as the temperature soared to more than 42°, and Mark's near-fatal mistake was to insist that he and his mates should race each other.

The last thing he remembers before collapsing is that he held almost a kilometre lead on his friends.

Mark was rushed to Wagga hospital suffering from heat exhaustion and severe dehydration.

Doctors there packed his body in ice in a desperate bid to cool his body, whose temperature had rocketed to a dangerously high 42.8°.

But the damage had already been done, and Mark's life will never be the same again.

In less than an hour, the fit runner's thigh muscles had overheated and liquefied.

The muscles in his left leg died and doctors later were forced to amputate the leg at the hip because of gangrene.

His kidneys collapsed when toxic proteins were released from the dying muscles into his bloodstream.

Doctors said the blood would have resembled molasses and affected every organ in his body.

His heart stopped beating at least once and he suffered brain damage.

When Mark awoke from a three-month coma he could not walk or talk.

It was only much later that doctors discovered that Mark suffered the rare condition rhabdomyolysis, the most extreme form of muscle fatigue and dehydration.

Doctors said it would have been avoided if Mark had drunk water regularly during the race.

Looking at the skin-and-bones 62 kg frame in a bed at Sydney's St Vincent's Hospital, it is difficult to imagine that Mark was once a strapping 83 kg athlete.

Mark still cannot turn over or get out of bed without help. His breathing is shallow and he speaks in a painfully slow, raspy voice.

Despite the daunting prospect of months of intensive rehabilitation, Mark spoke confidently of his future: 'I want to get back into sport as much as I can. It's always been a part of my life. I'm not going to stop doing something which I enjoy.

'Others have lost their legs before me so it's up to me now to just get on with my life.'

Source: Shane Burke, *Sun*, 6 August 1988

Learning experience

ENVIRONMENT AND SPORT

Research some other examples of athletes who have suffered environmental extremes for their sport.

Share your stories with classmates in small groups.

Chapter review

Training limitations

Know

1 Review the online resources available that relate to training limitations and compile a list of websites that could be useful or interesting to you.

Comprehend

2 a Rank the list of websites on training limitations according to:
- reliability of information
- relevance to your specific training limitation needs
- other useful sites to which it links.

b Select five websites to share with your classmates.

Apply

3 Observe a training session at a local club (it could be your own). What evidence do you see of (ensure you are specific):
- overtraining?
- fatigue?
- prevention of injury practices, e.g. warm-up?
- injury?

4 To what extent were these issues of training limitation managed, solved or attended to?

Analyse
Evaluate
Synthesise

5 Respond to the following statement: 'It is the job of the athlete to be responsible for their own safety and wellbeing when training or competing.'

6 Do you agree with the statement? Provide convincing and discerning evidence to justify your decision.

7 Create a concept map highlighting the relationships between training limitations and:
- fatigue
- injury
- recovery
- rehabilitation.

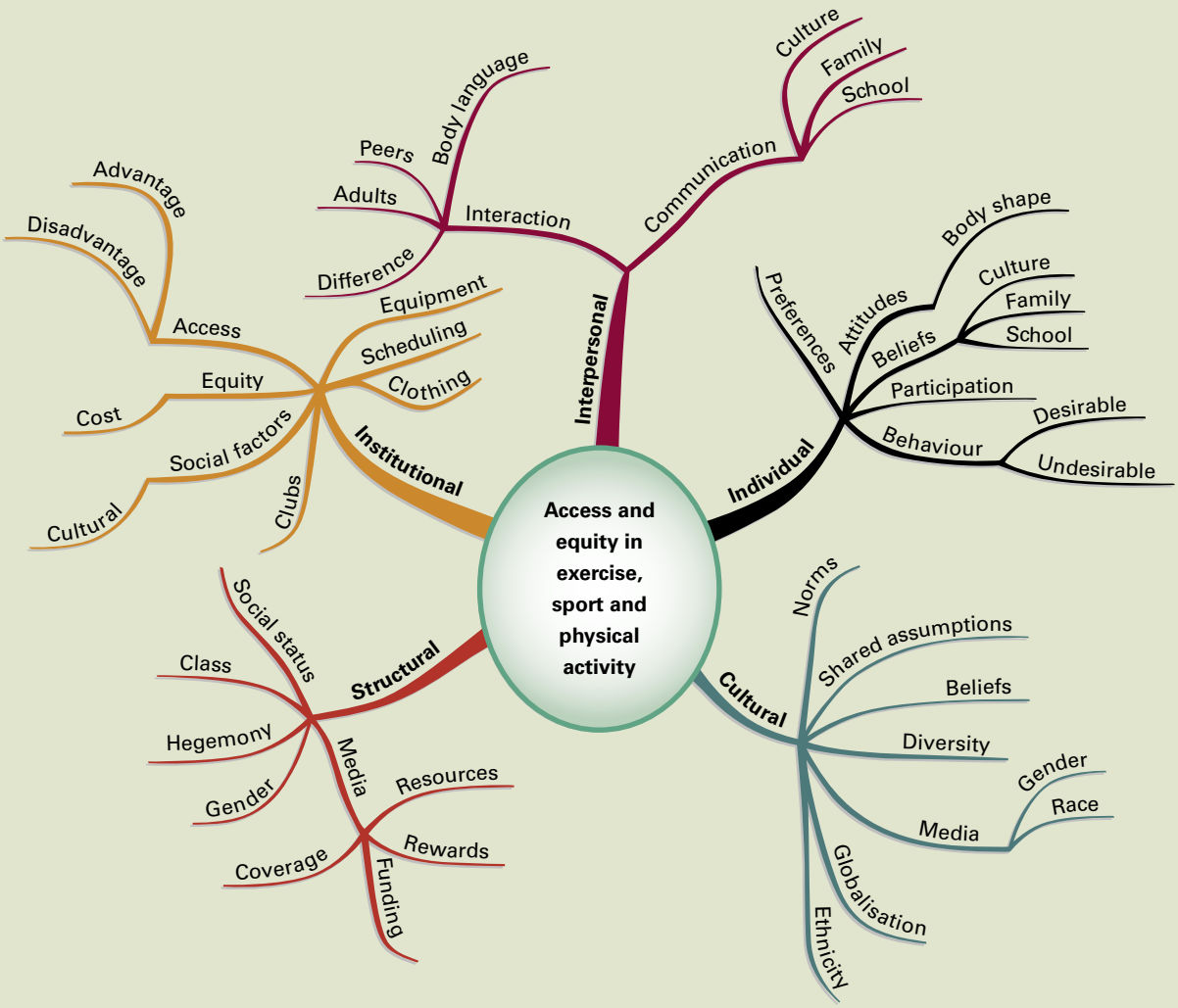
Focus Area C

Equity and access to exercise, sport and physical activity in Australian society

WHAT ARE THE INFLUENCES THAT SHAPE PERSONAL, TEAM AND COMMUNITY PARTICIPATION AND APPRECIATION OF SPORT AND PHYSICAL ACTIVITY WITHIN AUSTRALIAN SOCIETY?

To be physically educated, students should have an understanding of the complexities that surround and influence sport and physical activity. Sport and physical activity exist within an Australian and, increasingly, a world context. Students need to critically reflect on the power of these sociocultural influences to better understand their place, their participation, and the place of physical activity and sport within society. Figueroa's framework is a useful tool for examining the sociocultural factors influencing equity and access to sport and physical activity in Australian society.

Source: *Physical Education 2010 Senior Syllabus*, published by Queensland Studies Authority


Access and equity in exercise, sport and physical activity
Interpersonal
Communication
Culture
Family
School
Interaction
Body language
Peers
Adults
Difference
Individual
Preferences
Attitudes
Body shape
Beliefs
Culture
Family
School
Participation
Behaviour
Desirable
Undesirable
Institutional
Access
Advantage
Disadvantage
Equity
Cost
Social factors
Cultural
Equipment
Scheduling
Clothing
Clubs
Structural
Social status
Class
Hegemony
Gender
Media
Resources
Rewards
Coverage
Funding
Cultural
Norms
Shared assumptions
Beliefs
Diversity
Media
Gender
Race
Globalisation
Ethnicity

Figueroa's framework

HOW HAVE INDIVIDUAL, INTERPERSONAL, INSTITUTIONAL, STRUCTURAL AND CULTURAL FACTORS SHAPED YOUR OWN PARTICIPATION IN PHYSICAL ACTIVITY AND SPORT?

chapter 17

Access and equity: Figueroa's framework

Exercise, sport and physical activity play an important role in many people's lives. Your study in this focus area offers you the opportunity to consider sport and physical activity from different viewpoints and to critically examine its various aspects. You can apply your analysis and evaluation to many contemporary sporting issues, and propose possible changes and solutions to emerging problems in sport. For example, a study of the **sociocultural** influences on sport and physical activity may help you to better understand the powerful social forces that influence your involvement and participation in exercise, sport and physical activity. You may then use that acquired knowledge to develop more control over your own participation and that of others.

Donnelly's (1996) research suggests that:

> *Each of us has a gender, a social class background, a racial or ethnic affiliation and a variety of other social characteristics that serve as advantages or disadvantages in the various structural and cultural circumstances of our lives, and we relate to each other on the basis of ours and theirs.*

Every one of the complex factors listed by Donnelly interacts and contributes to our own participation. These and other factors interact to determine **access** and **equity** in exercise, sport and physical activity.

Sociocultural refers to both social and cultural factors.

Access is the opportunity to participate.

Equity is concerned with giving value to, and celebrating, social and cultural differences of individuals and society.

Access, equity and equality

Article 26 of the United Nations Universal Declaration of Human Rights (1948) recognised that 'everyone has the right to education'. In Australia, the Melbourne Declaration on Educational Goals for Young Australians (2008) has as a central goal the promotion of equity in Australian schooling. The Queensland Studies Authority (2010) promotes a statement on educational equity in its syllabus documents in which equity is defined as 'fair treatment for all'. Various agencies, including the United Nations, different levels of government and key curriculum bodies are obviously concerned with protecting the rights of all students to have access to an education (including Physical Education), regardless of economic status, gender, race, ethnicity or ability.

But what do these words really mean? Clear definitions of terms such as 'equity', 'access' and 'equality' are difficult to identify, and these words are used and interchanged for each other regularly. The perception about each of

these terms is somewhat variable. A number of researchers have attempted to define these terms and provide clear definitions, but they acknowledge the problem of clarifying the precise meaning of these words. Each word develops different meanings in different contexts.

However, there are distinct common features associated with the use of these terms, which include equal treatment of individuals, respect for individual differences, justice and fairness. Professor Peter Figueroa argues that **equality** refers not to sameness, or a notion of the lowest common denominator, but to fairness or equity. Inclusion of others and their needs are central concepts in this discussion. Dr Dawn Penney, another recognised sociologist, suggests that equity is concerned with celebrating and giving value to the social and cultural differences of individuals within society. The issue of equity is about viewing difference as an opportunity to enrich each other's lives. This explanation suggests that differences should not be considered as problems needing to be resolved or removed, but instead, acknowledged as being important to every individual and to society. Celebrating difference then becomes a way of breaking down traditional **stereotypes**, eliminating prejudice and respecting a variety of cultural identities. Equality and equity, therefore, are not conflicting alternatives but complements of each other.

Equality is the state of being equal in some respect.

Stereotypes are the fixed, narrow views of individuals' characteristics—a set form or convention.

SNAPSHOT

Professor Peter Figueroa

A Jamaican who settled in Britain, Peter Figueroa was a full-time member of the University of Southampton Department of Education from 1976 to 2001, first as a Lecturer, then as a Senior Lecturer, Reader and finally as Professor. His particular research interests have been in citizenship and diversity, multiculturalism and race relations, particularly in the United Kingdom, but also at a global level.

Figure 17.1
Lisa Sthalekar of the Australian Southern Stars signs autographs during the launch of Cricket Australia's 'Playing in Harmony' School Initiative. The program, which stems from Cricket Australia's partnership with the Federal Government's Department of Immigration and Multicultural Affairs, aims to encourage children to discuss important social issues and celebrate cultural diversity and inclusion.

Barriers are factors that restrict or prevent access to exercise, sport and physical activity.

We need to recognise that many people do not have similar opportunities to participate and benefit from involvement in exercise, sport and physical activity. Some **barriers** might include the availability, provision and location of local facilities, the costs of entry and membership fees, the scheduling of facilities and access to transport. These barriers may mean that individuals who would like to participate in some form of exercise, sport or physical activity are effectively denied access.

Does providing a right of **access** ensure equality of opportunity? This key question and the meaning of the phrase 'equality of opportunity' will be the central idea of our study in this Focus Area. Professor Figueroa interprets equality of opportunity as differential provision, according to need. He defined equality of opportunity as:

> *… the principle that relevant similarities and relevant differences should be given due recognition, while irrelevant similarities and irrelevant differences should be ignored … In Physical Education, this means giving full recognition to everyone's rights and legitimate needs, and inseparably recognizing and taking into account relevant similarities and relevant differences and relevant disadvantages, but disregarding irrelevant ones.*

Ethnicity refers to groups of individuals sharing common characteristics that differentiate these individuals from other groups in society.

This definition implies the removal of any unfavourable treatment on the basis of membership of a particular group or category (e.g. colour of skin, **ethnicity** or socioeconomic status) that may be irrelevant when accessing a particular form of exercise, sport or physical activity. It also suggests that where there are relevant differences (such as age or gender differences) that affect an individual's ability to benefit from their involvement in exercise, sport or physical activity, these differences are carefully considered to enable each individual the optimum circumstances and chances of achieving his or her potential.

Learning experience

RESEARCH REPORT

> *Sports equity is about fairness in sport, equality of access, recognising inequalities, and taking steps to address them. It is about changing the culture and structure of sport to ensure that it becomes equally accessible to everyone in society.*
>
> Source: adapted from Sport England (2008)

Propose a series of strategies to overcome issues of equity in your school Physical Education program and predict the impact of increased access to opportunities to participate in sport.

Figueroa's framework

The concepts of equity, access and equality are difficult to define and understand. They present complex issues for discussion and provide individuals and society with significant challenges. The framework developed by Professor Peter Figueroa has been a useful tool in the

investigation of issues and ideas surrounding equity, access and equality in exercise, sport and physical activity. The framework initially supported Figueroa's research investigating racism, but it is a useful tool to investigate the ways in which inequities can be challenged in the area of exercise, sport and physical activity.

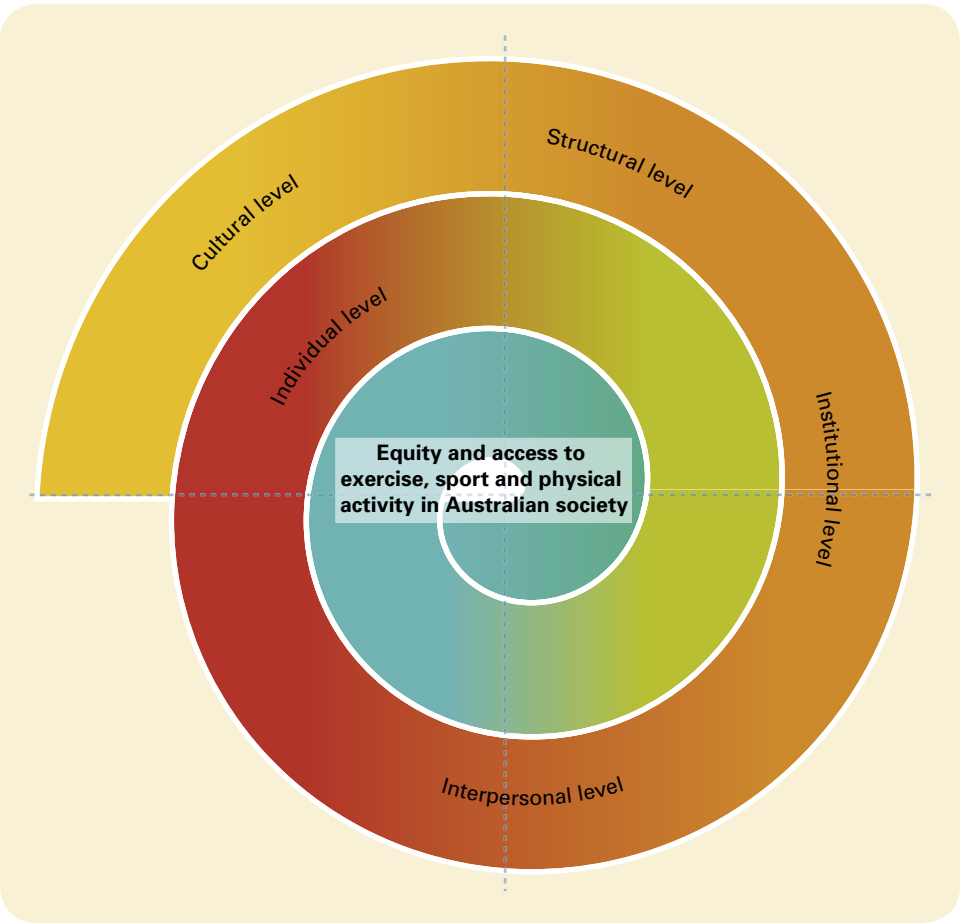


Figure 17.2
A representation of Figueroa's framework for examining access and equity in exercise, sport and physical activity. Observe how each level of the framework is closely related.

The framework is constructed across five separate levels (individual, interpersonal, institutional, structural and cultural) with each level strongly interconnected with the others. Each specific level contributes a role in shaping the adjoining levels. It also indicates the different functions that each of us can play in creating or removing, reinforcing or eliminating barriers, inequities and access in exercise, sport and physical activity. We cannot overcome all barriers by simply acting at the *individual* level. Instead, all the different levels of the framework need to work cooperatively to effectively overcome these barriers and challenge the inequities that exist.

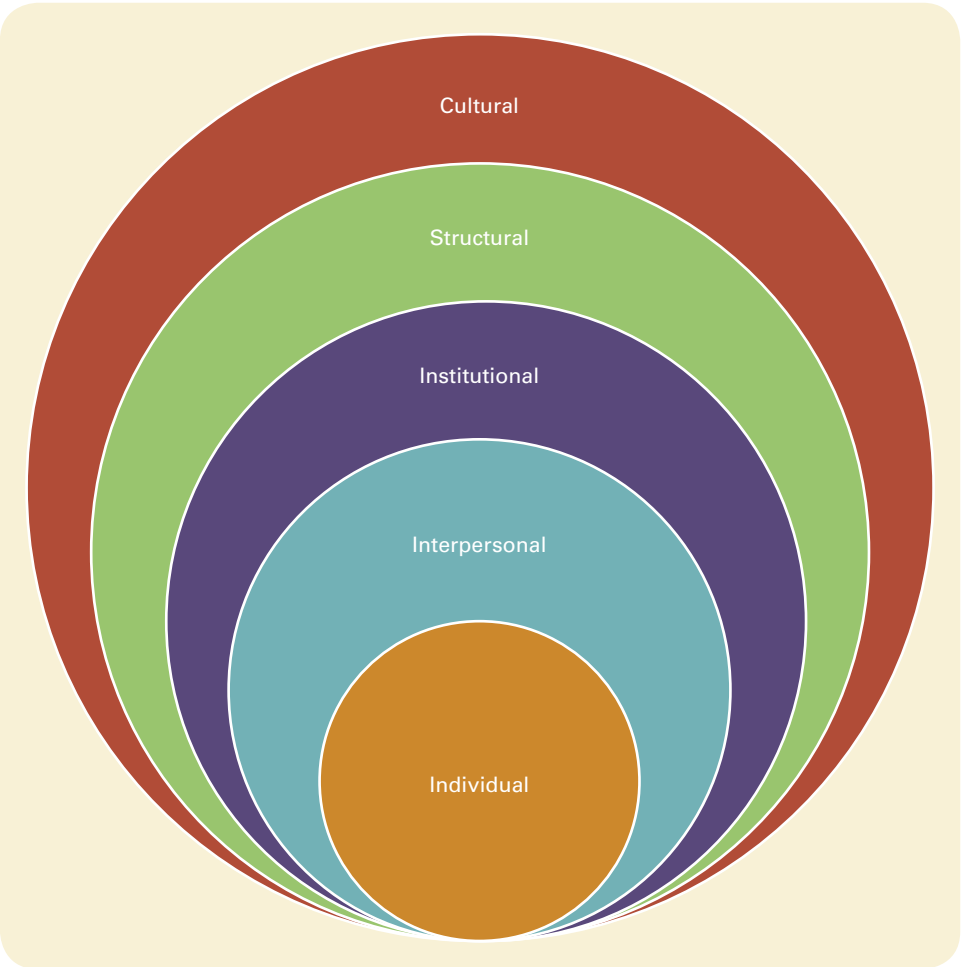


Figure 17.3
Another perspective on Figueroa's framework

Individual level

Personalisation is an important organising principle in our study in Physical Education. It is therefore appropriate that we begin an outline and discussion at Figueroa's *individual* level. This also indicates the important personal role that we can play in addressing issues of inequity in exercise, sport and physical activity. The *individual* level is involved with our own attitudes, values and beliefs, particularly those related to stereotypes and prejudices. The *individual* level encourages us to think critically about our own perceptions of exercise, sport and physical activity. What factors have been involved in shaping our own attitudes, values and beliefs? What factors have been important and influenced our own participation, access and opportunities in exercise, sport and physical activity?

Interpersonal level

The *interpersonal* level is concerned with our interactions with others, our relationships with peers and others, as well as our patterns of influence and how these might affect access and equity to exercise, sport and physical activity. At this level, our attitudes, values and beliefs about difference might be critically evaluated. Inequity through factors such as how we relate to our peers, and prejudices and stereotypes we might construct, as well as discrimination and exclusion of particular groups could be considered.

The *interpersonal* level encourages us to think critically about our own relationships with our peers and their relationships with others. We should consider the needs and interests of others and encourage a greater understanding of others' differences. Consider which people have had the most influence on your participation in exercise, sport and physical activity. Determine how these individuals have influenced the participation of you and your peers. Have they encouraged or discouraged your participation?

Learning experience

Consider the following poem, written by A Ahlberg.

Picking teams

When we pick teams in the playground,
Whatever the games may be,
There's always somebody left till last
And usually it's me.

I stand there looking hopeful
And tapping myself on the chest
But the captains pick the others first,
Starting, of course, with the best.

Maybe if teams were sometimes picked
Starting with the worst,
Once in his life a child like me
Could end up being first!

Source: A Ahlberg, 1983, *Please Mrs Butler*, Kestrel Books, Penguin Books Ltd, Hammondsworth, p. 35.

Critique the sentiment behind this poem. Use Figueroa's framework to suggest how access and equity could be enhanced in this situation.

Institutional level

The *institutional* level examines laws, patterns or rules within different agencies. This level of the framework also considers processes or arrangements and organisational structures and how these might impact on access and equity to exercise, sport and physical activity. It is concerned with the ways in which organisations such as schools or clubs might operate to advantage or disadvantage particular groups with specific needs, which are different from 'mainstream' groups. These might include discriminatory rules or regulations, such as dress codes, membership rights, fees charged or scheduling of facilities, which create inequalities among specific groups or marginalise or exclude some people. The *institutional* level encourages organisations to think critically about their own rules, policies and procedures which may advantage or disadvantage specific groups who would like to be involved in exercise, sport and physical activity at the *institutional* level.

Structural level

The *structural* level of Figueroa's framework examines inequities within society on a much larger scale. It examines how social status might impact on the types and levels of participation by various groups within society. At the *structural* level, the framework is concerned with the way in which society considers such factors as race, gender or disability. It also examines the way in which resources, rewards and status are distributed to various sectors, and how the allocation of resources might impact on access and equity. It examines the effects and impact of power and relationships within society. The *structural* level encourages us, as active members of society, to think critically about the distribution of power, resources and status that may advantage or disadvantage specific groups who would like to be involved in exercise, sport and physical activity at the *structural* level.

Cultural level

The *cultural* level is concerned with shared assumptions, beliefs and values about issues such as gender or race and socioeconomic status and how these issues might affect access and equity to exercise, sport and physical activity. This level of the framework requires critical analysis of cultural norms and values, and examines how diversity is recognised and treated. These cultural norms, sometimes unknowingly, restrict or influence our perceptions and actions about involvement in exercise, sport and physical activity. These frames of reference consist of many beliefs, assumptions, values and attitudes that are taken for granted and which are reflected in issues such as the globalisation of sport and the role of politics in sport, as well as the impact of race and ethnicity on participation.

Learning experience

MULTI-MODAL TASK

How might the sentiments expressed in the poem 'Picking teams' be applied to other levels of Figueroa's framework? How could the framework be applied to overcome access and equity issues at the individual, interpersonal, institutional, structural and cultural levels? For example, how are the 'popular' sports treated at different levels of the framework? Do some sports attract preferential treatment ahead of others?

Conclusion

There are five distinct levels in Figueroa's framework that we will use to investigate issues of access and equity in exercise, sport and physical activity within Australian society. However, it is important to note the interactions between the different levels. Each level in the spiral interacts with the preceding level and the level following. No one level can stand alone as each is interdependent on the others.

Research by prominent sociologist Susan Piotrowski suggests that the demand for equality of opportunity is not a demand for recognition that all people are similar, or are exactly the same. There are clear **biological** and socially constructed differences, which must influence how individuals

Biological refers to life and living matter in all forms.

should be treated. If all individuals have the opportunities to develop their own potential in exercise, sport and physical activity, then it is important to remove any forms of discrimination that may act as barriers to participation. Piotrowski concludes that a commitment to equity seeks to prevent exercise, sport and physical activity from assisting to confirm and reinforce stereotypes, patterns of injustice and inequity in our wider society. We can begin addressing inequities by critically reflecting on our own values, attitudes and beliefs at the *individual* level—the first level in Figueroa's framework.

Chapter review

Access and equity: Figueroa's framework

Know	1	List and describe briefly the different levels of Figueroa's framework
Comprehend	2	Using the discussion within the chapter, give examples of issues that might impact on access or equality of opportunity within different groups.
Apply	3	Choose one level of Figueroa's framework. Examine the practices in your current Physical Education class and list a number of ways that equity and access may be enhanced at that level.
Analyse Evaluate Synthesise	4	Propose strategies to overcome inequities you may have experienced in exercise, sport and physical activity as a child and as an adolescent.
	5	Predict possible inequities you may encounter as an adult in future participation in exercise, sport and physical activity.

Levels of equity and access

HOW HAVE YOUR DECISIONS AND OTHER FACTORS SHAPED THE PARTICIPATION IN PHYSICAL ACTIVITY AND SPORT OF YOURSELF, YOUR PEERS OR OTHERS IN THE COMMUNITY?

chapter 18

Access and equity at the individual level

The *individual* level of Figueroa's framework is involved with our own attitudes, values and beliefs, particularly those related to stereotypes and prejudices. This level encourages us to think critically about our own perceptions of exercise, sport and physical activity. A complex range of factors interact to influence our participation at the individual level of involvement in sport and physical activity. The degree to which we take part is determined by a myriad of complex reasons. Many factors impact on an individual's capacity to gain access to, or be treated equitably in, various settings in exercise, sport and physical activity. These factors can encourage, or severely restrict an individual's participation.

Satisfaction, personal preferences and human needs

Abraham Maslow (1898–1970) was a psychologist who developed a theory concerning a hierarchy of human needs. In the levels of the five basic needs, the individual does not fulfil the second need until the demands of the first have been achieved or the third until the second has been satisfied, and so on. This theory accurately describes many realities of individual experiences. You may be able to relate each of these human needs to your own and others' participation in exercise, sport and physical activity.

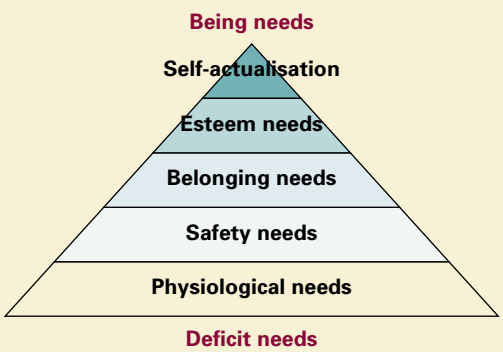


Figure 18.1
Maslow's needs hierarchy

The hierarchic theory is often represented as a pyramid, with the larger, lower levels representing the lower needs, and the tip representing the need for self-actualisation.

Many people find they can understand this theory, because they can recognise some features of their own experiences or behaviours which are true and recognisable but which they have never been able to express. Maslow's hierarchy of basic needs are described.

Physiological needs

These are biological needs. They consist of needs for oxygen, food, water and a relatively constant body temperature. They are the strongest needs because if a person were deprived of all needs, the physiological ones would come first in the search for satisfaction and survival. Participation in physical activity can fulfil some of these primary physiological needs. We develop the capacities, through training, to enhance our efficiency to utilise oxygen and metabolise energy derived from the food we eat. We also need to maintain our hydration levels and nutritional uptake, if we are to perform consistently and effectively. Physical activity places additional demands on our physiological needs, and if these needs are not met, our participation becomes less effective. The ability to satisfy our physiological needs is critical to our participation in exercise, sport and physical activity.

Safety needs

When all physiological needs are satisfied and are no longer controlling our thoughts and behaviours, the needs for security can be enabled. We become increasingly interested in finding safe circumstances and developing a sense of stability and protection. We might also develop a need for structure, for order and some limits, such as rules or procedures. When we participate in exercise, sport or physical activity, it is essential that these needs are met. Many individuals do not find participation in some forms of physical activity as developing their need for safety and security. Others participate because they feel safe and protected, and are surrounded by structure and limits to unsafe behaviours. These safety needs can all become potential barriers and enablers for access and equity in physical activity.

Needs of love, affection and belongingness

When the needs for safety and for physiological wellbeing are satisfied, the needs for love, affection and belongingness can emerge. Maslow stated that people seek to overcome feelings of loneliness and alienation. This involves both giving and receiving love and affection and the sense of belonging. These needs, too, can be achieved through positive experiences in exercise, sport and physical activity.

Recent research by sociologist Dianne Schmalz suggests that social stereotypes such as race, class, religion, physical characteristics and gender are strong influences on participation in sport and physical activities. These stereotypes have a major impact on a person's sense of love, affection and belongingness. However, the extent to which individuals are conscious of the **stigmas** imposed by social stereotypes and the extent to which people let stigmas affect participation differ from person to person. For some, these factors may not be an issue as far as access or equitable treatment is concerned, but for others these stereotypes may have a strong impact on their participation.

A **stigma** is a characteristic mark or a sign of a defect—that is, a stain on reputation.

Needs for esteem

When the first three classes of needs are satisfied, the needs for esteem can become dominant. These involve needs for both self-esteem and for the

esteem a person gets from others. Humans have a need for a stable, firmly based, high level of self-respect and respect from others. When these needs are satisfied, they feel self-confident and valuable as a person in the world. When these needs are frustrated, the person feels inferior, weak, helpless and worthless. Inclusion or exclusion in physical activity can contribute extensively to an individual's self-esteem and the level of esteem obtained from others. Exercise, sport and physical activity have major roles to play in this important human need.

Needs for self-actualisation

When all of these needs are satisfied, then and only then, are the needs for self-actualisation realised. Maslow described self-actualisation as a person's need to be and do that which they were 'born to do'. For example, an athlete must excel in sport, an artist must paint, and a musician must perform their music.

These needs, if not met, result in signs of restlessness. The person feels on edge, tense and lacking something; in short, they are restless and unsettled. If a person is hungry, unsafe, not loved or accepted, or lacking in self-esteem, it is very easy to know what they are restless about; but it is not always clear when there is a need for self-actualisation.

Importantly, Maslow believed that the only reason a person would not achieve self-actualisation is because of hindrances placed in their way by society. We need to identify barriers that prevent us or others from accomplishing these needs, particularly through our study of participation in physical activity.

SNAPSHOT

Abraham Maslow (1908–1970)

Abraham Harold Maslow was born on 1 April 1908 in Brooklyn, New York, to a poor, immigrant Russian Jewish family. He was their first child, six more were to follow. His parents saw education as a route to advancement in the United States, and placed great emphasis on their children's progress in school.

In line with his parents' wishes, Abraham Maslow began to study law but, later, following a transfer in his law studies from New York to Wisconsin, he became fascinated by psychology. He soon became involved in researching rhesus monkeys under the supervision of the celebrated Harry Harlow. He did not graduate in law, but was awarded junior and senior degrees to PhD level in psychology by the University of Wisconsin between 1930 and 1934.

After a period of further research at New York's Columbia University he was employed as a lecturer, and eventually as a full professor in Psychology.

What we now know as Maslow's hierarchy of need dates, in its initial conception, from circa 1943. This hierarchy is applied to human beings and is built upon the perception that some needs take precedence over others.

In later life Maslow was plagued by ill health and withdrew from full-time teaching. He was only sixty-two years of age at the time of his death in 1970.

Source: E Hoffman, 1988, *The Right to be Human: A Biography of Abraham Maslow*, St Martin's Press, New York

Learning experience

Referring to Maslow's hierarchy of needs, evaluate how your personal involvement in exercise, sport and physical activity has contributed towards your 'journey' to self-actualisation. How has this contributed to each of Maslow's needs for you as an individual?

Body image and self-concept

As we examine the influences of a range of factors on an individual's participation in sport and physical activity, we will be discussing concepts such as 'body image', 'self-image', 'self-concept' and 'self-esteem'. First, however, we need to clarify what each of these terms means.

Body image (or 'body concept' as it is sometimes called) refers to the image you have of your own body and how you feel about it. If you are happy with your body shape and size, you have a positive body image. If you are conscious of not being the desired shape or size, then you have a poor body image.

Body image is the image you have of your own body and how you feel about it.

Self-image and self-concept

'Self-image' and 'self-concept' have similar meanings. They refer to the picture you have of yourself as a total person. Your self-image includes your body image, personality, intellectual capacity and ability to 'fit' into society. People with a positive self-image feel satisfied with life and the role they play in society. On the other hand, people with a negative self-image generally see themselves as not fitting into society and therefore find many situations threatening.

Self-esteem

Self-esteem is closely linked to self-image. It refers to the feelings you have about yourself that are based on your self-image. Self-esteem describes an individual's overall evaluation of themselves, or how they feel about themselves. People with low self-esteem generally suffer from feelings of inadequacy, anxiety, self-doubt and inferiority. Those who have high self-esteem generally feel happy, assume active roles in social groups and express their views frequently and effectively. Generally speaking, high self-esteem generates self-confidence.

Self-esteem refers to the feelings you have about yourself.

The importance of a positive body image

How you view yourself and how others view you are sometimes very different. During the last 20 years, there has been considerable research on how our body image and self-image develop, the connection between body image and self-esteem, and the effects that physical activity has on body image.

We all have an image inside our head of what our body looks like. This image is affected by cultural messages and societal conditioning, our personal attitudes and feelings towards our bodies, and the attitudes of peers and family members.

Perhaps the most valuable finding of this research is that people with a positive body image tend to have a positive self-image and greater self-esteem than those who have a poor body image. Therefore, development of a good body image is an essential ingredient in developing self-confidence and a positive outlook on life. A positive body image is a significant factor in our participation in physical activity.

Learning experience

MULTI-MODAL TASK

Which individual factors have been most influential on your own participation in exercise, sport and physical activity? Propose and justify reasons why they have been most influential.

Genetic predisposition to exercise, sport and physical activity

The classical Greek philosopher Plato (429–347 BCE) suggested that 'we are bound to our bodies, like an oyster to its shell'. In many ways, Plato identified that we each have a specific genetic predisposition for involvement in physical activity. We are born with a specific genetic makeup, which we cannot change. However, the debate about the 'nature' or 'nurture' of athletes has been going on for decades and has been the subject of considerable research. This debate revolves around whether athletes are 'born' or 'made'.

In 1987 Birrer and Levine identified that success in competitive performance was dependent upon a number of significant mental and physical components. Our body shape, known as **somatotype**, our motor skill development, age, nutritional status and physiology, psychology, training level, genetic endowment and injury risk are some of the major independent variables influencing performance.

Somatotype relates to the different body shapes of the human body.

Somatotype and body shape

Although the first attempts at classifying human bodies have been attributed to Hippocrates (460–377 BCE), a Greek physician who is considered to be the founder of modern medicine, a systematic approach did not emerge until the twentieth century. Of these pioneering research efforts, WH Sheldon, in 1954, described a body-shape classification of the relationships between human physique and personality that remains the best known and most controversial. Sheldon's research resulted in a system of categorising body shapes in terms of **ectomorphy, endomorphy** and **mesomorphy** (i.e. in terms of relative proportions of fatty tissue, muscle and bone). In the mid-1960s

Ectomorphy is a tendency towards slenderness, the body component relating to thinness.

Endomorphy is the body component related to levels of fatty tissue within the body.

Mesomorphy is the body component related to muscularity.

Figure 18.2 The assessment of skin fold is an important factor in calculating the somatotype of an individual.

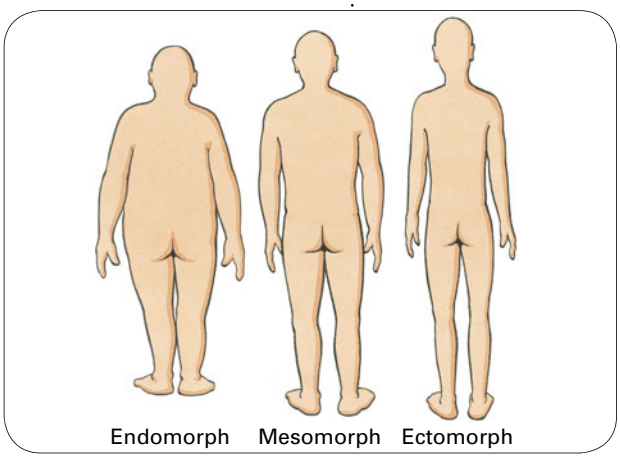


Figure 18.3 The three basic categories of body shape, based on the research of WH Sheldon: the endomorph, the mesomorph and the ectomorph

sports physician JM Tanner extended Sheldon's research in a study of Olympic athletes and attempted to link specific body shapes to specific athletic events. He endeavoured to identify males with suitable physical characteristics to predict athletic potential.

Although mesomorphy, and to a lesser extent ectomorphy, are positively associated with enhanced performance, successful athletes tend to have somatotypes characteristic of individuals already successful in a particular sport. A broad variation of exceptions can occur. Research has widely established that body shape and somatotype can be altered by participation in exercise, sport and physical activity.

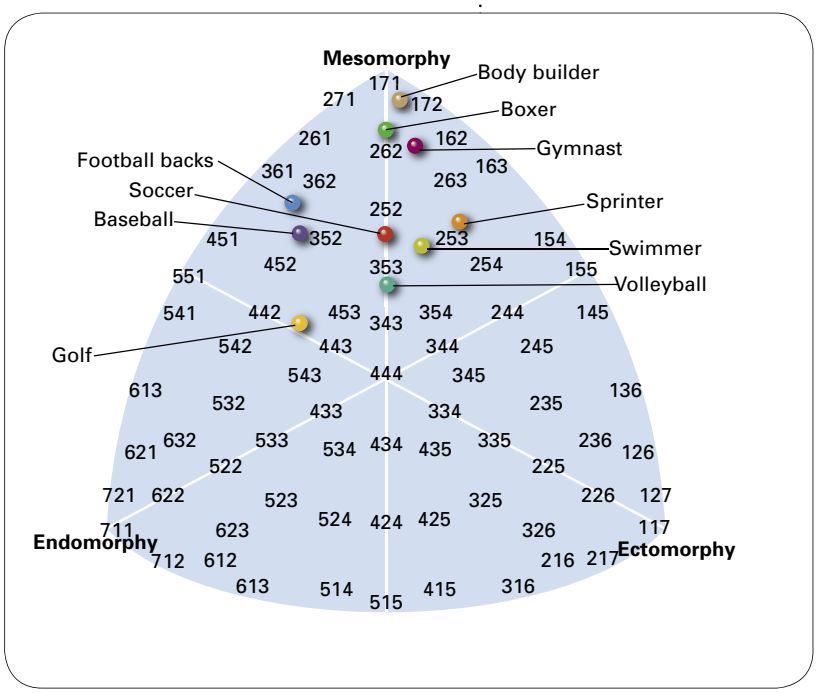


Figure 18.4 Research suggests that athletes are better suited to particular sports because of somatotype. Where might your body type sit on this chart?

Talent identification in sport

The belief that natural talent is a primary determinant of exceptional sporting performance is reinforced regularly by media reports and broadcasts. 'Highly skilled' and 'talented' are used synonymously. However, some researchers now contend that, contrary to this belief, exceptional sporting performance can be attributed to extended amounts of high-quality practice and training, with innate abilities playing a minimal role.

European-based research during the 1970s investigated 'sport talent detection'. During this decade, scientists, particularly in the Eastern bloc

countries such as the then Soviet Union and East Germany searched schools throughout their countries to identify young children who demonstrated skills and aptitudes that were supposedly going to lead to success in sport performance. The scientists attempted to predict performance by measuring a range of abilities, including psychological testing, as well as testing physiological and technical abilities.

These talent-identification programs have continued in current-day sports science and have achieved varying results. Talent identification results in the capacity to 'fast track' athletes who have demonstrated abilities, streamlining their preparation, with an aim to produce optimal returns for an 'investment' in sports.

Figure 18.5
Talent identification involves a number of specific fitness tests.

An individual's growth and development is also a major confounding variable in talent identification during adolescence, according to research conducted by Pearson, Naughton and Torode (2006). They describe numerous hormonal changes during puberty which result in physical (e.g. height and body mass) and physiological (e.g. level of oxygen uptake) characteristics important for sporting performance. Therefore, significant changes during puberty make the prediction of adult performance from adolescent data difficult.

Despite past and future research, the 'nature or nurture' debate will not be resolved quickly. It is clear from the current research that talent is not an 'all or none' phenomenon. It is a dynamic process that is determined by a number of innate and environmental characteristics. We cannot change our genetic composition, but we can change our environment to make our access and participation as effective as possible, to improve our performances in exercise, sport and physical activity. Factors such as carefully planned and effective training practices, support from family, and accredited and informed coaches and teachers, as well as adequate and sufficient physical resources all play significant roles in the achievement of exceptional performance.

Learning experience

RESEARCH TASK

Create a series of tests that might indicate talent in the particular physical activity you are studying. Justify why these tests are valid and reliable indicators of talented performance.

Personal beliefs, values and attitudes

Our personal beliefs, values and attitudes are important determinants in our participation in exercise, sport and physical activity. It is well documented that an individual's core beliefs in any given area of their life will ultimately determine the perspectives from which they view their own life experiences and whether these experiences are positive or negative. Our personal beliefs include our self-esteem, which has been determined to have a very powerful influence on our participation and that of others. In examining more specific beliefs about ourselves, many researchers have focused on **competence** (or ability) **beliefs**, as well as **efficacy beliefs** and expectancy. These beliefs refer to an individual's sense of how good they are at given activities and how well they can organise and carry out different tasks. Our competence and efficacy beliefs relate to our performance achievement, the choice we make in given tasks, the amount of effort we exert to achieve the task and the specific strategies we use to achieve our goals, as well as our overall self-worth.

A **competence belief** is a belief in your own ability or competence in an activity.

An **efficacy belief** is a belief in your own effectiveness when completing a task.

Figure 18.6
Some people prefer to be involved in individual sports, while others enjoy the social interaction in team sports.

Values are culturally prescribed criteria by which humans evaluate people, beliefs, ideas, symbols and artefacts.

Our individual values present another important set of influences on the decisions and choices we make about exercise, sport and physical activity. **Values** are often defined in terms of observations of what is 'socially desirable'. They are considered as guidelines for actions. These personal values become the underlying and often unspoken assumptions on which our own personal and social goals are based. We often assess our own behaviour and that of others in terms of those values. Expressions of these values are frequently observed in our participation in exercise, sport and physical activity. They are also evident in our interactions with others, the way in which we express ourselves and how we give meaning to our own and others' involvement in physical activity.

Values and beliefs are strongly linked. Some researchers have examined individuals' subjective valuing of different activities along with individuals' beliefs about their own competencies and expectations for success. Researchers interested in this relationship argue that, in order to understand achievement behaviour and task choice, the individual's competence beliefs and values are required to be known. For example, despite an individual's belief that they are competent at a particular activity and that they can perform effectively in that activity, they may not engage effectively, because they do not value that specific activity.

Learning experience

ESSAY

Consider your personal beliefs, attitudes and values about exercise, sport and physical activity. Evaluate how these factors might have an impact on your personal participation, both now and in the future. Provide justification and evidence for your response.

Values are also often explicitly (and implicitly) demonstrated in rules and procedures of schools, clubs and organisations, as well as in the development and implementation of policies governing the conduct of sport. Values can therefore be observed, either implicitly or explicitly, in every level of Figueroa's framework to examine access and equity in exercise, sport and physical activity.

Offerings of exercise, sport and physical activity are quickly becoming more diversified. Exercise, sport and physical activity can be undertaken for fitness, personal health and adventure. There is commercial sport and private sport, and an array of sport-like activities. People participate or do not participate because of a broad range of reasons. Changing values in the diversity and motivations for participation, such as competition, discipline, structure and achievement, have linked with new values such as health, pleasure and excitement.

Chapter review

Access and equity at the individual level

Know	**1** Make a summary of Maslow's hierarchy of human needs. **2** List and describe what is meant by the following terms: 'values', 'attitudes' and 'beliefs'.
Comprehend	**3** Explain how Maslow's hierarchy of human needs is applied to exercise, sport and physical activity.
Apply	**4** Show how talent identification is used in your current sport under study. What is its purpose in this sport? How might this process impact on equity and access of individuals to play the sport?
Analyse **Evaluate** **Synthesise**	**5** Consider the values, attitudes and beliefs that you have developed about exercise, sport and physical activity. Evaluate how these were formed through your personal experiences and what influenced and shaped their formation. **6** Consider the somatotypes of different players at the elite level in the current physical activity under study. Evaluate the effectiveness of particular body shapes, and suggest reasons why some body types are more suitable than other somatotypes for this physical activity.

chapter 19

Factors affecting equity at the interpersonal level

Socialisation is a much-debated issue in discussion about sport. In this chapter we examine a number of different socialising agents that shape and influence our participation in exercise, sport and physical activity. We examine how each of these different factors influences the opportunities that we have to participate and how they affect our decisions about involvement and participation in exercise, sport and physical activity.

What is socialisation?

Prominent sociologist Jay Coakley from the University of Colorado defines **socialisation** as:

> *… a process of learning and social development, which occurs as we interact with one another and become acquainted with the world in which we live.*

Socialisation is the ongoing process by which individuals learn and are taught to conform to existing norms and values.

What Coakley is suggesting is that socialisation is a two-way process between ourselves and our world. It shapes our formation as individuals, who we are and what is important to us. Socialisation is an interactive process not a passive one. We are active participants in the process, as we form important relationships with others and help to shape those participants who influence us. Socialisation involves making meaning of what we see and hear by accepting, reviewing and dismissing those messages about who we are and what makes us who we are that we receive about our connection with our world. In brief, socialisation is about the transmission of culture. It is about how individuals learn to conform to **social norms**, and how we behave appropriately in accordance with our culture. We internalise these social norms and become committed to them and adopt 'social rules' of behaviour. The same process occurs as we become socialised into exercise, sport and physical activity. Research suggests that the most powerful forces on our own socialisation as individuals are our families, the schools we attend and the mass media. These institutions are powerful agents that can sometimes act in contradictory ways, which results in confused messages for us to process.

A **social norm** is a form of behaviour that is usually accepted as correct and 'proper' by the majority of members of the society.

This concept of socialisation stresses the abilities and capacities of us, as individuals, to adapt to our environment through a learning process. Values, attitudes and beliefs associated with exercise, sport and physical activity need to be socially acquired. These include body movements such as the physical

attributes required to participate, the skills and techniques and components of fitness such as agility, speed, power and endurance as well as characteristics of play. Each of these aspects shape our participation, and need to be learnt.

When we examine socialisation and sport, we will investigate two related aspects of the socialisation process:

a Socialisation *into* sport examines the factors that influence the ways in which we become involved in sport.
b Socialisation *via* sport investigates how involvement in sport has influenced us and others, including other participants.

Learning experience

ESSAY

Based on your own experiences in exercise, sport and physical activity, identify five 'social norms' that might be considered as acceptable and appropriate behaviours in sport. Suggest reasons for how and why these norms have socialised your conduct as a participant and provide specific evidence to support your point of view.

Agents of socialisation

Significant others in our lives, or **socialising agents**, include our immediate family members, our peers, close friends, teachers, coaches and the media. These 'significant others' teach us to accept and acknowledge our cultural customs, values and norms. Learning occurs through this process when individuals make meaning of these socialising agents and take 'on board' the messages being delivered to them. As we grow older, we are expected to behave 'properly'. When we are involved in selection processes for teams and participate in sport, we are expected to learn the rules of the game and the rules established by the coach. By the time we reach adulthood, we are expected to adhere to the 'rules' and laws of society. We are taught all these rules and laws through agents of socialisation.

A **socialising agent** is a catalyst for compliance with social norms and values.

For example, in a softball match a runner on first base is taught to maintain contact with the base, until the ball has left the pitcher's hand, otherwise the player will be called out by the umpire and the team penalised. Pitchers and fielding players (our peers, as additional agents of socialisation) have been taught to try a number of tactics to try to get the runner to leave the base. The coach, another agent of socialisation, will teach the runner on base to watch the movements of the pitcher and not move until the ball has left the pitcher's hand. When this concept is established as rock-solid, learning has occurred.

Once learning has occurred, and the behaviour becomes routine, it has been added to the script of acceptable behaviour of individuals. In this way, a highly skilled, representative player does not need to be taught this rule, because they have already learnt this in previous exposure to the game. Elite players should not need to be taught the fundamentals of this activity, because the basic rules of the game have already become part of their 'script'.

Figure 19.1
Involvement in sport and playing with peers is an important agent of socialisation.

Agents of socialisation are our sources of information about culture and social expectations. They are the other people, special groups or particular institutions who teach us to learn what we need to know, to enable us to perform effectively and appropriately in any given situation, including on the playing fields or courts, during exercise, sport and physical activity.

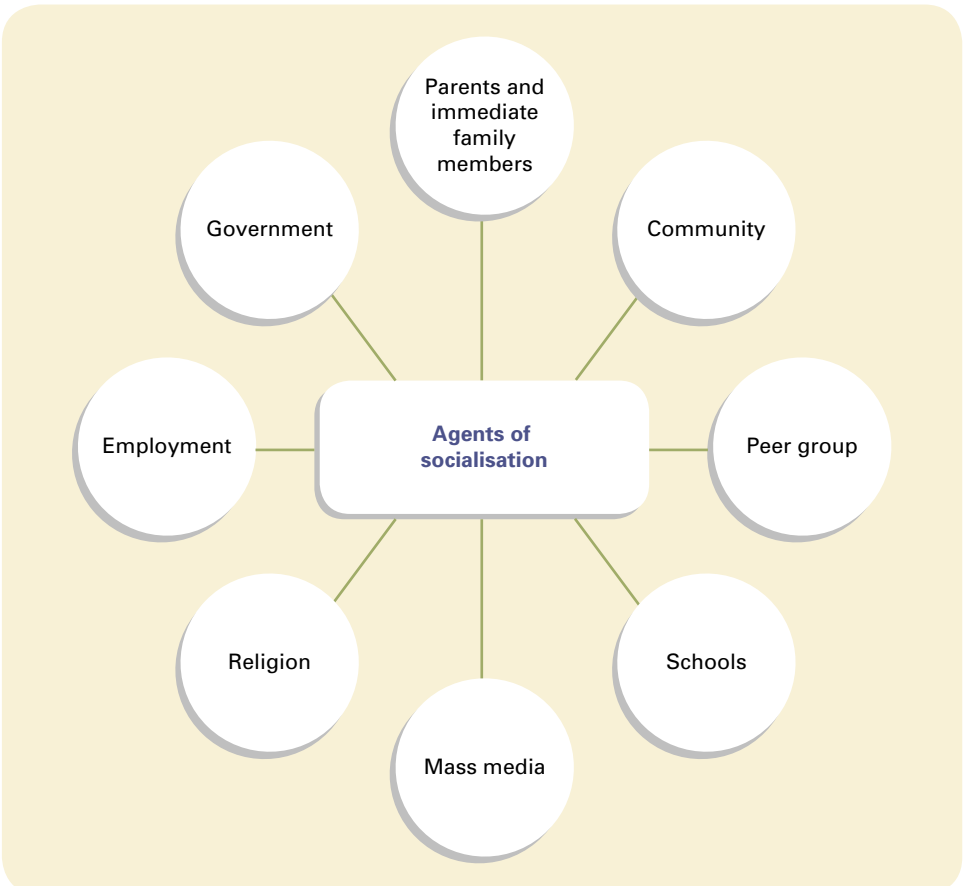


Figure 19.2
Agents of socialisation

Research suggests that the most powerful agents of socialisation for any individual are those people or agencies we hold in the highest regard and trust the most.

Parents and immediate family members

From the moment that we were born, we became completely dependent on our immediate carers. Parents and other close family members shaped our early preparation for life. They guided us to learn the basic requirements to function in the immediate world. As we grew and developed, our relationship with exercise, sport and physical activity was frequently shaped by this most powerful agent of socialisation.

Research has consistently demonstrated that children who are nurtured within a family that is enthusiastic about participation in sport are more likely to develop an interest and a passion for involvement than children within a family that has little connection with sport or physical activity. Current research also suggests that the family is also the primary predictor of sports participation for both boys and girls and that the father is the most significant socialising agent.

Parents who interact with their children, by simply throwing and catching a ball are assisting to develop skills, but are also reinforcing positive messages about sport participation. A child who has an older brother or sister who participates in exercise, sport or physical activity is more likely to participate. However, parents who attempt to force their children to play sport as a substitute for their own sporting involvement and success can often foster negative attitudes and reinforcement patterns. If a child or adolescent associates involvement in exercise, sport or physical activity with being yelled at, criticised or ridiculed for their efforts, participation will quickly lose its appeal and may be avoided, rather than appreciated.

Figure 19.3
Parents are powerful agents of socialisation.

SNAPSHOT

Dropping out of sport

Various studies, including a study at Michigan State University in the United States, found that approximately 75% of all children who played some form of organised sport have stopped playing by the time they reached the age of thirteen years. The main reasons cited by children from these studies included a lack of interest in the sport, the major time commitment required to participate successfully, a negative experience with a bad coach or too much pressure from coaches or families. The Bill of Rights for Young Athletes was written by Dr Vern Seefeldt, Professor Emeritus at the Institute for the Study of Youth Sports, and Dr Rainier Martens in response to growing concerns regarding the abuse of young athletes. This Bill has been used by a number of national organisations in the United States as a guideline for coaches and parents.

It is clear that parental influence is a key factor in young people's socialisation and participation in sport. For a young child's early involvement, the parents initially control the child's access. Because of this control, the values, attitudes and beliefs of the parents will strongly impact on the sporting experiences of the child. If parents are not actively involved, or do not provide these initial sporting experiences for the child, the chances that in future years the child will be encouraged to participate in exercise, sport and physical activity will be limited.

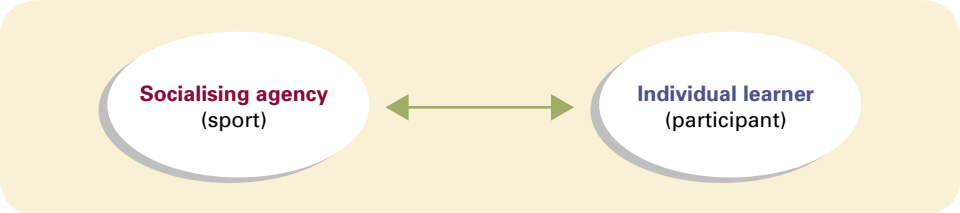
Peer groups

A **peer group** is a set of individuals who share certain common characteristics, such as age, ethnicity or interests.

The **peer group** is another of the 'significant others' and has a powerful socialising force, particularly in terms of involvement in exercise, sport and physical activity. Current research suggests that by the time the child is 10 years old parental influences begin to decline, and the attitudes, values and beliefs of the peer group begin to exert a more important role. Young children also tend to begin to compare themselves with others; for them physical competence and ability is an important comparison tool. Research suggests that children who are more physically competent tend to be more popular with their peers than children who are not. An individual's perceptions of themself can be strongly influenced by others' responses to their own abilities. If children are confident in their own abilities, then they are more likely in the future to become involved in exercise, sport and physical activity.

Figure 19.4
The peer group is another socialising agent.

Social interaction with peers is another important reason for an individual's participation in exercise, sport and physical activity. Through social interaction, an individual gathers information about the exchanges and symbols used to communicate the important aspects of the culture of a group. The individual then filters this information, linked with past experiences and perspectives they bring to the new experience. This social interaction allows individuals to interpret experiences to provide meaning to each situation.



Source: adapted from Stroot, SA, 2002, in A. Laker, (ed), *The Sociology of Sport and Physical Education*, Routledge Farmer, New York

Figure 19.5
The relationship between the socialising agency and the individual learner is a two-way process.

Other sociologists have reported that recognition from peers is strongly influenced by performance in physical activity. Physical competency and achievement in sport is highly valued by young people, and children who are competent have higher levels of self-concept and demonstrate better developed social relationships with other young people, compared with individuals who are less physically competent.

Kicking the habit

Bitten as a boy by the football bug, Christos Tsiolkas was later repulsed by its name calling and bullying. But eventually he came back to the park.

…

As a kid I loved kick-to-kick. Because my parents were immigrants, there were no traditional loyalties to slot into. Richmond was my team because I grew up there and it would have made no sense to support anyone else. All the family ended up supporting Richmond and Dad dutifully took us kids along to Punt Road Oval to watch the matches—even though he understood nothing of the game and missed the precision and skill of soccer. For some strange reason, cricket too proved to be a joy. Every weekend, winter or summer, me and my cousins would get together and play at being Lillee or Marsh or Chappell. The games we played, be they cricket or football, were competitive but hardly 'professional'—I doubt we even knew the rules properly. But I remember dreaming that one day I would run onto the ground in my yellow and black, playing for that premiership cup. It was a good dream. Then high school came along.

'You're useless, you wog!'

After just a few such insults as a 12-year-old, the worst nightmare at school is stripping off for phys ed. Increasingly I came to detest sport, to hate the humiliating pretence of being part of a team when the reality was that your peers were judging you solely on ability. If you didn't cut the mustard, then they wanted nothing to do with you. And not just my peers. My teachers were fanatics who approached their profession not as teachers but as selectors. I can't remember one taking me aside to encourage me. Instead, they echoed the insults from the field. Before long I started wagging and hanging out at the back of the oval, smoking and insulting the footy heads with the rest of the physical drop-outs. I even stopped attending professional games, turning more to books and the pleasures of the cinema. I enjoyed the solitary moments of sport: javelin, shotput, and the high jump. But I knew that the team stuff was all rubbish. Or rubbish if you had a useless wog body like mine. And it wasn't just the boys who were made to suffer. I had a friend whose parents were Chinese and she was always one of the last to be selected for netball or softball. 'Slopes aren't any good at games.' At 13, I made a crucial decision. On grand final day, I didn't go around to anyone's place to watch the TV but headed into town to watch a film ... What followed was a deliberate abandonment of any involvement in sport, a refusal to take seriously the cult of athleticism. I took on another pose, that of the bookworm and cynical anti-Australian. I sneered at the machismo of sport ...

I came back to footy when I realised that the poses I had taken on were just as riddled with contradiction and hierarchy as was the locker-room banter of the jocks—if not more so…

And then one year, heartbroken, I moved from Melbourne to Perth. I was living down the road from Subiaco Oval and I found that much more than books, much more than film, going to the footy gave me joy. I went to see Richmond play West Coast and, though we lost, I walked back up the hill singing the old song. I remembered every word. I was hooked again.

I met a woman whose grandfather played for Richmond and she told me

>>

how in the past they used to tape the team fixtures on the windows of the shops on Bridge Road. That time has gone. But in giving ourselves over to nostalgia, in decrying corporatisation, we shouldn't forget that the past was also the place where Aboriginal footballers had to put up with being called 'nigger' or 'boong', and where it would have been impossible for someone like Ian Roberts to come out and still play Rugby League. I'm inspired by a friend who is an old Fitzroy supporter. He supports the local game, plays for Cooma, and tells me that their anthem is sung to the tune of the *Internationale*. I'm back in Melbourne again now. I've got my Richmond membership but I think it's worth becoming a member of Box Hill, too…

Source: Christos Tsiolkas, *Bulletin with Newsweek*, vol. 117, no. 6205

Learning experience

CULTURAL BACKGROUND AND SPORTS PARTICIPATION

1. Read the article by author Christos Tsiolkas in which he reflects on his cultural background and involvement in sport and physical activity.
2. Develop a concept map of all the influences on Tsiolkas' participation in physical activity and sport.
3. Describe some of the significant barriers to participation that may confront people in your school or community who are from different cultural and linguistic backgrounds.

Schools

When we started at school (or day care) we began to interact with another array of socialising agents, particularly adult authority figures—teachers and assistants, carers, principals and others. These agents began to teach us rules and procedures about our activities within these institutions. Teachers, especially, played a particular role, with daily interactions to establish relationships with us as students, which provided opportunities to exert influence over our behaviour.

The role of institutions has a significant part to play in shaping the socialisation of individuals and peers in exercise, sport and physical activity. This role will be discussed in more detail in the following chapter.

Mass media

Prominent sociologist Jay Coakley argues that large parts of society are immersed in the media coverage of sport and almost no aspect of life is untouched by it. This statement suggests that the media possess a most powerful role in the socialisation of individuals both *in* sport, as a factor that influences the ways in which we become involved in sport, and *via* sport, through how involvement in sport has influenced ourselves and others, including other participants.

A **symbiotic** relationship is an interaction of two agencies that is advantageous or necessary for both to function.

The strong **symbiotic** relationship that exists between the media and sport suggests that they have merged to become one. However, sociologists

argue that sport has been mediated and manipulated by the media. Sport, through the media, carries messages about gender, race, class, nationality and violence—even what is good sport and bad sport. Sport and the media both play a significant role in structuring and informing people's lives. The sustainability and future of sport has become inextricably linked to income generated either directly or indirectly from the media.

Figure 19.6
Sport and the media both play a significant role in structuring and informing people's lives.

The study of sport and the media and its impact on socialisation has so far tended to be dominated by television, rather than print media or the emerging internet. Television has invested very heavily in sport and seeks a greater degree of control over sports products, because of this significant investment. However, the activities of the newspapers and other print media, the traditional method of communicating sports knowledge and understanding to the public, is also included in the discussion.

We need to be aware of the messages and meanings transmitted by the media. Elite athletes enjoy a high profile in the media. Their exploits, both on and off the sporting field, become objects of considerable attention. Their careers, incomes and livelihoods can be enhanced or destroyed by the attention and coverage from the media. This 'personality creation' is only one of the ways in which the media can influence and direct the sporting experience of the viewers of their product. The way the media can structure knowledge, messages and meanings embedded in sport has become a significant area of research interest. The research examines the content of sports coverage and how this reflects, reinforces or creates attitudes, values and beliefs predominant in society.

The media has developed an increasing involvement and control over sport and sporting organisations. They have placed themselves in very powerful positions to determine the structure and characteristics of events, or to change the structure of particular sports by changing the rules or the format of games. Sport's control over itself has been reduced. The media have influenced the rise of new competitions, with older formats becoming marginalised. Sporting uniforms worn by athletes and equipment used to

Figure 19.7
Personality creation is only one of the ways in which the media can influence and direct the sporting experience of the viewers.

play the game have evolved to reflect the media's interests. Sponsor's logos are proudly displayed on the field of play and on players' uniforms, and have assisted media, sport and commerce to link. Major sport stadiums are emblazoned with advertising to add to the television spectacle.

The manner in which sport is promoted and distributed is a strong socialising agent within our society. Which sports are covered and which are not have major influences on an individual's access and opportunities to participate. This information, knowledge and exposure is often determined and controlled by the media.

Learning experience

ESSAY

Evaluate the role of the mass media in your socialisation *into* and *via* exercise, sport and physical activity. How has the mass media influenced your participation? How has the mass media influenced participation by your peers and others?

The social construction of gender and its impact on access to sport

The terms 'male' and 'female' refer to the biological sex of an individual. Sex differences refer to physiology, anatomy, genetic makeup, hormones and so forth. Whether a person is male or female is determined by genes, but the ways in which males and females are expected to behave are determined very much by cultural values, attitudes and beliefs. The term 'gender' refers to all

non-biological aspects of differences between males and females and might include clothing, interests, attitudes, behaviours and aptitudes.

Society expects males to behave in ways that are quite different from the ways in which females are expected to behave. These societal expectations are not based on any specific criterion, but have arisen from stereotyping the gender roles. For example, the stereotyped man is often thought to be rugged, unemotional and aggressive, whereas the stereotyped woman is thought to be emotional but passive.

As discussed previously, powerful agents of socialisation in our society include parents and family, peer groups, religious authorities, schools and the mass media. Parents and families are two of the most powerful influences on socialisation. Parents usually treat girls and boys differently from the time they are born. They talk to boys and girls differently and have different expectations of them. Males are often encouraged to be active, aggressive and to be able to 'fight like a man', whereas females are encouraged to be nurturing, passive, patient and understanding. Boys tend to receive toy guns, trucks, footballs or cricket bats as presents; girls tend to receive dolls, tea sets and books.

Learning experience

THE SOCIAL CONSTRUCTION OF YOUR GENDER

Evaluate how your own gender and the roles that you play have been constructed. What factors have influenced the construction of your gender?

By the time children reach school age, gender roles are well established and readily observable. At this stage, the peer group also becomes an increasingly important socialising agent. For adolescent males, sporting ability has a very high status, so strong recognition and admiration are usually achieved through success in sporting contests. However, for girls success in sport is often overlooked, or achievements are downplayed.

The most powerful socialising agent that pervades the whole of society is the mass media. The electronic and print media reinforce societal attitudes, beliefs and values, including those relating to sport.

Figure 19.8
By the time children reach school age, gender roles are well established and readily observable.

The construction of hegemonic masculinity

The term 'hegemonic' is a form of the word 'hegemony', which refers to the leadership or dominance of one group over other groups. Sociologists therefore use the term 'hegemonic masculinity' to describe structures and relationships in society that appear to be based on male dominance and female oppression.

There is much evidence of hegemonic masculinity in sport and physical activity in Australia. In current times, despite specific programs and initiatives to foster equal opportunities for women, sport and physical activity remain shaped by early history in which sport and physical activity were

viewed as mainly a male domain. Sociologists contend that sport and physical activity continue to play key roles in the development of masculinity and male dominance within Australian society.

Sport and physical activity have long been regarded as a masculine domain and are some of the main sites for the social construction of masculinity in contemporary Australian society. This 'creation' of masculinity endorses the development of a sense of power, forcefulness and mastery of skill.

Organised team sports, in particular, have often been considered a primary site for the construction of masculinity. It has frequently been argued that sport develops a strong sense of male 'belonging', encouraging males to identify with each other. The playing fields, the change rooms and the social settings after sport (e.g. bars and nightclubs) are all locations where this masculine identification is reinforced. Some sociologists have argued that boys' sport, in particular, has become a 'rite of passage' into adulthood.

Figure 19.9
Organised team sports have often been considered a primary site for the construction of masculinity.

In the context of male sport, femininity tends to be defined in a very negative and disparaging way, emphasising a lack of skill and the inability to play games valued by males. These attitudes and perceptions are often expressed in the form of abuse. For example, when they are not performing well, players are likely to be accused by coaches and spectators of 'playing like a girl'.

Other fundamental aspects of hegemonic masculinity are heterosexuality, homophobia and the male construction of females as sexual objects. For example, when they play poorly, players are rebuked for playing like 'fairies', 'sissies' or 'poofters'. The conclusion from these examples is that females are 'naturally' inferior to males and that being female in sport means being a failure. This attitude further increases opportunities for men and boys and disadvantages women and girls.

The masculine ideology of sport: sissies and tomboys

All boys develop in a different way, entering puberty and maturing at individual physiological and psychological rates. Boys who mature earlier than others and display mesomorphic physiques (i.e. a muscular or sturdy build) have a distinct advantage over other boys, particularly in physical contact sports, where success is often determined by physical size, strength and muscular development. The boys who mature earlier often take on a man-like appearance because their physiques resemble those of adult males. Such boys are often held in high esteem and are successful at sport, and develop positive self-esteem and a strong body image. Psychologically, boys who develop earlier than their peers have a distinct advantage during adolescence, tending to have higher levels of self-esteem and positive body image.

The same cannot be said for boys who are late developers, small in stature or frail in physique, or boys who are obese. These characteristics can often result in low self-esteem and poor body image. These boys often avoid opportunities to participate in sport and physical activity and are frequently labelled as 'sissies'.

Conversely, girls who excel in physical activity and sport are often called 'tomboys'. Initially, they are often praised, because their actions are valued—i.e. they exhibit skilled performance in sport, demonstrating much-admired 'male' attributes. However, as the athletic girls grow older, the dominant gender identity is altered. Being physically strong and tough is not as important as being physically attractive. The tomboy tag is then often replaced by a 'lesbian' tag, because their actions do not fit into the dominant stereotype of femininity. Calling women who devote themselves to 'manly' sports lesbians is another example of the presence of homophobia in sport.

From an early age, females tend to underestimate and undervalue their capacity and potential for successful participation in sport because of its masculinised structure. These perceptions of their capacity are shared by other members of society, including their male peers. As a result, a girl's skills and abilities in physical activity constantly fall behind those of her male peers. She may select only activities that are traditionally seen as 'female' or, worse, be reluctant to participate in sport or physical activity altogether.

Learning experience

RESEARCH REPORT: GENDER STEREOTYPING AND PERCEPTIONS OF SPORT

Develop a survey to collect data and prepare a report on students' perceptions of sports as being gender-appropriate or gender-inappropriate. Survey students from different year levels and observe any changes in perception between ages. In your analysis of the data, evaluate the possible influences that have shaped students' perceptions. Justify your conclusions using text and journal articles, in-class learning experiences and journal entries.

Gender stereotyping of sports

Many studies have been conducted to gauge whether children perceive certain sports to be 'masculine', 'feminine' or 'gender-neutral'. Early research in the 1960s indicated that acceptable sports for girls and women were individual activities that emphasised aesthetic qualities such as grace, poise and style. More recently, studies have explored perceptions of sports on the basis of whether they are seen as 'gender-appropriate' and 'gender-inappropriate', rather than as specifically 'masculine' or 'feminine'. All of these studies examined the ways in which each sport conformed to stereotypical views of 'appropriate' male and female behaviour.

Findings from the research indicated that certain sports continue to be perceived as gender-specific. For example, children at kindergarten through to students at secondary school continue to see football and wrestling as male-appropriate sports, and aerobics and gymnastics as female-appropriate. Some sports such as basketball, golf, soccer and tennis were perceived as appropriate for both genders.

The research also indicated that many sports continue to be viewed mainly as the domain of males (e.g. football, boxing and wrestling). Children and adolescents in the studies did not perceive 'feminine' sports as being appropriate for boys; so, although we may see girls participating in 'masculine' sports, the opposite does not seem to be true for boys and feminine sports. This does not mean that girls and women are socially accepted when they participate in masculine sports, but it seems they do see the opportunity to participate.

Stereotypes of gender and gender roles are major determinants of opportunities to participate in various sports and physical activities. However, the stereotypes further reinforce access and equity issues related to gender and participation. Certainly, images of women and sport are generally stereotyped with an emphasis on grace, balance and aesthetics, all of which are consistent with traditional images of femininity.

Figure 19.10
Is cricket gender-appropriate or gender-inappropriate?

Chapter review

Factors affecting equity at the interpersonal level

Know	1	Explain how the mass media is an agent of socialisation.
Comprehend	2	Identify at least three specific examples of socialising agents to which you have been exposed in relation to participation in exercise, sport and physical activity.
Apply	3	Why are processes of socialisation important in understanding issues of access and equity in exercise, sport and physical activity?
Analyse Evaluate Synthesise	4	Evaluate the different socialisation experiences of males and females in Physical Education. In your own experiences, what messages are being transmitted to males and females? How might access and equity be influenced?
	5	The Bill of Rights for Young Athletes was written by Martens and Seefeldt in 1979. These rights include: 1 *The right to participate in sport* 2 *The right to participate at a level commensurate with each athlete's maturity and ability* 3 *The right to have qualified adult leadership* 4 *The right to play as a child and not as an adult* 5 *The right of children to share in the leadership and decision making of their sport participation* 6 *The right to safe and healthy environments* 7 *The right to proper preparation in sport* 8 *The right to an equal opportunity to strive for success* 9 *The right to be treated with dignity* 10 *The right to have fun in sport* Consider the Bill of Rights for Young Athletes, which was written more than 30 years ago. Evaluate how each right affirms access and equity at the personal and interpersonal levels of Figueroa's framework.

chapter 20

Factors affecting equity and access at the institutional level

Each society is distinguished by a number of relatively fixed and interrelated social structures that give it its own unique characteristics. Some of these structures might include your family and how it is organised and arranged, how governments are configured and constituted, and how sporting clubs might be managed and shaped. Sociologists have developed the term '**social institutions**' to describe these social structures. Giddens (1989) regards these social institutions as 'the cement of social life'. They provide us with such things as basic living arrangements that we devise together to achieve continuity across generations.

Social institutions refer to social practices that are regularly and continuously repeated and legitimised by social norms.

Figure 20.1
Sporting clubs, as institutions, can draw communities together. They can provide the 'cement of social life'.

The *institutional* level of Figueroa's framework examines laws, patterns or rules within different agencies. This level of the framework also considers processes or arrangements and organisational structures and how these might impact on access and equity to exercise, sport and physical activity. It is concerned with the ways in which organisations, such as schools or clubs, might operate to advantage or disadvantage particular groups with specific needs that are different from 'mainstream' groups. These might include discriminatory rules or regulations, such as dress codes, membership rights, scale of fees charged or scheduling of facilities that may create inequalities

among specific groups or marginalise or exclude some people. The institutional level encourages organisations to think critically about their own rules, policies and procedures that may advantage or disadvantage specific groups that would like to be involved in exercise, sport and physical activity at the institutional level.

Exercise, sport and physical activity are each contained within institutions, that, in turn, are embedded within large-scale social structures. Prominent Canadian sociologist Richard Gruneau suggests that we can only understand the activities and experiences of an individual at the personal level within these institutions, by examining the dynamics of the societal level. This argument, once again, supports the interrelated nature of Figueroa's framework and the influences of each of the different levels on access and equity in exercise, sport and physical activity. We can really only understand our own and others' personal experiences by investigating the influence of the broader levels of the framework. We need to examine how these larger-scale institutions impact on our own and others' experiences or facilitate our current and future involvement in exercise, sport and physical activity.

The impact and role of the family

Participation in organised sport requires considerable money, time commitment and some important organisational skills, in order to optimise involvement. These resources are usually drawn from parents. Because of this, involvement in organised sport, particularly by young people, becomes a 'family affair'.

Sociologists such as Jay Coakley indicate that little research has been carried out to investigate the role of families and young people's involvement in exercise, sport and physical activity. However, he discusses a few studies and a number of **anecdotal** situations in which evidence suggests that involvement of families in young people's sport can draw the family together by developing a more supportive environment, or it can create problems within family relationships.

Anecdotal refers to short narratives of particular incidents or occurrences.

SNAPSHOT

Parents and sport: the ugly parent

From anecdotal evidence derived through the Australian media, a number of sports have been affected by inappropriate parental conduct that has included abuse and harassment of officials, referees and players. This abuse and harassment has been verbal and, at times, physical, sometimes leading to fights between parents. It has encouraged aggressive behaviour among young athletes. A number of sporting associations as well as various levels of government have intervened, to reduce the levels of disrespectful and sometimes violent actions of parents who are spectators at junior sport fixtures. Initiatives have included awarding bonus points for positive behaviours on the sideline during a game, the capacity to send spectators away from the field of play if negative comments persist, or suspending unruly spectators from venues for a period of time during the competition season. The Australian Sports Commission website contains further details of policies and suggestions to prevent inappropriate spectator behaviour.

Problems that may arise include parents becoming so emotionally involved in the family members' involvement in sport that they can apply considerable pressure on their children to perform, or they may fail to see that their consuming interest and involvement are counterproductive and may pressure young people to continue their participation without enjoyment. This may place young people at the centre of a dilemma. If they withdraw from sport and quit, they may feel that their parents will stop supporting them and not pay attention to them or they may be criticised by their parents, if they do not perform to their parents' expectations. Alternatively, if they perform well and excel, they may not be allowed to participate in other more 'normal' activities of their peers. Other research on parental expectations indicates that young people who believed their parents placed great importance on their success showed higher levels of both confidence and cognitive anxiety than young people who believed their parents placed less importance on doing well.

Learning experience

ESSAY

Evaluate the role your parents and your immediate family have had on your participation in exercise, sport and physical activity. Have the influences been positive or negative? Give evidence of specific examples to support your viewpoint.

Division of labour refers to how roles and tasks might be allocated to individuals or groups.

Parents tend to be involved in exercise, sport and physical activity in different ways. Anecdotally, Coakley reports that the **division of labour** between parents seems to be gender-related. In other words, fathers and mothers performed different roles in supporting their children in their involvement and participation in exercise, sport and physical activity. Mothers tended to be drivers to and from training and practices, provide meals at appropriate times, schedule the activities of other siblings and wash uniforms. They also serve on committees and provide emotional support for children when they do not perform well, play badly or when criticism is targeted towards them from coaches and fathers. Fathers, on the other hand, tend to be involved in fundraising, coaching, ground and facility preparation, officiating and organisational administration.

Parenting style and participation in exercise, sport and physical activity

Research by Jane Summers, a marketing expert, indicated that the style of parenting experienced by young people often influenced the ways in which teenagers selected and participated in exercise, sport and physical activity. More permissive parents, characterised by parents who seek to remove as many parental restraints as possible without endangering their child, were most likely to have young people who engaged in regular sports participation and were more likely to be supportive of their children's involvement in sport.

By contrast, apathetic parents were least likely to have teenagers engaged in active sport. This group of parents provided little encouragement to their children in this area. This and their view of their children as being capable of meeting their own needs, combined with their own low interest in sport, would have resulted in a household distinctly uninterested in sport. This group of parents was also the least likely to even watch sport on television.

Rigid and controlling parents are known to display the greatest emotional detachment of all parental styles, and their lack of interest and support of children in relation to participation in exercise, sport and physical activity reflects this. These parents tended to force maturity on their children, and the decision to play or not play sport would therefore be left to the child, with little or no influence or intervention from these parents.

Authoritative parents in this study, while not likely to play sport themselves, were somewhat supportive of their children participating in sport. Authoritarian parents were also noted as having some success in influencing their teens to be sport '**consumers**' and to participate in sport. Given that participation in sport is often seen as a form of self-discipline and that many sports have definite and unquestionable rules and regulations, this outcome is not surprising.

A **consumer** is someone who uses a commodity or service.

The importance of family girls' participation

Research has indicated that girls whose parents exercise regularly are much more likely to continue their involvement in sport than those whose parents are inactive. This is particularly the case for those girls whose mothers are involved in exercise. However, although many girls receive encouragement to play sport from their parents, some are treated quite differently from their brothers. Examples of this include fathers instructing sons but not assisting daughters in their endeavours in sport. Parents may also take their sons' sport more seriously, by being more interested in their results of their sons' achievements and performances. Some parents also make great efforts to watch their sons compete, but do not show the same desire to watch their daughters play. Other anecdotal evidence from the research includes parents making fun of a daughter's skill level or sporting prowess in comparison with her brother's. Needless to say these actions, whether explicit or subtle, can be very discouraging.

Figure 20.2
Research indicates that parents have an important role to play in encouraging interest and participation in exercise, sport and physical activity.

The impact of schools

Schools can play a powerful role in the socialisation of individuals into exercise, sport and physical activity. In primary schools, participation is encouraged through the curriculum, but major roles in the socialisation process into sport are taken on by parents, neighbourhoods, peer groups and involvement in voluntary, community-based sport. In secondary schools, exercise, sport and physical activity, while still supported within the curriculum, has formed an important part of some young people's culture and is highly valued by many students, parents, past students and teachers.

Observation of many secondary school campuses indicates the extent to which sport and physical activity has become part of the values systems of

schools. This includes the size and extent of athletic and sporting facilities, the wearing of blazers and jackets by successful athletes to recognise their achievements, the number of pages and photographs devoted to sport and physical activity in school yearbooks, the prominent placement of sports trophies and memorabilia within the school, the social importance placed on sports activities and the number of days devoted to sport in some schools.

Coakley's research suggests that playing in a school sports team places students in a position where they can align themselves with various social groups, or **cliques**, within the school. These choices made by participants are most likely to influence how other students and teachers identify them and the place they have within the culture of the school. In some situations, these choices may allow some students to undertake their academic studies more conscientiously; in other situations, sport participants may focus more on social activities with other teammates than on academic pursuits.

A **clique** is a group of exclusive individuals.

A number of studies have indicated that interschool sport may provide a **context** in which participants are rewarded and receive accolades for their skills, talents and performances outside the classroom. Many rewarding learning experiences and life skills can be practised. Sport participation can have a meaningful contribution to educational development, if sporting programs are structured to value its participants. However, if sporting programs are structured in such a way to suggest to young people that adults are controlling their activities and performances for their own purposes, then negative and inappropriate outcomes can occur.

A **context** is the circumstance or facts that surrounds a particular situation.

Figure 20.3
Research suggests that playing in a school sports team places students in a position where they can align themselves with various social groups.

Positive developments concerned with participation in exercise, sport and physical activity are more likely to occur if students are active participants within their schools and are presented with a range of opportunities and choices to enable them to develop and display competence and skill in settings where they are noticed and rewarded.

Exercise, sport and physical activity in schools can also provide opportunities to allow young people to meet adults who may become mentors and advocates in their lives. These mentors may enable the development of important decision-making skills and expand young people's awareness of the larger world in which they operate.

Research has also indicated that exercise, sport and physical activity is more likely to achieve valuable educational outcomes if students, teachers and coaches take these activities seriously as learning experiences. Prominent researchers, Thomas Martinek and Donald Hellison in particular, have conducted significant studies that link positive outcomes with providing students with responsibility, by including them in activities that will assist them in their development of skills, by rewarding them for their competence and, finally, making connections with adults who can exert positive influences on young people's lives.

However, research also indicates that individual students, their peers and teachers bring many different perspectives to exercise, sport and physical activity programs within schools. Some participants bring favourable perspectives; others have less favourable expectations of the outcomes of their participation. A large number of studies have investigated students' attitudes, values and beliefs about exercise, sport and physical activity within the school setting. This research indicates that exercise, sport and physical activity serve to promote the importance of fun and participation, and provide

an opportunity for release from classroom routine and structure, allowing students' opportunities to work and socialise with their friends and an opportunity to learn new skills and engage in new activities.

Learning experience

RESEARCH TASK

Survey a number of participants within your school about their attitudes towards exercise, sport and physical activity. Choose a range of different year groups to survey. What favourable perspectives do students have? What unfavourable perspectives do your peers bring to exercise, sport and physical activity. How do attitudes to exercise, sport and physical activity change as students grow older? Develop a report to indicate your findings.

Research by educators Terry Carlson and Peter Hastie suggests that teachers can also play an important role in the development of students' attitudes towards exercise, sport and physical activity, as they often determine and control programs within schools. By considering students' preferences during planning processes and allowing students to have some input into typically teacher-driven experiences, students are more likely to participate effectively and appropriately.

The impact of sporting clubs

Sporting clubs are part of social practices and have highly characteristic social structures. These institutions are required to interact with their environment and respond to the social and cultural relationships that exist within and beyond their organisation. Sports clubs, just like other organisations, are required to continue and change.

The 'drop out' rate from sport during adolescence is reported by many studies throughout the world. For many individuals, one of the major barriers to accessing participation in exercise, sport and physical activity beyond the organised sport provided by schools has been the admission to sporting clubs. Many sporting clubs have been interested in only a few talented young people, or those who were identified as a result of high performance in school or junior competitions and who were able to gain entry. Now many governing bodies make a much greater attempt to set up more 'youth friendly' clubs. In fact, some young people have suggested that they found sports clubs 'intimidating' and 'unwelcoming' places. Few clubs actively recruited junior members. Most junior members were introduced by parents who were already members, or by coaches who were already affiliated with specific clubs, and with whom young people had engaged as part of school sporting programs.

As voluntary associations, clubs are under pressure as a result of a number of social forces and changes. Committees members, who are generally volunteers, and club managers encounter a range of dilemmas, tensions and problems that arise not only from individual member's perceptions of the relevant offerings of the club, but also from the committee's own actions. The choice between

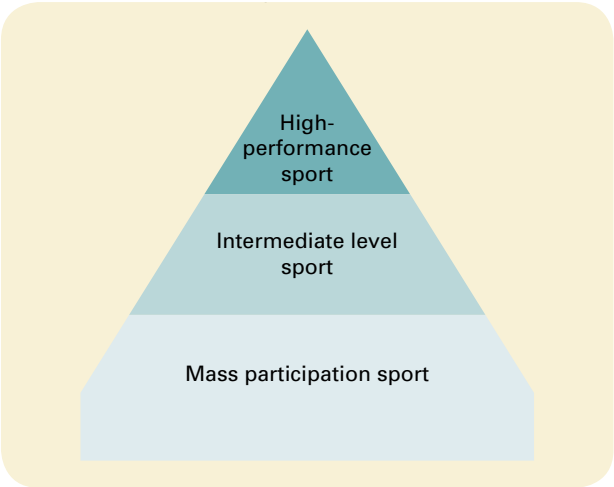


Figure 20.4
The pyramid model of sport participation

performance-oriented and recreational exercise, sport and physical activity is a difficult question for many clubs to resolve. The majority of clubs employ a 'pyramid' model that requires a club to have a broad base, with a large number of members, particularly junior members, in order to ensure a smaller optimum number of performers in the top team, at elite level.

However, current social trends are threatening this structure. These include demographic changes as a result of fewer young people remaining in provincial centres, sociocultural developments such as different interests by patrons who demand wider and more diverse choices, and educational changes that make demands on young people's time, as well as a re-orientation of market forces related to the image of sports.

The question of what makes a club or association viable is reflected in the understanding of the term '**vitalisation**'. Vitalisation is the process whereby sports clubs and managers consciously deal with social changes and changes in the ways in which sport is perceived by its members. In other words, to what extent do committees and managers consider the social setting of the club? How are finances, membership, club officials, relevant achievements, culture, identity and communication with members identified and analysed? How might these be reflected in the core values of the club?

Vitalisation is the process by which sports clubs and managers consciously deal with social changes and changes in the ways that sport is perceived by its members.

Researchers have identified a gradual transition in the orientation of core values of sporting clubs, with competitiveness and ideals derived from the work ethic, such as discipline, regulation and devotion to duty, being replaced by values linked to leisure time, improved quality of life and self-realisation.

The voluntary nature of many sports clubs is a dominant organisational feature. Members join on a voluntary basis and undertake (or may not undertake) tasks on behalf of the membership of the club. Voluntary sports clubs can be considered to be **mutual support organisations** that exist 'of, by and for' the membership of the club. These organisations are strongly values-based and share a number of common interests that assist to bind people together. Voluntary involvement is the common central value and provides guidelines for action.

A **mutual support organisation** is one formed 'of, by and for' the membership of a club.

Learning experience

RESEARCH TASK

Review the rules, regulations and policies of a sporting club of which you are a member. Indicate how these rules, regulations and policies might impact on equity and access of participation. Justify your response by including evidence of your research.

Other challenges and tensions that clubs must face are the increasing popularity of involvement in youth sport, as well as the constant socially significant ways in which the operational environment of clubs is changing.

Sociologist Jay Coakley has identified five significant changes that are occurring within the current sporting landscape.

The first is the emerging trend in which many organised programs are becoming increasingly privatised, with users paying costs associated with participation. Many aspects of organised sport for young people are now sponsored by private and commercial organisations, with reduced support and funding from public, tax-supported bodies. When local government agencies, which fund many community-based programs, face budget reduction and funding losses because of state and federal government policy changes and funding cuts, they are often forced to reduce or drop some social service programs. As a consequence, privately funded sporting clubs and organisations have been established by middle- and upper-middle class parents for their children's benefit. These newly established institutions require fundraising and membership, as well as sponsorship, in order to provide services to their participants. As a consequence, these institutions are too expensive and often inconveniently located to enable access for would-be participants from low-income families and suburbs. These commercial programs are usually selective and exclusive, and provide few opportunities for these potential members.

The second significant change is the increasing emphasis on the 'performance ethic', whereby participants are encouraged to improve performance skills, to further enhance competition levels of achievement. In these institutions performance becomes a measured outcome and an indicator of quality sporting experience. Categories of programs are often delineated by different skill levels such as bronze, silver or gold, to indicate a participant's status in the program. It has been observed by Coakley that the emphasis on the performance ethic is more widespread in commercial and privately funded programs than in public programs.

The third significant change noted by Jay Coakley is the increase in the number of private, elite sport training facilities that are dedicated to producing highly competent and trained participants to prepare them for higher levels of competition. Commercial programs in tennis, golf, gymnastics and swimming have emerged in recent years. Research by sociologists such as David Kirk has suggested that parents may be paying in excess of $1000 per year for their child's participation in these programs. Participation fees such as these make sport less accessible and add to the elitist profile that many sports have attained.

The fourth trend has been the increased involvement of parents concerned about the progress, participation and success of their children in organised sports. A young person's success in sport is important to many parents, who may measure their own 'moral worth' as parents by their child's achievements in sport. This may lead many parents to take young people's sport very seriously.

The fifth and final trend observed by Jay Coakley is the increased participation in alternative sports and action sports. Many young people have taken up these alternative, less-structured options to organised sport, which allow them to participate more freely in physical activities and on their own terms. Many young people find these activities far more engaging than their experiences in competitive sporting programs.

Figure 20.5
A current trend is the increased participation in alternative sports and action sports.

These dilemmas and challenges are faced by sporting clubs across this country. How they respond, as institutions, greatly affects the access and equality of opportunity in exercise, sport and physical activity for young people.

The impact of religions

Exercise, sport and physical activity involve complex issues related to religion, race and ethnicity. Sociologist Harry Edwards suggests that these issues are increasingly relevant as global migration of individuals and families, as well as political changes, bring together people from different racial, ethnic and religious backgrounds and create new challenges for people living, working and playing together. He regards these challenges as among the most important we will face in the 21st century.

Throughout history, sports have primarily been used as a means to meet socially with others, to display skills and physical prowess, and to entertain. Many early cultures such as the Ancient Greeks and the Aztec Indians incorporated religious and political elements into their games, but there was always a desire for recreational play that eventually inspired the organisation of early games and the invention of new ones. The ancient Olympic Games centred on the magnificent temple of Zeus at Olympia. When these games began in 776 BCE, the Greeks offered sacrifices and took oaths in honour of Zeus to emphasise the religious significance of the games. This religious phenomenon was used by Pierre de Coubertin in his writings of the modern Olympic movement. The important source of this movement was the search for a 'humanistic' or 'civil' religion. Thus the sentiments, themes, conceptions and actions encompassed in Olympism and the Olympic Games have religious connotations.

Today, there are a number of interesting parallels between sports and religion, including the 'worship' of athletes as gods and heroes (e.g. Olympic sprint champion Usain Bolt and AFL Brownlow Medallist Gary Ablett Jr), the 'idolisation' of former athletes in sport halls of fame, the daily 'reading' of the sport pages by the 'devout' fan, the collection of 'symbols of faith' such as trophies, uniforms, game balls and sport-related memorabilia, and the charisma that is attached to the elites and leaders in the sporting setting. Sport and religion have often been used to create strong collective emotions and celebrate selected group values through rituals and public events.

In the Muslim and Hindu communities, religion strongly controls the extent to which women can participate in sports. This is apparent in international sporting events, such as the Olympic Games, in which Hindu and Islamic countries seldom have women athletes or women's representative teams because the women are not permitted to expose any parts of their bodies in public. Research by Kahan into the study of sports among these groups, presented findings that Muslims, Hindus, Sikhs and Buddhists, and particularly females, did not participate in sports to a great extent and the main reason is deeply rooted in their religious obligations.

> *It may not be that simply professing allegiance to a religion is important. It is reasonable to speculate that Muslim females who are strongly affected by their belief might well avoid sports as normally practised … because they demand what for them, would be immodest.*
>
> Source: Ruphine Obare, 2000

Hence physical activities among Muslims and Hindus are nearly always sex segregated; men are not allowed to look at women in certain settings and women must cover their bodies in certain ways even as they exercise. Norms such as these are very strong among the essential principles in each religion.

Kahan's research also suggests that in some cultures certain activities are problematic and cause stress and anxiety for students, as participation can contravene family, religious or social rules. This is particularly so for Muslim children who are often cast as 'problems' in exercise, sport and physical activity settings within schools. For example, during the holy festival of Ramadan, the Islamic month of fasting, most Muslim families insist children go without food or water from sunrise to sunset. During this time, activities such as swimming are problematic because water must not enter the mouth. Additionally, strenuous activities can cause fatigue and dehydration. The dilemma these children experience is that they are often seen as 'not trying'.

Figure 20.6
The creation of women's football teams in Iran and Kuwait were banned after being dubbed as 'un-Islamic' by religious clerics and government officials.

Where race and gender intersect, there is the potential for conflict for female Muslim students. Muslim girls have particular restrictions placed upon them regarding presentation of their bodies as well as how they spend their time. They are expected to cover their bodies and limbs at all times and must not be in the company of males in informal settings. The Muslim community sees these restrictions as positive action to protect values and culture. However, when exercise, sport or physical activity experiences in the school setting require these girls to expose their bodies in any way, there can be real feelings of guilt and shame, especially in the company of males or in open fields where they can be seen by the public.

The impact of politics

Exercise, sport and physical activity have long been connected to **politics** through governments and other decision-making processes. However, any analysis of the impact of politics on access and equity in exercise, sport and physical activity would be incomplete if we restricted our investigation to the local, state and federal governments of Australia. Politics is present in any organisation or club that makes decisions or has disagreements about the distribution of resources such as funding, knowledge and the use of authority. Power and decision making exists within 'non-political' as well as sports governing bodies within this country. Each of these institutions can have significant impact on access and equity in exercise, sport and physical activity.

Politics is the processes and procedures of making decisions that affect people, from small groups to societies and even multiple societies that are unified for certain purposes.

Jay Coakley defines politics as:

> *… processes and procedures of making decisions that affect people, from small groups to societies and even multiple societies that are unified for certain purposes.*

Examining Coakley's definition reveals that politics is about making decisions (and therefore exercising power) that influence and impact on

people's participation in sporting contexts. Politics comprises all processes by which people are governed, and the administration of policy, principles and guidelines at every level of organisation, in both public and private settings. Politics, therefore, has become a fundamental part of sport at local, state, national and international levels.

Learning experience

How are decisions made in the clubs of which you are a member? What information do the decision makers gather before making their decisions? Are all members' views considered? How do these decisions impact on access and equity by members?

Figure 20.7
Institutions affect participation at local, state, national and international levels.

The role of these sports institutions at local, state, national and international levels is to provide opportunities for people to participate in exercise, sport and physical activity. Their additional roles include managing this participation through the formulation and administration of rules, policies and procedures. These governing bodies also control and regulate competitions, as well as publicising and promoting them. They also acknowledge the achievements of the competitors. Jay Coakley suggests that these appear to be basic and clear-cut roles for the governing bodies to oversee; however, they are rarely achieved without considerable debate, comment, negotiation and compromise. The decisions these bodies make clearly impact on the opportunities of individuals to participate in exercise, sport and physical activity.

Members of these institutions frequently agree on many issues, but often conflicts arise when the following questions are considered:

- What qualifies as exercise, sport or physical activity?
- What are the rules of the exercise, sport or physical activity?
- Who makes and enforces the rules of the exercise, sport or physical activity?
- Who organises and controls exercise, sports events and physical activities?
- Where do the exercise, sports and physical activities take place?
- Who is eligible to participate in these exercise, sports and physical activities?
- How are rewards distributed to competitors and others associated with the exercise, sport or physical activity?

Each of these questions is inherently political in nature, as the answers clearly affect the opportunities of individuals, groups and communities to participate in exercise, sport and physical activity.

Learning experience

MULTI-MODAL TASK

Examine the information available on the Australian Sports Commission website <www.ausport.gov.au/about> and debate the questions listed above with your class.

Learning experience

ORAL TASK

Present your findings of your 'journey' through exercise, sport and physical activity, from the past, to the present and into the future, using the participation model in figure 20.8:

- Drop in, Drop out, Stay in, Come and go! Which of these catch phrase/s represents you in terms of exercise, sport or physical activity, now and in the future?
- Plot your journey on the grid.
- Justify your current placement.
- What aspects of your understanding of individual interpersonal and institutional factors have influenced your participation?

Figure 20.8 A participation model

Examine the following material sourced from the Australian Sports Commission (ASC) website.

CASE STUDY

The Australian Sports Commission: sport in Australia

Sport is widely recognised as an integral part of Australian life, and the Australian Government provides funding for sport as an investment in the community in terms of national pride, improved health, economic activity and stronger communities. Our national sports system is a partnership between the Australian Government (represented by the ASC), national sporting organisations and their affiliated bodies, state and territory government sports agencies, and other groups.

National sporting organisations rely on us for support and advice that helps them encourage more community participation by making sports safer, more inviting and better managed. This means that all Australians—including coaches, people with disability, Indigenous Australians, juniors, officials, older people, volunteers, and women and girls—have opportunities to be involved.

Our commitment to developing a strong grassroots involvement in sport, as well as providing opportunities for developing elite excellence, means that the ASC:

- manages the internationally acclaimed Australian Institute of Sport, the national centre of sports excellence for the training and development of high performance athletes and teams. The AIS gives athletes access to expert coaching, world-leading sports science and sports medicine services, state-of-the-art sports facilities and opportunities for travel, work and study
- supports the development of the Australian sport system from the grassroots to high performance level through our Sport Performance and Development division, which gives national sporting organisations access to information and resources, including funding, policy development advice and management models, education, emerging information technologies and evaluation frameworks.

ASC funding is carefully structured and applied to develop sport from the grassroots to the high performance level. The dual concepts of participation and elite pathways for athletes, coaches, officials and administrators lies at the heart of a sport's effective planning processes. The ASC directs its funding to ensure these pathways are in place and are effective in delivering increased participation and continued international sporting success.

The National Elite Sports Council (NESC) is comprised of the directors of Australia's key state, territory and national sports institutes and academies. Through the NESC, the eight state and territory sports institutes and academies and the Australian Institute of Sport form a national network of principal providers of high performance sport programs and services.

Both the ASC and the NESC play significant roles in supporting and delivering high-performance programs on behalf of national and state sporting organisations in Australia.

What is the ASC?

Who we are

The Australian Sports Commission (ASC) is a statutory authority of the Australian Government. The roles and responsibilities of the ASC are laid out in the *Australian Sports Commission Act 1989*. The ASC is governed by a board of commissioners appointed by the Australian Government. The board determines the ASC's overall direction, decides on actual allocation of resources and policy for delegated decisions, and is accountable to the Minister for Sport and to Parliament.

Since its establishment in 1989, the ASC has earned a national and international reputation for its innovative, quality programs and for the delivery of these programs. The internationally renowned Australian Institute of Sport (AIS), a key component of the Commission, is a leading centre of excellence for the training and development of high performance athletes and coaches.

The ASC is comprised of six divisions:

- the Australian Institute of Sport
- Sport Performance and Development
- Corporate Services
- Commercial and Facilities
- Community Sport
- Finance

The ASC is administered from Canberra at the AIS Bruce campus. Other AIS operations are located in Adelaide, Brisbane, Gold Coast, Melbourne, Perth, Sydney, as well as Spain, Italy and the United Kingdom. The ASC also has close to 60 Active After-school Communities program offices across Australia.

What we do

The ASC is Australia's primary national sports administration and advisory agency, and the cornerstone of a wide-ranging sports system. On behalf of the Australian Government, the ASC plays a central leadership role in the development and operation of the Australian sports system, administering and funding innovative sport programs and providing leadership, coordination and support for the sports sector.

The ASC is recognised as a world leader in the development of high performance sport and sports participation. Services are provided in a range of fields including:

- high performance coaching
- sport sciences
- sports information
- sports management
- facility management
- education and resources
- participation development
- delivery of funding programs to national sporting organisations.

Our mission

'To enrich the lives of all Australians through sport'.

Our vision

To continue to be recognised as the world leader in developing high performance and community sport.

Our values

In its relationship with its stakeholders, the ASC will:

- be responsive to their needs
- consult and endeavour to reach common understandings
- be open and transparent
- listen and communicate openly
- accept full responsibility for its decisions and actions.

Consider the impact that this peak body has on access and equity to sports participation within Australia. How might participation be influenced by this institution?

Learning experience

- What qualifies as exercise, sport or physical activity?
- What are the rules of the exercise, sport or physical activity?
- Who makes and enforces the rules of the exercise, sport or physical activity?
- Who organises and controls exercise, sports events and physical activities?
- Where do the exercise, sports and physical activities take place?
- Who is eligible to participate in these exercise, sports and physical activities?
- How are rewards distributed to competitors and others associated with the exercise, sport or physical activity?

Chapter review

Factors affecting equity and access at the institutional level

Know	1	Define and give examples of social institutions within Australia.
Comprehend	2	Explain how family and school experiences might impact on your own participation in exercise, sport and physical activity.
Apply	3	Survey a group of your peers to compare the impact of institutions on their own access and equality of opportunity in exercise, sport and physical activity.
Analyse **Evaluate** **Synthesise**	4	Recommend positive changes that could be made to further promote access and equity within the institution of which you are a member.
	5	Critique the role of an institution of which you are a member and investigate how your membership has influenced your participation in exercise, sport and physical activity.

Factors affecting equity and access at the structural level

Chapter 21

The *structural* level of Figueroa's framework examines inequities within society on a larger scale. It examines how the status of organisations and institutions within exercise, sport and physical activity might impact on the types and levels of participation by various groups within society. At this level, the framework examines the way in which resources, rewards and status are distributed to various sectors, and how the allocation of resources might impact on access and equality of opportunities to participate. It examines power and relationships and the various ways these affect members within society. The structural level encourages us, as active members of society, to think critically about the distribution of **power**, resources and status, which may advantage or disadvantage specific groups that would like to be involved in exercise, sport and physical activity at the structural level.

Power is the control or influence over others.

Government influence on the distribution of sporting resources and rewards

Sociologist Jay Coakley's research indicates that involvement of government in sport is generally related to support and sponsorship, organisation and administration, as well as the provision of facilities. He suggests that government involvement generally occurs to:

- protect and maintain public order within society
- sustain the health and fitness of its people
- promote the prestige and power of different groups, communities or the nation
- promote a sense of identity, belonging and unity among its people
- reproduce values consistent with the dominant ideology
- increase the support for the government, its structure and its leaders
- promote economic development.

Governments set rules and policies and determine funding priorities. These decisions reflect the political struggle about the distribution or rewards and resources within the communities involved in exercise, sport and physical activity. However, this does not mean that all groups of people benefit when government becomes involved. Government involvement rarely results in equal benefits for everyone. For example, when funds are allocated

directly to sporting bodies for the development and training of elite athletes, reduced funds are available to foster general participation programs.

Involvement by the federal government within sport, recreation and other forms of culture in the early 1970s was a turning point in the development of sport in Australia. The government became increasingly active in leisure planning for the population, in trying to improve the health of Australians and in supporting popular culture. Sport and leisure became an issue of equity of access and opportunity. Government policies promoted and aimed to increase mass participation in sport.

After its election in 1972, the Whitlam government commissioned two significant reports on sport and recreation which made recommendations about mass and elite sports participation, and the need for a centre of excellence to develop and foster Australia's elite sporting performers.

In 1975, a Liberal–National coalition government was elected with a mandate to cut government spending in many areas, including sport. During the 4 years between 1975 and 1979, funding to sport was cut by more than 20%. This period coincided with the decline in Australia's overall performance at the 1976 Montreal Olympic Games, where our team won five medals, none of which was gold.

Meanwhile, public perceptions and expectations about the success of Australia's elite sporting teams and individual athletes had been changing. Australians began to question why athletes were no longer winning. What was wrong with the Australian sporting system in which clubs provided the foundation for competition and success? Although teams and clubs were underfunded and often managed by volunteer staff and untrained coaches, Australia had been successful in the past. What was happening now? Where were our national heroes and heroines?

Australia's performance at the Montreal Olympic Games prompted a parliamentary investigation into amateur sport and the government's role in its development. During this period, in 1976, the Confederation of Australian Sport was formed. This comprised an independent group of sports bodies able to express opinions on federal government policies and decisions about sport. The organisation developed a 'Master Plan for Australian Sport', which paved the way for the establishment of the Australian Institute of Sport (AIS) in 1980. The AIS was charged with the responsibility of developing Australia's elite athletes. In 1984 the Australian Sports Commission was created to provide a more coordinated approach to sports development throughout Australia. Today, the Australian Sports Commission continues to lead the management and development of Australian sport by promoting participation in sport, increasing the membership of sporting organisations, and supporting elite athletes to perform in the international arena of sport with distinction.

Learning experience

Review Jay Coakley's rationale for government involvement and support for exercise, sport and physical activity. Can you list practical examples from your own research and observation to support his argument? How successful have government programs been to increase access and enhance equality of opportunity to exercise, sport and physical activity?

At the federal level, sports policy has had two major objectives: increased participation in sport and sports activities by Australians, and excellence in sports performance by Australians.

To achieve these objectives, the programs of the Australian Sports Commission have included greater 'grass roots' participation by young people, women, Indigenous Australians and people with a disability. The Commission also developed programs to increase sports participation in rural and isolated areas, improve management standards of sports administration at a national level, and sustain high performance in sport by Australian teams and individuals.

Figure 21.1
The Australian Sports Commission was created to provide a more coordinated approach to sports development throughout Australia.

The Australian Sports Commission has provided financial support for more than 100 different sports throughout Australia. This support has been in the form of finance for athletic scholarships to the Australian Institute of Sport, funding for additional high-performance programs and capital grants for sports development.

Funding was designed to balance the requirements of elite sports and broad-based sports, but its implementation has been controversial. High-profile sports such as swimming, rowing, hockey and athletics tended to receive more funding than lower profile sports such as cycling, gymnastics and netball. Some people have also been concerned that there is too much emphasis on the Olympic sports at the expense of the more popular sports played in Australia, which have large numbers of both spectators and participants. The imbalance of funding of elite sport at the expense of mass participation sport has been justified on the assumption that any sporting success at the elite level encourages the public to become physically active. What is ignored in this assumption is that important factors that impact on participation in physical activity such as gender, age, ethnicity, race and income are still significant determinants of successful involvement by many, while elite sport is favoured and privileged in terms of funding, recognition and participation levels. The debate is indeed, complex.

The sports funding debate: distribution of resources, rewards and status

There is a widespread debate about how government policy on sport should be directed and implemented and how governments should fund sport. Government policy on sport directly controls the distribution of resources and rewards, and provides status to institutions and their sports. Which policy will achieve the best outcome—sport for the elite or sport for all? The debate appears to be focused on three specific issues:

- Should funding be selective or broad-based?
- Should funding be administered centrally or locally?
- Should elite sport or mass participation in exercise, sport and physical activity be supported?

CASE STUDY

The future of sport in Australia

The debate surrounding sports funding gained considerable momentum following the release of a paper outlining recommendations planning for 'The Future of Sport in Australia' by the Independent Sport Panel, chaired by David Crawford. 'The Crawford Report', as it has become known, was released in 2009 by the federal government to provide sport in Australia with a vision to ensure that the Australian sporting system remains prepared for future challenges at both the community and elite levels.

The report identified the need to address our goals and aspirations in exercise, sport and physical activity at both the elite and participatory level, taking account of some significant economic and demographic changes, immigration and resultant new cultures, population shifts—rural to urban—and the changing nature of sport and physical activity.

At the start of the review into 'The Future of Sport in Australia', the Panel investigated the amount of money being spent by all Australian governments on sport, recreation and physical activity, and its impact. It was surprising to discover there is no current reliable information available to answer those threshold questions. The only data found was derived from 2000–01 Australian Bureau of Statistics data. It confirmed that approximately $2 billion was spent on sport at that time across the three tiers of government. Only 10 per cent came from the Australian Government, 40 per cent from state and territory governments, and the remaining 50 per cent from local government. State, territory and local government spending was predominantly directed to facilities and their upkeep. The report argued that Olympic medal counts seemed to be the one area where success was being carefully defined and measured. No parallel objective had been expressed for community sporting participation for which outcomes are not even measured.

There is no doubt that elite sporting success is an important matter for our nation and requires a continuing focus. But the report strongly argued that a balance needed to be achieved between the amount of money invested by all levels of government and the achievement of outcomes, particularly in the context of Olympic and Commonwealth Games performance. The Australian Government funding for sport that is currently disseminated through the Australian Sport Commission (ASC) was distributed overwhelmingly to Olympic sports. In 2007–08, for example, the ASC distributed nearly $90 million in grants to national sporting organisations. About 80 per cent of this went to Olympic sports, and more than 90 per cent of this allocation went to 'high performance' programs.

The report recommended that the funding imbalance between Olympic and non-Olympic sports should be questioned. It also contended that more emphasis should be given to sports that are popular with many Australians. For example, there are 19 Australian teams which hold 'top three' world rankings and more than half of these are in non-Olympic sports. The report argued that the bias towards funding of primarily Olympic sports leads to outcomes that make little strategic sense for Australia. For example, the report cited that more government funds were provided for archery than for cricket, which has more than 100 times the number of participants according to unpublished ASC data. Water polo receives as much funding through high-performance and AIS programs as golf, tennis and lawn bowls combined—even though these sports can rightly claim to be 'whole of lifetime' sports and significant contributors to the Australian Government's preventative health agenda.

The report also argued that the level of funding needed to be more rigorously assessed. It suggested that the long-term level of funding required over four years to win Olympic and Commonwealth games medals has been very high. Australia's medal ranking in Beijing in 2008 was sixth—a highly creditable result and this country's third best performance in 30 years. This resulted in 14 gold medals and 46 medals in total. The ASC's funding to Olympic sports for their elite programs has run at over $60 million per year and this does not include state and territory funding or Australian Olympic Committee (AOC) contributions. Over four year cycles, it is easy to derive figures in the order of $15 million per gold medal or $4 million per medal. Higher figures are routinely raised in the national media.

The obvious response is that we underestimate the many intangible benefits of success at international level. But the same is true of many other sports. Australians are very interested in what happens in cricket, golf and surfing—not excluding the various football codes. On what basis are these sports not equal claimants on the public purse?

Importantly, the report found little evidence that high-profile sporting events like the Olympics (or Wimbledon or the Australian Football League Grand Final) have a material influence on sports participation. The report stated that if future funding of sports are to

be channelled to encourage wide participation, some priority should be given to those sports played throughout the country and even more so to those that engage their participants through their lifetimes.

The report prompted considerable debate and public comment from all levels of the community. In the section below are three different viewpoints about sports funding in Australia.

SNAPSHOT

Australian sport: the pathway to success

The Australian Government published its response to the Crawford Report in May 2010. The report included a commitment to boost funding to both community and elite sport, and also, for the first time, to deliver significant investment to the development pathway that connects grassroots participation and high-performance sport. The government response focused on three main areas to enhance the future of sport in Australia. These included increasing the number of Australians participating in sport, strengthening sporting pathways and new strategies for striving for success at the elite level. A total funding allocation of $325 million over four years was to be provided as ongoing baseline funding for sport through the Australian Sports Commission (ASC).

Learning experience

RESEARCH REPORT

Investigate the level of funding distributed to the physical activity you are currently studying. Evaluate the expenditure of this funding throughout the different levels of the sport. How might this expenditure influence access and equity in this sport? Where is the expenditure directed—to high-performance programs or grassroots participation? Develop a report to communicate the findings of your research.

Funding Olympic sport is no game

An open letter written by John Coates for the *Sunday Telegraph*

As a raw rowing manager many years ago, I dreamed that one day Australia would again host the Olympic Games. In Sydney in 2000, I felt privileged to be part of a celebration that engulfed the entire nation and earned Australia, and Australians, accolades throughout the world.

Indeed, the 2000 Games delivered much more than the 58 medals won by the home team.

Up there with the feats of Cathy Freeman and Ian Thorpe was the outpouring of national pride. To see Australians standing on trains singing the national anthem made me so proud I thought I would burst.

Australians are usually reserved, but during the Olympics they found their voice.

When Sydney won the bid in 1993, then Prime Minister Paul Keating said: 'This is an opportunity for Australia and Australians to show we can hack it in the big time.'

Mr Keating felt the Olympics were an opportunity to tell the world we could achieve anything in business or sport—that we were a 'can do' nation.

He was right. When we hosted the Games, Australians sang from the rooftops and the world listened.

Almost a decade on from 2000, the lure of the Olympics has taken on even greater importance for those desperate to win the right to host the Games.

In a world gripped by terrorism, war and poverty, US President Barack Obama and his wife Michelle attended the International Olympic Committee (IOC) meeting in Copenhagen last

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month to try to win the 2016 Olympics for Chicago.

Mr Obama wanted the Games for two reasons. Chicago is his home town but, more importantly, he saw a chance to repair fractured relations with countries around the globe and to promote world peace.

He said he wanted to restore America's image as a friendly nation and Olympic sport was key to achieving that aim.

Mr Obama told delegates: 'Peaceful competition between nations is all that is good about humanity.

'Over the past few years, the fundamental truth of the United States has been lost … [and] the Olympic Games could restore it.'

I believe Prime Minister Kevin Rudd understands the necessity of maintaining Australia's standing in elite sport, as his friend Mr Obama certainly does.

I am sure Mr Rudd is also well aware of the power of engaging through sport internationally. He has said Australia's global standing lies in the fact that we are an enormously competitive nation on the international field of sporting endeavour. It is part of who we are as a country.

In a speech at the Hall of Fame Sport Awards in 2008, Mr Rudd said: 'When you reflect on the history of sport in this country and you reflect on how it has been ingrained into the nation's soul, you cannot separate the two.

'Our sporting heroes are part of the soul of the Australian nation. And you know that from the soul of the nation comes the spirit of the nation. Let me say, the inspiration of our sportsmen and women becomes even more important.'

The Crawford panel is putting all this in jeopardy. According to David Crawford, 'The bias towards funding Olympic sports leads to outcomes that make little strategic sense for Australia.'

The US President and the First Lady were not alone in Copenhagen. The President of Brazil was there, as were King Juan Carlos of Spain and the Japanese Prime Minister. All had their eye on the prize.

Mr Rudd was in China last year with 70 other world leaders to watch the Beijing Olympics. He sat in the stands with George W Bush. He saw first-hand how sport enables countries to forge closer ties.

China is our largest trading nation and the friendships established at the Beijing Olympics only strengthened those ties.

The Australian Olympic team was by far the most popular team in the Olympic village. The athletes did an outstanding job 'selling' their country to the world.

They deserve recognition for their work, on and off the sporting arena.

Austrade leveraged the Olympic brand during the Beijing Olympics to clinch more deals in China. It's asking if it can do the same for Vancouver and London.

We are delighted to assist the federal Government, but it's a two-way street.

You can't say, 'Sorry, guys, you don't deserve any extra funding but, by the way, we want to hang off your coat tails again and knock over a few more trade contracts and business deals in Vancouver and London, and beyond.' That's a bit rich.

Australian athletes have been rubbing shoulders with the world's best for some time.

Little Australia, with just 20 million people, finished fourth in the medal tally at the Sydney Games.

It was up there with the superpowers again at the Athens Olympics in 2004 and in Beijing in 2008.

Their achievements give other Australians the confidence to go out and try their hand on the world stage.

Australians love to win but, in his report, David Crawford suggests that we should accept second-best and aim for eighth or 10th on the medal tally.

This is like telling Kevin Rudd to forget about being a member of the G20 summit, aim to be 21st or 31st and lose his seat at the top table. Become an also-ran.

In the 1930s, Australians had little to cheer about following the Great Depression.

We fell in love with a racehorse called Phar Lap.

In the 1940s, we idolised a little bloke in a baggy green cap called Don Bradman.

They are still part of the national ethos.

Yet Mr Crawford offers this gem: 'There should be debate about which sports carry the national ethos.

'Swimming, tennis, cricket, cycling, the football codes, netball, golf, hockey, basketball, surfing and surf lifesaving are among the most popular sports in Australia and a part of the national psyche.'

Is he seriously suggesting that the gold medals won in Beijing last year by Matthew Mitcham in diving, Steve Hooker in pole vault, Emma Snowsill in triathlon and Ken Wallace in canoeing meant nothing to the Australian people?

Such athletes give Australians something to cheer about in yet another gloomy economic climate.

Even more insulting is Mr Crawford's failure to recognise the greats of the past.

When you talk of national ethos, names like Marjorie Jackson, Betty Cuthbert, Marlene Mathews, Shirley Strickland and Herb Elliott spring to mind.

I've read the knockers who say we place too much emphasis on sport and spend too much achieving gold medals, but I believe those golds are worth every cent. I think the vast majority of Australians agree with me.

A survey carried out by Sweeney Sports in August, 2008, found: "Almost half of all Australians support extra government funding of Olympic sports if it results in more gold medals being won".

'Six out of every 10 people consider that good performances at the Olympic Games are good for Australia's sense of optimism.'

A report by Woolcott Research in September, 2008, argued that 'although the current economic crisis makes

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provision of extra funds for sport a difficult choice for governments, it could be an important step to boosting national morale'.

UN secretary-general Ban Ki Moon was also in Copenhagen for the IOC meeting. He said: 'Sport builds bridges throughout the world'.

'I travel to countries mired in poverty, to communities struggling to survive, to war-ravaged places where all hope seems lost.

'Suddenly, a ball appears made out of plastic bags or newspapers and we see sport give life to hopes and dreams.'

Kevin Rudd, let's keep the dream alive.

Source: John Coates, President, Australian Olympic Committee, 22 November 2009, <corporate.olympics.com.au/news.cfm?ArticleID=10485>, accessed 5 January 2010

Learning experience

MULTI-MODAL TASK (DEBATE)

Topic: That the funding of Olympic sports should be increased

Examine the text of the articles and letters published in this section of the chapter and debate the issue in class. Use personal examples from your research to affirm or negate the topic.

Give sport a chance I

Why we mustn't underestimate the power of physical activity to teach and inspire

There has been no shortage of people talking about the 'Independent Sport Report' and its impact on major sports. What seems to have been missed by many is a notion that all sports would support encouraging more children to play sport. Any sport.

Whether children are swimming, playing tennis, golf, netball, hockey, cricket or any of the football codes, it doesn't matter. The main thing is that these sports are united in providing opportunities for young children to develop a life-long love of physical activity.

That's not only our responsibility as organisers of sport but also as a community.

More children playing sport is a great objective and if there are more kids playing sport, there are more kids striving to be the best they can in their chosen pursuit.

If we are providing more opportunities for kids to play sport—any sport—we will end up with a community that is physically and mentally healthier. So the recommendation in the report to provide more funding for community sporting facilities, which can be used for non-sporting community activities as well, is a good thing.

So is the section looking at the role of sport in school and what can be done to build physical activity and sport into the curriculum to encourage kids to be active. That recommendation certainly has our backing. Not just from a sports point of view but also from the point of view that sport can—and does—provide opportunities for young people, along with lessons in life that go way beyond classroom learning.

The support for community volunteers expressed in the report is another which has been overlooked in the desire to focus on dollars. The respect that the report shows for community volunteers and the important role they play should be applauded.

The report recommends that volunteers be given greater support. All of us who have played sport will remember the people who had such an influence on our love of the game—the volunteer coaches, officials, trainers and the mum and dad taxi drivers who gave up their time so we could take part.

It's often the passion and the energy of volunteers that ensure sport plays an important community role beyond the pool or oval. It brings people together, not just to strive to win—but to share.

For an example of the impact of a community sporting club, look no further than the Kinglake Football and Netball Club which rose out of the ashes this year.

Football helped to pay for an administrator for the club after local Kinglake residents came together and voted that despite the devastation to the town, it was important that the football club play on.

That wasn't necessarily about winning a premiership, although Kinglake almost pulled off a fairytale end to the season when, in front of Prime Minister Kevin Rudd, they played off in a grand final.

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But it was about uniting the community. Bringing people together to celebrate the game, to laugh, cry, talk, support each other and to share their grief and their desire to live through it.

People from across the community were able to join together—not just the netballers and footballers but also the supporters, family and friends.

It was in Kinglake that locals like club vice-president Daniel Heal—who's still living in a horse float after losing his house—worked tirelessly around the club while also raising more than $100 000 for the community. He has been nominated for the Victorian Sport Volunteer of the Year award. Meanwhile, his club committee has done so much more than run a sports club.

As administrator Rick Wall said this week, many people gave money to the club to get it back on its feet, but the club donated more than $150 000 back to local emergency services, schools, community dining and other groups to help deal with the trauma of Black Saturday.

With the help of the Australian Institute of Sport's Jason McCartney, the Kinglake club also helped to encourage men to seek counselling to deal with the impact of the fires.

It also instigated a scholarship scheme to help local youth find apprenticeships or other work while the footballers and netballers found themselves playing a leadership role in the community. In some ways that reflects the emphasis that Australians place on sport.

That is the power of sport—the power to strive to be the best of the best, the power to inspire but also the power to know that sport in itself is not the be-all and end-all. It is what it can do for the community, whether at a national or local level, that is important.

This week there has been a lot of talk about heroes but we should never forget the unsung heroes at all levels of the community who need and deserve our support.

Source: Andrew Demetriou, Chief Executive of the Australian Football League, *The Age*, 22 November 2009

Give sport a chance II

Sport is all about the magic. It shouldn't be conscripted for national service.

Out on the waves at the back beach, the kid was having trouble. He was 13 or 14, in a new wetsuit, trying to stand up for the first time. The waves were too big and he couldn't move through them, or they crashed too early and he couldn't get out. And then the right one came along, and he got it right. He went up and down it like a seismograph, he kept it going and he came out of the surging foam standing. The ride was a thing of itself, a moment. A few people applauded. He didn't catch another wave that day.

That is sport at its best—wild, random, the meeting of chance and skill, drawing out the best of us in the service of play. But it's not an aspect of the activity you find much of in the recently released Crawford report on the 'Australian sports system'. Though most of the criticisms have focused on its suggestion that Olympic over-achievement is fools' gold, that is not where the report's real problems lie.

Rather, it is that their alternative—a greater focus on participation for community-building and preventive health—is another side of the same tossed coin. It is sport as a means to an end, rather than as a celebration and expression of human meaning and possibility. The report is explicit about this, saying it will not reflect on what sport is for. The Crawford report has dodged the ultimate tackle—a deeper consideration of what sport is in a changing culture.

There are many who will welcome the report's urge to move away from Olympic obsessiveness: as the report points out, sports like archery, canoeing and taekwondo get up to 100 times the funding of other more popular sports, purely on the grounds that we have a medal shot. They will be equally pleased at the new focus on community participation, drawing marginalised and unrepresented groups in, and using sport to tackle the nation's obesity and other health problems. However, the question is whether, in turning away from the five-ring circus, the report has too little place for the pursuit of excellence as an end in itself. Indeed, is the community participation model merely another version of the Olympic mania—using sport as an adjunct to national goals, and priorities set by the state, this time in a more Ruddite manner?

Sport has always had a dynamic relationship with the two forces—the state and, more recently, the market—that seek to co-opt it. The games of ancient Greece and pre-Columbian South America arose from tribal contests and the spiritual celebration of hunting and combat—and then became expressions of aristocratic rule in city states. The modern Olympics with its spectacular opening ceremony and ultra-elitism is famously a Nazi creation of 1936, and though that can be subverted, the spirit of Albert Speer tends to return.

Beijing 2008 was an essentially fascist celebration of the human body. Less visibly, sport is transformed by the market, for better and worse, from the 1897 creation of the VFL out of an ever-changing set of leagues and rules, to its current role as a feeder of pay-TV content. What is gained in the bargain is specialisation, intensity and the chance of seeing something really extraordinary.

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One of the paradoxes of elite AIS-style sport is the way in which the body of the athlete disappears in a welter of muscular, metabolic and behavioural data. Occasionally, the absurdity of this pokes through, as with the recent swimsuit fiasco, in which the competition became one between fabric designers; or the use of stents to rehydrate AFL players a few years back.

So the Crawford report's aim to restore a focus to community-based sport and active participation is to be welcomed. But it doesn't tackle the deep problem of how sport is changed in a high-tech, ultra-controlled, mediatised society. In particular, it does not take sufficient account of the way in which excellence and exceptionality—or the possibility of it—has to be a part of all sport. The report's over-easy division between 'elite' and 'community' sports is, at its worst, another version of the Rudd Government's social democratic elitism.

This is something that people recognise in the way they play and talk about sport—in the difference between a 'social' game and a real one, in the organisation of leagues and rules, the way in which new sports emerge.

Every game in a suburban amateur league lives off the possibility that this one might be where it all comes right, where something exceptional is created. There are policy and funding measures that are better or worse for that, but what needs to be emphasised is the cultural importance of pursuing excellence over and above mere participation. Sport is a particular and important instance of that, where mind meets body, nature meets culture, the ape rises to the angel.

To lose that while at the same time breaking free of the Olympic obsession would be the ultimate dumper.

Source: Guy Rundle, *The Age*, 22 November 2009

'The future of sport in Australia' report also made recommendations to the federal government to address other issues of equity and access to exercise, sport and physical activity. A large section of the report was devoted to a discussion 'ensuring Australia's sports system was open to all'. The nine areas identified in the report were:

- *women*: by supporting and encouraging leadership roles and sport, and implementing more effective ways to recognise their presence in exercise, sport and physical activity
- *the ageing population*: by supporting more relevant sport and recreation opportunities and ensuring that appropriate infrastructure is provided
- *young people*: by understanding their diversity of interest and options, as well as encouraging engagement in new forms of exercise, sports and physical activity
- *Indigenous communities*: to ensure that resources reach and foster 'grassroots' participation and ensure that sustainable programs are provided
- *the time-poor*: to provide innovation and new ways of providing less structured activities
- *the disadvantaged*: by confronting access and affordability issues
- *people with disabilities*: to assist in the facilitation of additional access and inclusion in exercise, sport and physical activities
- *migrant communities*: to encourage inclusion and provide appropriate access
- *homophobia and sexuality discrimination*: in sport to examine new opportunities for inclusion.

As suggested in previous levels of Figueroa's framework, politics is present in any organisation or club that makes decisions or has disagreements about the distribution of resources, such as funding, knowledge and the use of authority. There is much disagreement and opinion about the distribution of power and resources and the status of different sports. Decisions made at the structural level may advantage or disadvantage specific groups who would like to be involved in exercise, sport and physical activity.

Learning experience

ESSAY

Government intervention and involvement in exercise, sport and physical activity often influences how each of these pastimes are defined and organised in a community or society. If within your community all sports in which you are involved were sponsored by government organisations, what would they emphasise and how would they differ from the ways in which they are working now? How might access and equity be influenced by the government's involvement?

There have always been groups in our community who have not participated in sport. Policy makers and sports administrators need to understand why some people choose to participate in exercise, sport and physical activity, while others are less inclined.

What factors impact on access and equity at this structural level? 'The future of sport in Australia' report suggests that the barriers for many people and the impact of our changing demographics and lifestyles on Australians' engagement with sports and physical activity need to be examined so the system can be opened to all. According to survey data, about 50 per cent of Australians participate 'regularly' in sport and physical activity. The 'missing half' has become a formidable policy challenge. If sport contributes to the nation's health and community cohesion, a key task for sports policy makers and administrators is to address the factors and, in some cases, the barriers that prevent participation.

Media influence on the distribution of sporting resources and rewards

The media in Australia have evolved from print-only newspapers, to film and television, and to the multimedia electronic broadcasting of today (internet coverage, satellite television and high definition, digital transmission). The Australian sports sociologist Brian Stoddart has identified six trends that this evolution has created in the relationship between sport and the media.

Increasingly superficial coverage of sport

The first trend is towards increasingly superficial coverage of sport in the electronic media. Stoddart believes that this superficiality is the result of space restrictions—column inches in the newspaper were replaced by minutes for radio coverage, then seconds for television. Television provides the viewer with highlights of the match, the great catches, or goals, or tries. There is a trend away from words towards pictures. A visual image

requires little verbal explanation, as viewers can see it for themselves. Coakley's research also supports this viewpoint. He refers to this coverage as 'mediasport'. **Mediasport** is the product transmitted to viewers, through selected images and descriptions. Today, a telecast of a major sporting event is a symbolic creation, representing the ideas that certain people have about sport, values, social life and the relationships with the viewing audience. Images used and accounts of passages of play are selected to make 'good television'. The particular highlights shown are selected for the viewing audience. Coakley suggests that this selection is not natural, in that the process occurs after consideration of certain criteria, based on a series of values, including what makes 'good television'.

Mediasport is the product transmitted to viewers, through selected images and descriptions.

Figure 21.2
Mediasport is the product transmitted to viewers, through selected images and descriptions.

Increasing advertising power of sport

The second trend is the increasing advertising power of sport on television. Before the introduction of radio, newspapers advertised sport and provided publicity for sport. Radio provided increased opportunities for advertisers to be linked with sport during coverage of sporting events. When television began to broadcast sport, the degree of advertising through sport increased further. Sports venues and the participants themselves began to become 'saturated billboards', advertising various companies and their products.

The majority of the media companies are privately owned. They are organised to make financial profits from their company's investments. Sports are selected for their coverage on the basis of their appeal to audiences and the revenue-raising potential that these sports are able to generate. Media images and description of sport are presented to provide as much of the event as possible, with consideration to the perceived interests of viewers and sponsors, who pay large sums of money for the access and opportunity to market their products to the television audience. Advertising has become an integral part of the media–sport relationship.

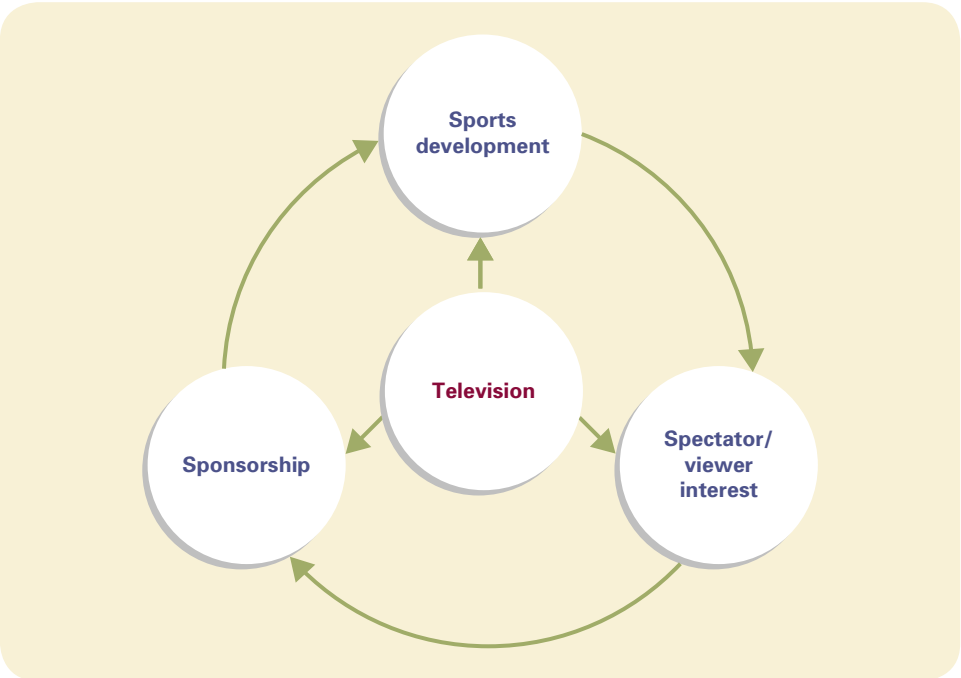

Figure 21.3
The sponsorship cycle, with television at the hub.

Increasing role of the media

The third trend is the increasing role of the media in orchestrating the playing conditions and practices of different sports. Previously, sporting events were generally held on a Saturday afternoon. Now, game times and schedules are increasingly altered to suit television schedules. Sport is frequently played at night, during the week or on Sundays and screened at prime time.

Today more than 15% of all television time is consumed by sport. Television has seen the establishment of exhibition-type matches or special events that allow advertisers to further promote their products by using sport and sporting personalities. 'Skins' tournaments (in which high-profile golfers compete for large purses of prize money on each hole they contest), exhibition tennis matches, Twenty20 cricket, celebrity car races and pro-am tournaments (where amateur players, business executives and celebrities compete with professional players) have been developed specifically for television. The implementation by the FIVB (the international governing body of volleyball) of various rule changes (including a point scored on each rally), as well as uniform changes that were mandated for players, is another specific example of how the nature of a sport has been changed to attract media and sponsorship attention. Prior to the rule changes in scoring, it was often difficult to predict the length of games, given the scoring system. That was something that television organisations disliked, because on-air scheduling required strict adherence to timing that was planned in advance. If the duration of a match is not fixed, or is not highly predictable, then that game is not suited to live broadcast through the media. The FIVB acted to address these concerns held by the media.

For volleyball's guru, sex appeal is key to future

Tokyo—When Ruben Acosta walks into a room, it's easy to tell that looks matter.
At the world championships, which ended Sunday in Tokyo, … athletes had to slip into provocative, new skintight uniforms or risk being fined by the volleyball federation's fashion police—as five women's and seven men's teams were.

The outfits, designed to make the game more attractive to television, sponsors and advertisers, did bring the championships added exposure—but of a sort that many of the players were uncomfortable with. Often, their skimpy uniforms shriveled with the first bit of exertion.

The federation is attempting to bring indoors the sex appeal of the beach version of the game. All surf, sun, and tanned athletic bodies, it has proven to be a ratings grabber.

And volleyball is preparing to undergo a more radical face-lift in an effort to secure its place in an increasingly crowded and competitive sports market.

…

These championships also saw the introduction of a 'libero' player, a defensive specialist who wears a different color shirt and can substitute freely, and a new multicolored ball.

'We must give volleyball a chance to survive,' said Acosta [President of the FIVB], defending the changes to a roomful of hostile media. 'Sports that don't have the favor of television will fade away—that is a fact, that is the reality.

'It was decided volleyball needs more speed and power,' he said. 'Look at the most popular sports, Formula One, soccer, athletics—they all have speed and power every moment.

'Volleyball does not want to be a conservative sport. You have to sell your event and people are not willing to buy something that has no value. The uniform changes, rule changes, new balls are all directed at making the sport a more interesting product to television and sponsors,' he added.

Some of those in the sport are unhappy, particularly with the dress code.

…

Acosta is determined to proceed. He said that by the time the sport returns to Japan next November for the World Cup, which will also act as the qualifying tournament for the 2000 Olympics, everyone will be on the same fashion page.

Source: *New York Times*, 30 November 1998, <http://www.nytimes.com/1998/11/30/sports/30iht-volley.t.html?scp=1&sq=Acosta%20volleyball%201998&st=cse>, accessed 7 January 2010

Creation of sports stars

The fourth trend is for the advertising power of television to lead to the creation of sports stars who earn large salaries and other income from sport. Stoddart contrasted the careers of Peter Thompson, the Australian golfer who

Figure 21.4
International volleyball has implemented rule changes and a new uniform dress code to increase media ratings.

won five British Open Golf Championships during his career, and a more recent day performer, Greg Norman, who has won the British Open once. Only 20 years separated their playing careers, but television made Greg Norman one of the most instantly recognisable sports performers on the international stage. His image has been used to advertise airlines, prestige cars and a huge range of other products. In return for use of his image, advertisers pay him a fee. Fifty years ago, the print media (newspapers, magazines etc.) and the electronic media (radio and early television) did not give Peter Thompson the exposure that modern television gave to Greg Norman. The increased use of sport for advertising, and the increased money paid by advertisers are part of the reason for Norman's continued high profile, despite the fact he is playing much less tournament golf. His business activities have now branched into other areas such as land development and golf course design.

Sports media also have the ability to present images and accounts of play that hype sport by exaggerating the spectacular, sometimes inventing and focusing on rivalries, and developing reasons why events are important. Cultural studies scholar, Garry Crawford (2004) explains the strategy used in this process:

> *The mass media construction of celebrity often lacks depth of character, as figures are frequently painted in one-dimensional terms … Much of the language used to describe sports stars draws on the narrative of melodrama. Heroes rise and fall, villains are defeated and women play out their roles as supporting cast members to men's central dramatic roles.*

Increasing internationalisation of Australian sport

The fifth trend is the increasing internationalisation of Australian sport, and a possible dilution of our national identity. Television and satellite technology have allowed sports played throughout the world to be broadcast instantaneously to Australian audiences. American sport has provided sports programers in Australia with a product that is readily available to be screened around the clock. The culture of American sport has influenced many Australian sports. Marketers and sports administrators in Australia have developed ranges of sporting clothing and other memorabilia for sale to fans and supporters, and introduced rituals such as performances by cheer squads, brass bands and other entertainers as promotional techniques and to provide increased entertainment for spectators.

The major media players also have begun to emphasise elite sports competitions. As an example, since the 1990s newspapers and television have tended to increase their coverage of commercial and professional sport, and decreased coverage of amateur sport, with only a few exceptions. This trend was also focused on a growing emphasis on winning, heroic actions and nationalism, instead of other factors associated with sports participation.

Maintaining the social status quo in sport

The sixth trend is towards maintaining the social status quo within Australian sport. The conservative nature of television and advertising has ensured that traditional male-dominated sports, which were well established before television, have been given the most coverage. New sports receive little coverage, although they have the potential to attract large audiences. Women's sport also receives little coverage.

Learning experience

RESEARCH REPORT

Examine the six trends linking the media and sport and relate these to the physical activity under study. How have these trends impacted on this physical activity? What impacts (if any) have the media had on this physical activity? How might these influences have affected access and equity in this physical activity?

An impact of inequitable distribution of resources and rewards

Every four years, the Australian Sports Commission conducts research on mass-media coverage of sport to monitor how sport is promoted in Australia. This research has indicated that there is considerable inequity in the coverage of men's and women's sport.

The most recent survey analysed media coverage of women's sport in newspapers, magazines, radio and television stations during a 2-week period. The results showed that media coverage of women's sport is treated very differently from men's sport. One example highlighted by the research demonstrated this difference. In a commercial 'current affairs' style sports show, there was a 6-minute segment devoted to guinea pig racing, yet the only story about women's sport screened for 15 seconds.

Television coverage of women's sport for the sample period was just 2% of total sports broadcasting. Radio coverage of women's sport comprised 1.4% of all sports broadcasts, and sports magazines devoted 6.8% to women's sport. Newspaper coverage showed that 10.7% of newspaper sports space was allocated to women's sport, compared with 79.1% to men's sport.

The report also commented on the positioning of articles on women's sport in newspapers. Many were placed at the bottom of pages, or at the inner pages of the sports section. Only 5.6% of women's sporting stories made the back page.

Language usage also differed between sexes. Women were often described in ways that emphasised fragility, compliance and triviality. This language detracted from the athleticism of the individuals featured in the articles. Athletes were frequently described as 'girls', regardless of age. Physical traits were frequently the focus of media reports (e.g. descriptions such as 'perky', 'blonde' and 'powderpuff' were used), as were their perceived emotional states. Phrases such as 'dissolving into tears' were often used, but men who faced stressful or courageous situations during competition were often commended for their 'toughness' in the media reports.

Consistent, ongoing media coverage can promote the profiles of various sports within Australia. The media also have the capacity to promote positive role models to the Australian population and develop increased spectator appeal for various sports. However, the playing field is clearly not level when examining the gender composition of media reports. Despite the national, international and Olympic performances of our female athletes, they still struggle to attract consistent, long-term coverage of their efforts.

Learning experience

RESEARCH REPORT: MEDIA ANALYSIS

Choose a section of the mass media (newspapers, magazines, free-to-air TV, pay TV) and monitor sports coverage over a set time period to determine whether there is evidence of gender bias. For example, if you choose to analyse a newspaper, you could investigate the following aspects of coverage for males and females in sport:

a number of stories
b story length
c content (e.g. factual, personal, occurrence of injuries, match-related information)
d type of language used
e positioning of stories on the page
f placement of stories (e.g. inner pages of sports section, back page)
g relevance of season and time of year to the sports covered.

Present your findings as a research report, commenting on the extent of gender equity in media coverage. Use other media analyses and studies published on the internet or in magazines, journals or texts to support your findings.

Pay TV and free-to-air broadcasts

The rise in prominence of 'mediasport' leads us to question whether this represents sport for everyone, or just sport for some. The extensive involvement of pay-TV companies in the broadcasting of sport, through dedicated channels, have clearly led to an array of options and choice for viewers as to which sports they can consume. However, this has come at a financial cost to viewers, in terms of subscriptions and equipment and installation of satellite dishes or additional set-top boxes.

Government in Australia has begun to address this concern of access and equity, as major sporting events and the broadcasting of these through free-to-air channels have come under threat. It could be argued that pay TV is the emerging media power in Australia, especially for sports broadcasting. Currently, many major sporting events such as the NRL Grand Final, AFL Grand Final, the Melbourne Cup and the Australian Tennis Open are broadcast on the commercial television networks. The federal government has legislated that these events be available on free-to-air channels; however, the situation is volatile and could change quickly should the intense lobbying by sports promoters and pay-TV companies succeed.

During an interview on ABC Radio National's *The Sports Factor*, News Limited Chairman Lachlan Murdoch argued that the rules governing sports broadcasting in Australia favoured the free-to-air networks. He suggested that the networks were limiting sports coverage, to the detriment of the viewers. Free-to-air television companies make bids to broadcast specific sporting events. Once they secure the rights to broadcast, they may choose to screen the events live, delayed or as a highlights package. The commercial television networks can also choose the extent to which they broadcast specific events such as the early rounds of major tennis tournaments, one-day cricket matches or test matches played overseas. These are the issues that concern Lachlan Murdoch, whose company News Limited operates a pay-TV channel.

The federal government composes a list of sporting events that are to be broadcast on free-to-air networks rather than the pay-TV subscription networks such as Foxtel, Optus and Austar. This list serves dual purposes, depending on your point of view. It protects viewers from having to pay to see their favourite sporting events, or it denies viewers of paid subscription services the opportunity to view a comprehensive coverage of the event. However, it is important to note that most people in Australia still watch sport on free-to-air stations and consider this a right, not a privilege.

So far, the growth of pay-TV in Australia has been limited, with only about one-fifth of all households subscribing. However, because the Australian Competition and Consumer Commission agreed to an arrangement between pay-TV operators Foxtel and Optus to share content, subscription television in Australia looks certain to expand into more households. It could be argued that with shared content, programing will be less restricted and offer greater variety, regardless of the pay-TV channel to which households subscribe. People may be more likely to subscribe to pay TV that has a more diverse array of program offerings than free-to-air TV. Another catalyst for expansion is Foxtel's strategy of including the popular Fox Footy as part of the standard package of channels available. Fox Footy, which was introduced at the start of the AFL season in 2004, enables viewers to watch AFL football year round.

Learning experience

Evaluate the programing of exercise, sport and physical activity on pay TV and free-to-air TV. Which sports are screened exclusively on pay TV? Which sports are predominantly screened on free-to-air TV? Prepare a report on the findings of your research.

In both Britain and the United States, News Corporation has revolutionised televised sport through channels such as BSkyB and FoxSports. These channels have exclusive rights to major competitions, such as Premier League Soccer in Britain. Some media analysts predict that with developments such as high-definition digital television entering the Australian market and analog broadcasting being progressively phased out from 2011, the free-to-air broadcasters will no longer be able to generate sufficient advertising revenue, and will see their networks slowly decline as viewers move across to digital subscription television. Digital pay TV offers more interactive viewing, particularly for sports broadcasts. Different viewing angles can be selected by the viewer, and online statistics are instantly available. As more households subscribe to digital pay TV, free-to-air TV will become less attractive to advertisers, who wish their products promoted to the widest possible audience.

Whatever the outcome in the negotiations between pay TV and free-to-air broadcasters, it is clear that the role of televised sport is becoming more important—to fans, to broadcasters and to advertisers. This sector of the mass media exerts significant power over sport and physical activity in Australia. These changes also present issues surrounding access and equity, power and control over broadcasting content within communities.

Other examples of inequitable distribution of resources and rewards

Essentially, the idea of 'social justice' refers to creating a just society (i.e. identifying and eliminating inequities in our society). For reasons such as their gender, age, race, ethnicity, disability, location or socioeconomic circumstances, some people currently do not have equal opportunities to participate in the community or gain access to community resources and activities. These inequities exist in the field of sport and physical education, just as they do in many other areas, such as education, employment, housing, and health and welfare services.

Social justice in sport and physical education—and other areas—involves observing and applying the following principles:

- promoting equity in terms of access and participation
- acknowledging diversity
- creating supportive environments.

Promoting equity—access and participation

It is important that all individuals and groups have opportunities to share the benefits that sport and physical activity offer for general health and wellbeing. To do this, they must have access to, and be able to participate in, these activities. Where inequities exist (i.e. where people do not have equal opportunities for access and participation), we need to identify and meet the needs of those concerned, so that they have opportunities to participate in the physical activities of their choice. This requires a joint effort from individuals, communities, organisations and governments. All those involved in providing services in sport and physical activity need to recognise and respond to the differences among their clientele to ensure that all are treated fairly.

Acknowledging diversity

Acknowledging diversity involves recognising how various factors affect people's values and attitudes, and that each individual's needs for exercise, sport and physical activity are unique, and possibly different from our own needs. To encourage participation and to increase accessibility, we need to take account of these differences when planning and providing programs and facilities for sport and physical activity so that these cater for the particular needs, interests and abilities of individuals and groups in the community.

Creating supportive environments

To create a supportive environment in exercise, sport and physical activity, we need to establish facilities where people can feel safe and comfortable. Surroundings need to be welcoming, and a place where friends can meet and new friends can be made. For example, a local community recreation centre should offer opportunities for everyone in the community to participate.

This could include ensuring that facilities are accessible to people with a disability, and making directions, instructions and brochures about the centre's operations available in different languages.

Learning experience

ESSAY

Evaluate how the principles of diversity, social justice and the creation of supportive environments have been established within your school's exercise, sport and physical activity programs. What impact have these principles had on participation within your school's programs? Propose any changes or modifications to policies, programs and procedures which could improve access and equity. Justify the suggested changes using evidence from your research. Use the different levels of Figueroa's framework to guide your analysis.

Barriers to involvement in sport and physical activity

To apply the principles of equity and social justice successfully, we need to identify the barriers that limit people's opportunities to participate in sport and physical activity.

These barriers include:

- age
- socioeconomic circumstances
- gender
- ethnicity and race
- disability.

Exercise, sport, physical activity and age

Australia has an ageing population. In demographic terms, this means that the proportion of people in older age groups (particularly 50–59 years) is increasing in the population. Research indicates that large increases in the aged population are expected to occur in the coming decades. In addition, studies have indicated that participation rates in exercise, sport and physical activity decline with age. Considering the research predictions on Australia's demographics, a continuation of this trend will mean that in the coming years increasingly larger proportions of Australia's population will not be participating in active sports. If we are to promote social justice in sport and physical activity—and the health and wellbeing of our population—we need to identify and overcome the barriers limiting participation and access by the older members of the community. The most common reasons for this lack of participation are given in the following list.

What prevents many older Australians from playing sport?

1. Limited or inappropriate sporting opportunities, e.g. too competitive, open-age categories, and emphasis on elite competition
2. The belief that sport is no longer appropriate and that once a certain age is reached, people should slow down
3. The perception of family and friends that sport is no longer appropriate
4. A fear of injury, or even worse, exercise-induced death
5. A lack of sporting background or experience (of particular concern to older women)
6. A lack of time due to other commitments, e.g. work, family commitments, child minding for working parents
7. A lack of confidence in their own body to perform physically
8. A lack of role models and limited or patronising media coverage
9. Transportation issues faced by those without their own transport, those dependent on public services, and those who have lost confidence in their driving ability
10. The constraint of cost if people are dependent on government benefits
11. Physical inaccessibility such as steep steps, poor lighting, concerns over personal security and inappropriate surfaces
12. The failure of national sporting organisations to recognise masters sports in their development plans and therefore to make available suitable opportunities for older participants

Source: Australian Sports Commission, 'Actively Ageing'

Exercise, sport, physical activity and socioeconomic circumstances

Recent research by the Australian Bureau of Statistics showed a significant variation in sport and leisure participation rates of employed and unemployed people. People who were employed full time or part time participated in sport at significantly higher rates than people who were not in the workforce.

Other studies by the Australian Bureau of Statistics identified further factors relating to people's socioeconomic background which can affect their participation in exercise, sport and physical activity:

- A tertiary-educated person is twice as likely to be active than a person who left school when the minimum requirement was a Year 8 level of education.
- Higher income earners tend to regard fitness as more important than lower income earners. These higher income earners tend to be employed in white-collar jobs.

The data on employment status, education and income show that one of the barriers to participation could be the level of disposable income available to spend on sport and physical activity. In particular, research has suggested that unemployment and the costs associated with involvement in sport and physical activity are generally incompatible. This expenditure may well be beyond the

Figure 21.5
We need to identify and overcome the barriers limiting participation and access by the older members of the community.

reach of some people on limited incomes. Sport and physical activities become 'luxuries'—they are expensive to be involved in and consequently can be eliminated from the household's weekly budget and spending.

People's socioeconomic circumstances therefore tend to determine their ability to access some sports and physical activities, because of equipment costs, admission fees and club membership fees etc. To promote social justice in sport and physical activity, it is essential to provide low-cost options that allow people to participate in the activities of their choice. Strategies such as government subsidies, rebates, discounts for various socioeconomic groups, low-cost rental charges for equipment and facilities, and reduced insurance costs may help to overcome the barriers some people experience because of their socioeconomic circumstances.

Physical activity and gender

Research indicates that women and girls continue to be under-represented in many aspects of sport and physical activity. Specifically, Australian Bureau of Statistics research shows that participation rates of women and girls are lower than those of men and boys. Women are also under-represented in all areas of leadership, management and decision making in exercise, sport and physical activity, as well as coaching, particularly at the elite level of sport. Also of concern is the high rate at which adolescent girls drop out of exercise, sport and physical activity.

Another factor relating to gender equity in exercise, sport and physical activity is media coverage of female sport. This coverage is often inadequate, superficial or inappropriate. To rectify the gender imbalance in sport and physical activity, we need to remove the constraints on female access and participation. Some that have been identified are:

- inappropriate social stereotyping
- lack of access to appropriate, affordable and acceptable programs, facilities and services
- lack of time, or perceived lack of time
- lack of accessible childcare facilities.

Exercise, sport, physical activity, ethnicity and race

Different ethnic groups often have their own sporting traditions, and certain sports and pastimes that are traditional to their culture or county of origin. With the immigration to Australia of people from a wide range of cultural backgrounds, our sporting landscape has become broader and more varied. For example, games that have been introduced or that have become more popular include soccer, bocce, boules and sepak takraw.

Games traditionally played in Australia, such as cricket, Australian Rules football and rugby, were initially unfamiliar to many immigrants with backgrounds of languages other than English (LOTE). More recently, however, there has been a steady movement of these people into participation in Australian Rules football, rugby and soccer. Studies of the broader community nevertheless indicate that ethnicity is still a significant influence on participation in exercise, sport and physical activity. Figures published by the Australian Bureau of Statistics showed that the rate of participation in sport of people born in Australia was generally higher than that of people born outside Australia. The rate of participation for people with LOTE backgrounds was particularly low. Cultural background and place of birth were also related to attendance at sport as spectators. Australian-born people had higher rates of attendance than people from the main English-speaking countries (e.g. the United Kingdom) and people from countries where languages other than English are spoken. Despite the major contributions of various ethnic groups to Australian sport, migrants, particularly those with LOTE backgrounds, still face substantial barriers in accessing sport and other kinds of physical activity.

Figure 21.6
Programs and environmental support need to continue to be offered to enable Indigenous Australians of all ages in remote and non-remote communities to participate in sport and physical activity.

Barriers to participation include language difficulties, cultural differences and a lack of social networks in which to engage in sport and physical activity. Some might also be reluctant to participate because they feel a sense of powerlessness in a 'new' country, or experience feelings of vulnerability and inferiority as they settle in their new surroundings. Another factor may be gender issues relating to the role and place of women in the culture of their country of origin.

Indigenous Australians also experience barriers to participation. These include a lack of opportunities to participate, lack of facilities that make access practical or possible, geographical remoteness, and racism. It would be easy to compile a list of successful elite Indigenous athletes who have provided Australia with some of its proudest moments at international sporting events, including the Olympic Games. However, the images created by these athletes are not a true representation of the involvement in sport and physical activity by Indigenous Australians. For example, research conducted by the Australian Bureau of Statistics and published in the National Health Survey indicated that 57% of Indigenous Australians living in non-remote areas participated in exercise (including low, moderate and high levels). This was significantly lower than the 70% of all Australians who participated in exercise during the period of the survey.

If we are to apply the principles of social justice successfully, we need to offer programs and environmental support to enable Indigenous Australians of all ages in remote and non-remote communities to participate in sport and physical activity. Strategies could include increased funding for exercise, sport and physical activity for various targeted, isolated regions, communities and organisations; the implementation of affirmative action policies; and improved training and education of Indigenous coaches, athletes and support staff.

Finally, we need to be aware that generalisations about ethnic and racial groups tend to overlook their broad diversity and cultural identities. There are many variables that influence the levels of participation in sport and physical activity, among them socioeconomic and cultural factors that have restricted full participation by ethnic and racial groups. All of these factors need to be taken into account when considering ways of providing more socially just and equitable access to sport and physical activity for people in these groups.

Exercise, sport, physical activity and disability

The conventional term 'disability' covers a range of physical and intellectual impairments. The Australian Bureau of Statistics has defined disability as 'any restriction or lack of ability (resulting from impairment) to perform an activity in the range considered normal for a human being'. During the last two decades, there have been major developments in the provision of access to recreational and leisure services for people with a disability. Early initiatives attempted to provide separate, segregated facilities and services, as it was considered that people with a disability had different needs, interests and capabilities from other people. The emphasis now is on integration and inclusion, and on improving access to facilities designed to cater for all members of the community. However, there is still much room for improvement. Physical access to many recreational facilities, such as gymnasiums, is still a problem for many people with a disability.

The social and emotional dimensions of disability are also of major importance. Inclusive practices in leisure, recreational and sporting activities for people with a disability can make a substantial contribution to enhancing self-concept and self-esteem.

In a recent report related to the immediate and long-term problems faced by people with a disability, the National Committee on Sport and Recreation for the Disabled highlighted key areas that required attention. These included:

- greater government recognition of the needs both of high-performance athletes with a disability and of those wishing to participate in recreational activities
- greater support for sporting programs for people with a disability
- more opportunities for integrating people with a disability into community sports activities
- reduction of barriers that prevent access to sports and recreation programs (not only barriers to physical access but also the real barriers relating to attitudes and perceptions of ability)
- support for the national sport and recreation organisations for people with a disability.

Learning experience

RESEARCH REPORT

Evaluate the feasibility of including students with a particular disability, within your school's Physical Education program, specifically in the physical activity currently under study.

Your report should address the predicted benefits and challenges that will occur as a result of the implementation of your proposal. Each aspect of your research needs to be carefully justified, stating clearly the reasons underpinning your plan. Your research could include:

- background information on a specific disability
- the particular needs of students with this disability
- suggested modifications to the program within the local community to meet the specific needs of these people, e.g. to enable effective and positive involvement in the physical activity under study, which could include
  - teaching style
  - rules and structures
  - environment
  - equipment.

Chapter review

Factors affecting equity and access at the structural level

Know	1	List reasons why governments are involved in sponsoring exercise, sport and physical activity.
Comprehend	2	Identify the level of government sponsorship and support within the sport you are currently studying. Is the sponsorship aimed at the 'grassroots' or the elite level? How has this allocation of funding impacted on access and equity?
Apply	3	View a television sports report on the nightly news. List any examples of gender bias in the reporting of the sport (e.g. language used in narrative, camera shots, active or passive poses, etc.).
Analyse Evaluate Synthesise	4	'Mediasport' as discussed in the chapter is 'reality' put through a filter, so what we actually read or observe is a collage of simulation of what is happening in live action on the playing field. Consider what you think 'rules' are in the context of mediasport. Critique these rules and provide examples from your own consumption of mediasport.
	5	Identify one male-dominated sport that females play (e.g. cricket, football or rugby) and select one female-dominated sport in which males are involved (e.g. netball, softball or gymnastics). Use an internet search engine to locate images of participants of both genders in the selected sports and evaluate the characteristics of the images portrayed.

Factors affecting equity and access at the cultural level

Chapter 22

The *cultural* level of Figueroa's framework is concerned with shared assumptions, beliefs and values about issues such as body image, the social construction of gender and ethics, and how these issues might affect access and equity to exercise, sport and physical activity. This level of the framework requires critical analysis of cultural norms and values, and examines how diversity is recognised and treated. These cultural norms, sometimes unknowingly, restrict or influence our perceptions and actions about involvement in exercise, sport and physical activity. Through a critical review, we will investigate many taken-for-granted beliefs, assumptions, values and attitudes that impact on participation in exercise, sport and physical activity.

Cultural influences on body image

When we refer to the 'ideal' body, we are really only talking about what society *perceives* or *constructs* as 'ideal'. These perceptions change over time, as is evident from an analysis of body types and shapes throughout history. There are clearly dramatic differences in what people regarded as ideal or beautiful in different eras. There are also variations between cultures in what is regarded as ideal in terms of body shape. What is regarded as ideal or beautiful in one time or place is not necessarily viewed in the same way in another time or place. Such differences and changes have always existed, and it's likely that people's perceptions of the ideal or perfect body will continue to evolve and change.

Even in recent times, the image of the perfect body has changed markedly. For instance, during the 1950s, the curvaceous, mature and well-proportioned female body was regarded as beautiful. Marilyn Monroe was seen as the ideal. In contrast, during the late 20th and early 21st centuries, our modern Western culture has placed a high value on the slim, healthy and young image.

Figure 22.1
In the 1950s, a curvaceous, mature and well-proportioned female body was regarded as beautiful.

Changes in the ideal body image throughout history, and differences between cultures, can be seen through a study of the arts (e.g. paintings, sculpture and, in modern times, photographs) of different eras and cultures. The following sections look at some of the idealised body images of different

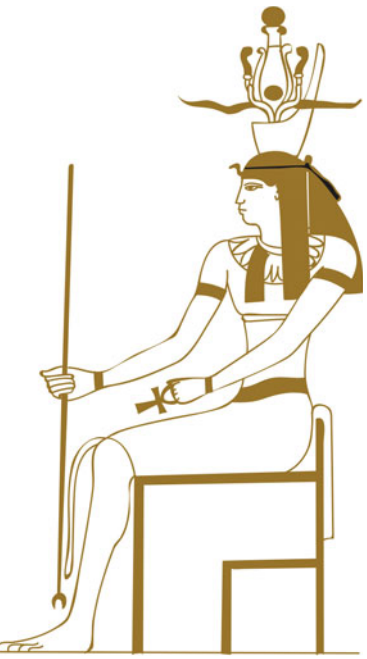

Figure 22.2
An illustration of the Ancient Egyptian Earth god Geb

times and cultures. Compare the range of body types and fashions considered beautiful in Ancient Greece and Rome, in Europe during the Middle Ages and the Renaissance, and in the Western world during the 1800s and earlier decades of the twentieth century.

Ancient Egypt

The Ancient Egyptians revered the human body and considered a thin, angular body to be the ideal. The wealthy adorned themselves with headdresses and jewellery. For both men and women it was important to be thin, neat and well groomed.

Ancient Greece and Rome

In both Ancient Greece and Rome, the admired stereotypes were athletic, well-muscled men and heavy-hipped women. The Greeks believed strongly in the importance of exercise. Male athletes often competed naked to give maximum freedom of movement.

The Middle Ages and the Renaissance

During the Middle Ages in Europe, religious authorities frowned on the flaunting of the body. Frequent wars and famines left little time for consideration of body image. During the 1400s and 1500s in Europe, large, soft-fleshed women were considered beautiful, and celebrated by painters such as Botticelli, Titian and, later, Rubens. Men, interestingly, wore voluminous suits of rich fabrics, often more highly coloured than women's clothing.

Figure 22.3
An athlete depicted on an Ancient Greek artefact

Figure 22.4
During the 1400s and 1500s in Europe, large, soft-fleshed women were considered beautiful.

The 1800s

During the 1800s in Europe and America, women wore corsets that thrust the bust forward and constricted the waist. These were often so tight that the wearers suffered from abdominal and breathing problems. (In Australia, the warm climate made this kind of garment very impractical and uncomfortable.)

Women's dresses were long and voluminous, and included bustles to accentuate the size of the wearer's bottom. Men wore tight suits with upturned 'wing-tipped' collars.

Figure 22.5
An example of a fashionable lady from the late 1800s

The 1930s

In the 1930s, the ideal image of women accentuated their natural shape. During the social revolution of the time against political and social oppression, women broke away from past restrictions. At the beach, Australian women began to wear one-piece swimming costumes that did not cover the arms and legs, and revealed much more of the body than earlier costumes. Although the New South Wales Government legislated against men going swimming bare-chested, the law was later repealed.

The 1940s

In the 1940s, women were considered the 'ideal' shape if they had an hourglass figure, namely a large bust, well-rounded bottom and small waist. Padded shoulders accentuated the hourglass shape. Men returning from World War II adopted more loose-fitting clothes than they had worn before the war. They wore lounge suits, similar to the style worn today.

Figure 22.6
Examples of 1930s swimwear. These costumes exposed the arms and legs of the wearer.

Figure 22.7
The 'hourglass' figure of the 1940s

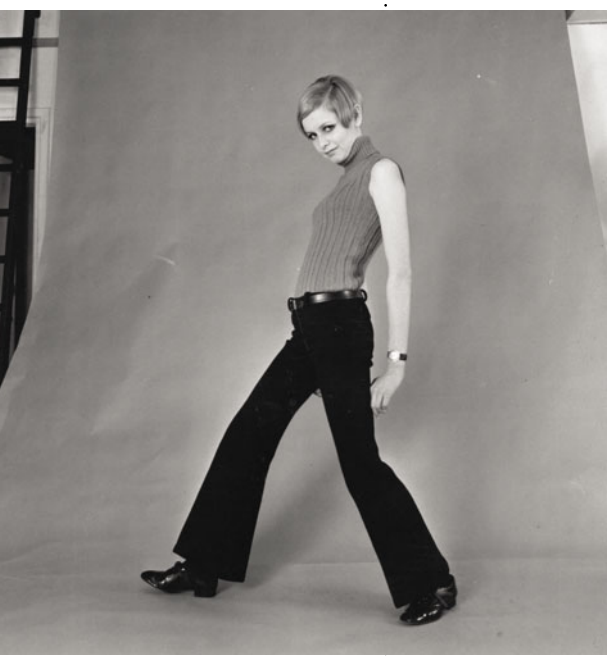

Figure 22.8
Twiggy was a supermodel of the 1960s. Thinness was the ideal for both males and females.

The 1960s

During the 1960s, the perception of the ideal body changed drastically. For both men and women, the ideal look was to be extremely thin. Supermodels, such as Twiggy, established a trend towards an anorexic-looking body shape. The miniskirt and bikini also became fashionable. Men's fashion moved toward the dishevelled look, with pop stars such as Mick Jagger and the Beatles setting the standard.

The late 20th century and early 21st century

In the late 20th century and early 21st century, women, in particular, have been very weight conscious. They have followed fad diets, joined gyms and become caught up in the public mania for body sculpting to try to achieve the 'perfect' body portrayed constantly in the mass media. There is increasing evidence to suggest that males are also being caught up in the desire to possess the ideal body. The ideal body shape for females is now a slim, well-toned athletic look, and for males a highly muscled, extremely low-body-fat, well-proportioned look.

Figure 22.9
The ideal body shape for males in the 21st century

Body image—influences and issues

Why has the image of the ideal body been formed and re-formed to such an extent over time? What shapes people's attitudes about the body and beauty? Where did our current ideal image come from? There are no simple answers to these questions—our perceptions of the ideal body are shaped by a complex combination of factors, including cultural traditions and social and historical developments.

Body image, however, does have a significant role to play in an individual's participation in exercise, sport and physical activity. Perhaps the most valuable finding of research concerning body image is that people with a positive body image tend to have a positive self-image and greater self-esteem than those who have a poor body image. Therefore, development of a good body image is an essential ingredient in developing self-confidence and a positive outlook on life.

The social construction of gender and physical activity

The terms 'sex' and 'gender' are frequently interchanged. However, they have different meanings, despite some similarities. The 'sex' of an individual is used to describe the biological and reproductive characteristics of that individual. We are born as members of the male of female sex. 'Gender' refers to a pattern of behaviours, recognised as 'feminine' or 'masculine'. Some sociologists argue that gender is a socially constructed, learned set of

behaviours. This is supported by evidence that gender characteristics differ between societies and across various social, ethnic and cultural groups within those societies. Even for an individual, gender behaviours may change over time and within different social contexts, as individuals adopt different roles throughout their life experiences. The term 'gender equity' implies that both females and males have equality of opportunity to participate in a broad range of interests, subjects in school, careers or lifestyles etc. This is particularly relevant to settings within exercise, sport and physical activity.

The **social construction** framework suggests that there is no essential or universally distinct set of behaviours that can be labelled as masculine or feminine. Given that behaviours are influenced and shaped by a broad range of factors, including socioeconomic class, culture, skills and abilities, religion, age, body shape and sexual preference, there is no specific pattern of behaviour that can be clearly labelled as masculine or feminine.

Social construction is the process by which individuals are influenced by various aspects of the culture and subcultures of society.

The theory surrounding the social construction of gender is based on information that males and females are actively involved in the construction of their own gender identities. This social construction of gender identity demonstrates a variety and range of femininities and masculinities that are dynamic, ongoing, changing and variable, rather than constant or permanent. Gender is 'learnt' through a range of experiences that are performed and lived in different social contexts. Cultural understandings of masculinity and femininity seem to be understood by children at an early age. They learn that their behaviours and actions are accepted if they are consistent with these cultural expectations.

Researchers such as Grieshaber have indicated that role models, significant others, institutions, the mass media and different social structures all contribute powerfully and influence how young males and females see themselves and each other. Research indicates that the construction of specific gender behaviours is well advanced by the time young people enter formal schooling.

It is evident in young males' emphasis on strength, power, the use of space, desire for competition and motor abilities. Girls, on the other hand, demonstrate gender behaviours in their emphasis on rhythm, words, partial

Figure 22.10
Construction of specific gender behaviours is well advanced by the time young people enter formal schooling.

body use and cooperative learning. Researchers such as Scraton contend that these differentiated skills and experiences assist in reinforcing stereotypes and commence this acceptance of 'natural' activities for young males and females. The social construction of gender indicates ways in which culture shapes difference and how these differences can be used, both positively and negatively.

Learning experience

RESEARCH TASK

Consider a social norm in exercise, sport or physical activity (e.g. the broadcasting of sporting competitions). On the basis of this norm, research to identify the gender-based allocation of rewards and resources to support this norm within the Australian culture. How does the community reinforce this distribution? How might the allocation of resources and rewards impact on access and equity in exercise, sport and physical activity in Australian society?

Ideology is the process by which people use images, symbols and ideas to represent and understand social conditions.

The **ideology** of gender determines what is expected of us as masculine and feminine identities. It also shapes what is allowed by us and how we are expected to behave, and contributes to how we are valued. Our skills and abilities need to be celebrated, adding value to the social and cultural differences of individuals within society. The issue of gender is about viewing difference as an opportunity to enrich each other's lives.

These expressions of gender can shape the construction of the expectations of masculinity and femininity, the roles we are expected to achieve and the relationships that we develop with each other. Gender also has a major influence on how women and men perceive themselves. The ideology of gender therefore contains norms and rules regarding appropriate behaviour and determines our individual attributes. Gender also assists to reproduce a range of beliefs and customs to support these norms or 'ways of doing things' as well as social rules or patterns that become routine over a period of time.

The ideology of gender also can determine the level of disadvantage and equity that we experience, the difference we experience in our daily lives, as well as discrimination. These aspects can be applied to our experiences within exercise, sport and physical activity and the opportunities that we receive with these activities.

Learning experience

MULTI-MODAL TASK

Evaluate practices and policies within your own Physical Education class which relate to access and equity issues. Using the different levels of Figueroa's framework, propose strategies to overcome inequality of opportunity within your class. Justify your response by providing evidence from your own experiences, or those of your peers.

Sport as a microcosm of society

A '**microcosm**' is a little world or a world in miniature. It could be argued that exercise, sport and physical activity share much in common with the 'real' world. If the features of society, as well as the features of sport previously discussed in the different levels of Figueora's framework, are considered and compared, then many similarities can be established. Sport is a microcosm of society because it reflects or mirrors the cultural principles of society. For example, society has become more corporate and materialistic over time, and sport has adopted similar principles. Just as we are encouraged to spend on goods and services, guided by advertising and corporate promotion, so too we are encouraged to spend on sports memorabilia such as team jerseys, caps, flags and banners.

A **microcosm** is a miniature representation of society that shares a feature of society on a smaller scale.

Sport serves as a useful microcosm of society, because it reflects both the positive and negative features of our society. Among the negative features of sport are elitism, racism, violence and sexual assault, extreme competitiveness, issues of drug use and abuse, both legal and illicit. These issues are prevalent in society so it should not be surprising that they also exist within the realms of exercise, sport and physical activity. Studying the positive and negative features of sport allows us to better understand why these behaviours and issues exist in the broader context of society.

Exercise, sport and physical activity also reveal many positive attributes of society, such as providing opportunities to achieve and attain success, promoting hard work as a means of progressing in life, as well as reinforcing the value of teamwork and cooperation.

Every social institution is filled with competition. Most members of society are in competition with others on a daily basis. Supporters of sports competition argue that sports participation prepares young people for the 'real world', one that is filled with high-stakes competition. However, one of the most prominent proclaimed benefits of competition is that it builds moral character. It is argued that losing on the sporting field will teach us to overcome adversity and learn from our errors, to compete another day. Hard work and determination are highly promoted pillars of our way of life and values that society regards highly. Being a member of a sporting team creates opportunities to foster leadership abilities, as well as learn the importance of cooperation and teamwork. These values are the fundamental building blocks of competition sport.

Figure 22.11
How are the Olympic ideals mirrored in society?

Learning experience

RESEARCH REPORT

Evaluate the ideals of Olympism at the website of the Olympic Movement <www.olympic.org>. Do the values indicated in the Olympic Charter transfer to society? Research and present your findings in a report.

An analysis of the sports pages of newspapers can sometimes resemble the news pages in other sections of these publications. They are often filled with stories of crime and deviant behaviours, as well as stories praising the positive performances of individual athletes, champion teams and successful competitions, promoting their hard work and accomplishments. Prominent sociologists Stanley Eitzen and George Sage suggested over two decades ago that:

> *The types of games people choose to play, the degree of competitiveness, the types of rules, the constraints on participants, the groups that do and do not benefit under existing arrangements, the rate and type of change and the rewards systems in place in sport, provide us with a microcosm of the society in which sport is embedded.*

Source: Eitzen, DS & Sage GH, 1989, *Sociology of North American Sport*, WmC Brown, Dubuque, IA.

An examination of the values and ethics of sport is valuable in the further understanding of how cultures influence access and equity in exercise, sport and physical activity. Fair play is a widely understood concept underlying all sport. Sport naturally presumes fair play. It is about the idea of entering a playing field to compete according to the rules of the game. If you cheat to obtain victory, the victory is diminished.

SNAPSHOT

Go to <www.playbytherules.net.au>. This website is aimed at making sport inclusive, safe and fair. Relate the various sections of the website to Figueroa's framework. How is the website promoting 'inclusive, safe and fair play'?

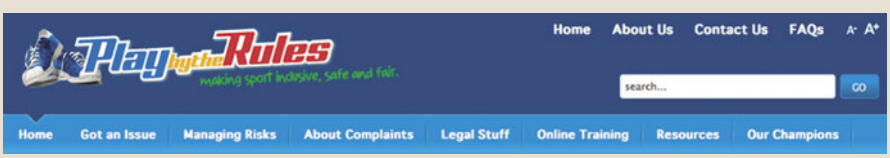

Figure 22.12 The play by the rules message is a positive one.

Central to the philosophy of fair play is respect for others and respect for the game and for sport generally. Without fairness, sport is devoid of real meaning or purpose and, as such, may become a detrimental experience for participants.

The governments of some countries have recognised the need to promote fair play in sport. In Australia, upholding fair play is part of the role of the Australian Sports Commission (ASC). A number of agencies have been established by the ASC to promote 'good sports' and oversee aspects of sport

associated with fair play. These include the Australian Sports Drug Agency, Aussie Sport, and the National Coaching Accreditation Scheme.

Ethics and values

Issues such as drug taking, violent and abusive actions on the sports field, and inappropriate behaviour off-field have prompted governments, sports organisations, players and the public to examine ethics and values in the context of sport and physical activity.

The word 'ethics' comes from the Greek word *ethos*, which means 'the essence of one's character'. The term is now used to describe the ultimate values and principles held by an individual. A recent ASC report defined ethics as being about 'respect, integrity, justice, democracy, fairness, equity, doing the right thing, and duty of care for participants, officials, administrators, coaches and the public'.

The term 'values' refers to the beliefs, attitudes and behaviours that individuals and societies regard as ideal or important. Values provide us with a foundation for decision making (e.g. about what *is* or *is not* ethical) and are related to personal integrity and identity. Values are often shaped by community expectations and the society in which we live and, because of these influences, can change over time.

As part of the fabric of our society, sport reflects many of the values of the people and institutions within it. Some values that have been integrated into sport are loyalty, sacrifice, teamwork, free speech, democratic decision making and equal opportunity. Sadly, sport does not always teach values such as honesty, justice and responsibility.

Sportsmanship and gamesmanship

According to Michael Josephson, an American researcher in ethics, there are two main models that describe the nature of sport:

- the 'sportsmanship' model
- the 'gamesmanship' model.

These models are based on very different philosophies about the nature of sport. Each philosophy has different values and assumptions.

Under the sportsmanship model, the way an individual plays the game is central. Sport is viewed as a special activity where noble conduct and glory are achieved, not through winning, but though honourable competition in pursuit of victory. This philosophy is similar to the principles of Baron Pierre de Coubertin, the founder of the modern Olympic Games, who said the most important thing in the Games was not winning but taking part. Sportsmanship demands a commitment to principles of integrity, fair play, respectfulness and grace. It seems that the more important it is to win, the harder it is to behave in an ethical manner. According to de Coubertin's model, a true sportsperson must be willing to lose rather than forfeit ethical principles, even when the stakes are high. The model also suggests that winning without honour is not a true victory.

In the gamesmanship model of sport, all that really matters is winning. Gamesmanship encourages and sanctions the clever and effective ways of bending, evading and breaking the rules to provide a competitive advantage over an opponent. These tactics are considered to be part of the game.

Athletes who operate by this model often believe they have no ethical obligation to play by the rules, because they maintain it is the role of officials to identify violations and impose sanctions. One of the major problems with the gamesmanship model of behaviour in sport is that there are no criteria for drawing a line between what is acceptable and what is not.

Learning experience

MULTI-MODAL PRESENTATION

Which of the two models do you think is most evident in Australian sport? Gather research from video or web-based evidence and debate a response to the question. Consider specific individuals, teams or competitions where gamesmanship and sportsmanship behaviours are most evident. How might these behaviours influence access and equity to exercise, sport and physical activity?

Playing by the rules

Rules define games and establish standards of fair play. Rules are also designed to prevent behaviour or conduct that creates unnecessary risk or injury. Generally, techniques that inflict pain or endanger athletes breach the fundamental principle of athletic competition. Physical intimidation, intentional injury, tripping and similar tactics are often considered to be 'part of the game', but they introduce unacceptably dangerous elements to it.

Refinements in rules occur regularly in sport. They act to develop a more free-flowing game or to establish new safety guidelines for player safety. Generally, these refinements do not alter the integrity or nature of the game. To say that a particular tactic is 'part of the game' suggests that it is consistent with the intended nature and spirit of the game and that it doesn't introduce irrelevant or inappropriate factors aimed at distorting the outcomes of competition. Tactics that change the nature of the game are unethical, because they violate the essential integrity of the sport.

Drug taking, racial abuse, violent players and crowds, bribery scandals and match-fixing allegations are just some of the features of modern sport that constantly appear in media reports. Has sport lost its way? Is it operating within a framework of values that condone bad or unethical behaviour?

To operate in an ethical sporting environment, participants (including players, coaches, parents, officials, sponsors and spectators) must ask themselves this question: 'What is the right thing to do?' To answer this question correctly, people must think about what they believe in and value.

University of South Australia researcher Jim Daly suggests that a good guide to ethical behaviour is the 'sunlight test'. This test involves asking yourself how you would feel if everybody you respect and admire knew what you had done because it was shown on the television news and written about in the daily newspaper, made transparent for all to see and 'held up to the light'. Your behaviour should be able to stand up to scrutiny by others. All actions and decision making should be capable of being held up to the public gaze.

Negative actions such as on-field cheating and other forms of cheating (e.g. equipment tampering and use of performance-enhancing drugs) undermine the positive impact of sport. Unsporting conduct such as taunting, sledging, disrespectful celebrations and complaining about umpire decisions are also all considered by many as inappropriate behaviours in sport.

Similarly, there are negative off-field behaviours that are seen as discrediting an individual, a team and the sport. These include criminal conduct such as acts of violence, sexual assault or vandalism, crude or bullying behaviour, drug use, and drunken driving.

Ethical decisions and individual values will assist players, coaches, parents, officials and sponsors to deal with the issues confronting contemporary sport. Each of these issues presents a considerable challenge to the future of sport and physical activity.

Figure 22.13 Negative actions undermine the positive impact of sport.

Naturalistic and constructionist views of body image and body regulation

Prominent sociologist David Kirk's research suggests that the **naturalistic view** of what constitutes body image and behaviour is based primarily on the biophysical sciences. This view considers the structure and function of the human body, and investigates the body as a biological and physical phenomenon. For example, this naturalistic view of the body may be used to explain the differences in male and female sports performances solely in terms of strength, speed and power on the basis of biological factors. It might also argue that differences in sports performances might be linked to the psychological attribute that males are more aggressive than females, and hence perform better. Researchers who consider the naturalistic view of what constitutes the male and female bodies will contend that biological

A **naturalistic view** is one in which the human body is viewed only in terms of muscle, bone and various tissues.

differences—body size, body shape and other physical characteristics—explain variations in behaviour and physical performance.

This naturalistic view has been challenged in recent years. Academics have argued to the contrary, i.e. that a person's understanding of the ways their body performs is shaped and formed by the society in which they live. In other words, these academics believe that the body is part of the social 'world' as well as part of the physical and biological 'worlds'. The body exists in both worlds concurrently. These academics have adopted a 'constructionist view' of the human body.

The **constructionist view** is one in which the human body is considered both biological and social in function. The body exists within both society and nature concurrently.

The **constructionist view** of the body is based on the thinking that biology does not solely determine physical behaviour. The constructionists would argue that there exists a broad range of behaviours producing different structures of masculinity or femininity. There is not one single behaviour that is 'typical' of masculinity or femininity. Kirk argues that while some groups within society consider a highly trained, muscular physique as being an essential quality of masculinity, there are men who do not have that body shape but who are still considered to be masculine.

The constructionist view of the body also helps us to identify how favourable and 'ideal' images of the body have emerged throughout history. It links the development of body image with other cultural factors, as well as the self-esteem of individuals. In addition, the constructionist view is able to consider the impact of the mass media in shaping the social values applied to different body shapes. The constructionist view also assists to explain why people behave in the ways that they do. Social and biological factors are evident in all these situations; the naturalistic view emphasises only one aspect of the behaviour.

Media influence on the evolution of culture

Because of the global access today to newspapers, magazines, film, television and the internet, the mass media have become powerful sources of information to inform and shape debate on matters of national and international importance. This flow of information also assists in the evolution of our culture. Prominent sociologist George Sage emphasises the omnipresence of the mass media, a factor that enables this industry to be an extremely powerful source for the formation of values and beliefs, as well as developing a consensus on issues of a national and international scale.

Sage suggests that the mass media perform two roles within society. One is to communicate information regarding various people and events; the other is to provide entertainment to its consumers. In doing so, the mass media assist in the process of social integration and contribute to social change. This industry helps to promote social integration by promoting values and norms that are shared by society. Social change is supported and promoted by publishing and announcing the latest research, social trends, the growth of technology, innovative social practices and values, as well as critiques of modern attitudes and behaviours.

Despite this power, the mass media are not major players in the realisation of social change. Most extremist views generated by calls for fundamental and political change often go unreported, or are dismissed by the mass media as being unacceptable.

Textual messages and meanings

Sociology lecturer David Stead suggests that heavy influences of ideologies such as capitalism, nationalism, patriarchy and racism are evident in the textual messages transmitted by the mass media. He contends that the philosophy of **capitalism** is apparent through the mass media's profit motive. Values such as the need for hard work and the spirit of free enterprise are evident in sports broadcasts because the mass media choose to highlight these values as praiseworthy. Core sporting attributes such as teamwork and competition are highlighted in noticeably positive terms.

Capitalism is a system under which the means of production, distribution and exchange are largely privately owned and directed.

Nationalism is evident when sporting events are used to call on people to unify behind a nation's athletes to rally to the cause and demonstrate allegiance. The home country's athletes are viewed as heroes, while athletes from other nations are sometimes viewed as villains or as athletes with inferior skills.

Nationalism is the sentiment, aspiration and consciousness of the value of a nation-state.

Patriarchy is evident in gender bias in the media and sport. The mass media are often seen to trivialise, stereotype and sexualise female athletes. Female athletes are frequently put down and dismissed for not fitting the appropriate male perceptions of femininity, or they are glamorised by the mass media. The connection between gender and the media extends beyond the coverage and promotion of female athletes. There are concerns shown about the treatment and coverage of male sport, with its increasing emphasis on violence and the imagery associated with these male bodies and what is 'appropriate' masculinity.

Patriarchy is a form of social organisation in which males have significant control.

Racism is reflected in the ownership and control of the major media empires across the world. National media ownership reflects dominant racial and ethnic interests. Consequently, the sporting achievements of specific groups of people are sometimes celebrated or played down in the mass media. Stereotyping along racial or ethnic lines is sometimes evident in mass media coverage of sport.

Racism is the belief that human races have distinctive characteristics that determine their respective cultures, usually involving the idea that one's own race is superior.

Learning experience

MULTI-MODAL TASK

Evaluate the televised broadcast of a major sporting event (e.g. opening ceremony, closing ceremony, sport grand final, Grand Slam tennis tournament). Identify any specific examples of capitalism, nationalism, patriarchy and racism and describe their role in the production of the event. How might these examples impact on access and equity for the general population to participate in exercise, sport and physical activity?

Despite the significant power and widespread influences of the mass media, it appears that much of the bias exhibited in broadcasts and promotions of exercise, sport and physical activity seem based on the maintenance of the *status quo*. The mass media focuses on the promotion of conventional norms and values. This industry seems to promote a **conservative** ideology for interpreting and supporting the dominant cultures and society's consciousness.

To be **conservative** is to be cautious or moderate, traditional in style or manner, and to wish to preserve existing conditions.

Nationalism and the impact of participation in sport

The rugby, football and cricket world cups, the Olympic Games and the Davis Cup tennis competitions are some examples of occasions when sport provides opportunities for countries to display sentiments and loyalties associated with national communities. Many different nations have their own specific national sports, as well as particular sporting clubs or individuals, that have become the focus of national and cultural identities. International sporting festivals and championships between individuals, clubs and teams often feature rituals and symbols such as flags, emblems, opening and closing ceremonies, uniforms and songs. These rituals and symbols demonstrate the attachment of individual athletes and sporting teams to a national identity.

Researchers such as Irene Reid and Grant Jarvie have suggested that the connection between nationalism and sport has been used to develop and shape an image of the nation, which contributes to a sense of the nation's importance and prominence on the world stage of sporting competition. They explain that this construction of a national image becomes the 'glue' that binds any social and cultural divisions across their society.

Sport provides a medium through which people can display a strong connection to their country, which distinguishes their nation from other nations. Some nations are known for their specific abilities and talents in sports (e.g. African nations and long distance running). These specific symbols of nationalism illustrate that there are many different nations competing in a major global event, such as an Olympiad or World Cup. Each nation brings its own specific characteristics to the competition. Each specific form of nationalism exhibited at these major global events features the specific historical, social, cultural and political characteristics of each nation.

Figure 22.14
Sport provides a medium through which people can display a strong connection to their country.

For us as individuals participating in exercise, sport and physical activity, nationalism may have little to do with our own experiences. However, there are many practical questions you might like to consider, for which a broader understanding of specific social, cultural, political and historical settings may assist you with your responses.

- Can sport contribute to international and cultural understanding?
- Does sport rise above specific social, political, cultural and economic barriers?
- Does sport effectively recognise and celebrate cultural diversity and difference?
- Why do governments invest so heavily in sport?
- How do governments justify their major investment in large sports festivals or a bid to host the Olympic Games?
- How does sport develop a sense of national unity and pride?
- How might sport at the national and international level impact on access and equity in exercise, sport and physical activity?

Reflect carefully on these questions. Think about specific situations in international sport, and draw on your knowledge of sociology to respond to the challenges that these questions provide.

The influence of dominant culture and history

> *Nations define themselves, not by how well they work, or how valiantly they fight, or how creatively they think, but how skilfully and spectacularly they play sport.*
>
> Source: Davison, G 'The imaginary grandstand: the links between sport and our national identity', *Meanjin*, vol. 61, issue 3, 2003

Do you agree with this statement or do you think a nation's cultural identity comprises a much more complex mix of components? Many people would argue that there are many different factors that have shaped our contemporary identity and established our place in the world, and that it would be too simplistic and one-dimensional to define our national identity in terms of sport alone.

At the same time, in Australia as in many other nations, sport is one of the interests and experiences many people share in one form or another, regardless of their different backgrounds and up-bringing. Sport has been, and continues to be, a part of our common experience and heritage, and a prominent feature of national life. So although sport may not be the *only* facet of our culture and identity, it has certainly played an important role in shaping that identity.

Australians have always been passionate about sport. Observers have often commented about the sporting 'obsession' of the Australian people, and it seems that life in Australia would not be the same without sport. With its the mission statement being 'To enrich the lives of all Australians through sport', the ASC obviously sees the value of sport as an inspirational experience. Australia's sporting success has long been one of the most enduring indicators of our national progress and development. Such success has, without doubt, been inspirational and uplifting for many Australians.

Learning experience

ESSAY

'Sport is frequently cited as the exemplar of Australia's egalitarian character.'

Critically evaluate this statement, with reference to the different levels of Figueroa's framework. How is equity and access in exercise, sport and physical activity determined in Australian culture? Use examples from your own experiences in exercise, sport and physical activity to support your argument.

Richard Cashman, a prominent sport historian, believes that contemporary Australian sport has developed as a conglomerate of different games, traditions and ideologies imported to Australia following European settlement. However, he contends that despite the fact that we have 'borrowed' much of our sporting background, there exists a strongly distinctive Australian culture of sport.

Barracking and a unique style of humour are part of this culture. Attend any sporting competition that draws a crowd and observe the ways in which people barrack. There is a distinctive style exhibited by the barrackers—irreverent, humorous and dry-witted. Also a part of this culture is the significance attached to facilities where sporting contests are held. Many of these have become 'icons' of the country, such as the Melbourne Cricket Ground, the 'Gabba' and Lang Park (now Suncorp Stadium).

Further evidence of this culture is the way Australian sport has utilised its unique environment to conduct competitions—the Brisbane to Gladstone and Sydney to Hobart yacht races, beach volleyball at Surfers Paradise, surfing competitions on Gold Coast and Sunshine Coast beaches, and the Gold Coast marathon. In some cases, techniques and strategies used in playing a game have developed a distinctly Australian stamp. For example, the phrase 'running rugby' describes the Australian style of Rugby Union play, and the term 'Australian crawl' shows the origins of the 'freestyle' swimming stroke.

Throughout Australian history, there has emerged a rich tradition of sporting heroes, both male and female. There are the 'professional' players, seemingly unsmiling, highly focused and calculating technicians; the larrikins, who exhibit a particular flair and approach to the games they play; and the sporting 'brats' whose behaviour is often questioned, but whose performances are praised. Australians seem to respect the professionals, love the larrikins and indulge the brats.

The origins of sport in Australia

A brief study of the origins of sport in Australia will help us develop a clearer image of the cultural identity of Australians and how sport and physical activity have assisted in shaping that unique identity. In colonial

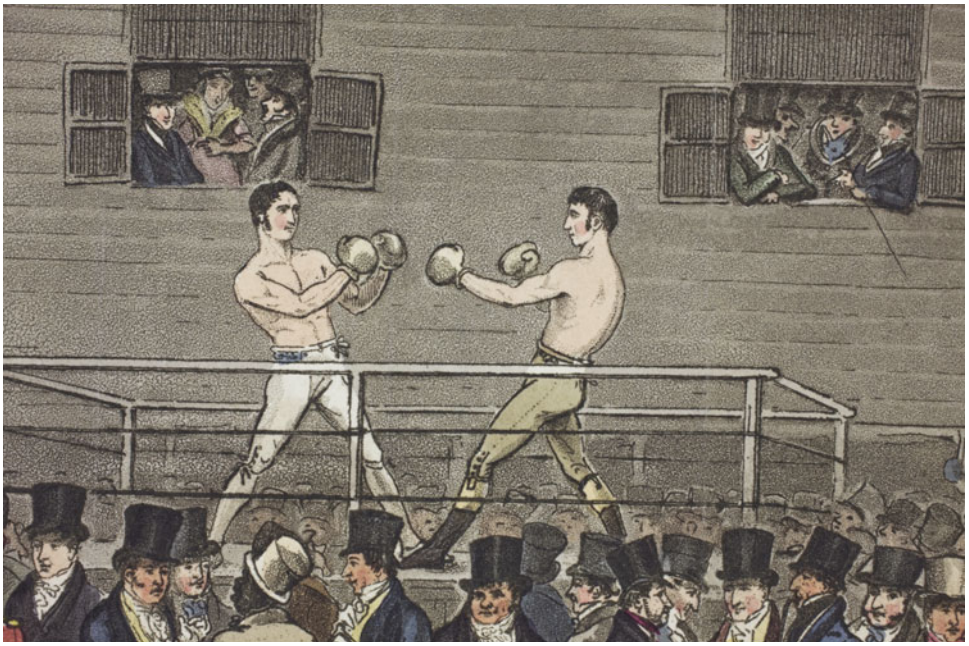

Figure 22.15
In the early days of European settlement, sport was essentially a male-dominated activity. Boxing matches were popular.

times, Australian men of European extraction were renowned for their commitment to sport, and male sport in particular. The 'bush ethos' was also alive and well, despite the fact that most of the population lived in small urban clusters. The 'have-a-go' attitude and rugged independence of the European settlers, and the spirit of 'mateship' quickly became social norms. There existed a toughness, a manliness and a 'never-give-in' attitude that seemed to determine people's very survival in a harsh and unforgiving land.

In the early days of European settlement in Australia, sport was essentially a male activity, with horseracing and professional foot racing being particularly popular. Gambling was strongly linked with both of these pursuits. Boxing and cock-fighting were also popular sports. These leisure pursuits called for a particular expression of masculinity, with the ideal qualities being harshness, toughness, aggression, competitiveness, physical skill and adeptness.

In direct contrast to this explicit expression of masculinity that emerged in 19th century sport were the perceptions of femininity and the types of physical activity thought to be acceptable for females at the time. Under the influence of the values, attitudes and beliefs of Victorian England, women were brought up to be 'ladylike' and were expected to conform to a code of restrictively genteel manners and behaviour.

Women's sports that emerged during this era were archery, croquet, tennis, swimming and netball. Females were permitted to indulge in these activities provided they did not lose their 'ladylike' demeanour. Sport for boys was competitive and involved rugged team games. For girls, only mild exercise to promote good health was encouraged. Women were not expected to raise a sweat, and were required to remain modest and graceful at all times. These gendered expectations of male and female behaviour are still clearly evident and influential in shaping the present cultures and structures of sport.

Common assumptions about sport and exercise in Australia

Myths, as described by prominent Australian social researcher Jim McKay, are:

> *… not total delusions or utter falsehoods, but are partial truths, which accentuate particular versions of reality and omit others. When myths come to be perceived as eternal truths, they are integral in defining what is normal and abnormal, rational and irrational and commonsense and nonsense. Unlike a book of fairy tales, myths are 'authorless'. This, and their tendency to become taken for granted in everyday life, make myths difficult to challenge.*

Sport in Australia is routinely depicted as an activity in which all Australians participate, regardless of social class, gender, ethnicity or racial background. Do you support this statement or do you consider it a myth?

Consider the following analogy, developed more than 30 years ago by Berry, a sociologist.

This was his impression of access and equality in sporting opportunities in 1977:

> *An equitably contested race would include all competitors starting at the same time, running the same course, under similar conditions, with the winner recording the fastest time, as first across the line.*

A competition in which inequitable terms exist could include some contestants who start 20 metres down the track, while others begin their race a metre behind the starting line. Other contestants might be warming up or still in the change rooms when the gun goes off. Yet others are at home, thinking that the race is to be held tomorrow.

The outcomes of the two competitions will be vastly different because of different opportunities for participation by each of the contestants. Which version of the event are you likely to support? How might Figueroa's framework be applied in each of these situations? How might you as a participant in each race affect and influence equity and access? What strategies might be implemented at the individual level? What course of action might be suggested at the interpersonal level? What innovations might be implemented at the institutional level to ensure access and equity? How might the situation change at the structural level? What might happen at the cultural level to ensure access and equity existed?

Chapter review

Factors affecting equity and access at the cultural level

Know	1	Describe how gender might be socially constructed.
Comprehend	2	Explain how images of the 'ideal body' have changed over time.
Apply	3	Produce a list of what might be considered as 'fair play' in sport. Develop an opposing list of 'unfair play'.
Analyse **Evaluate** **Synthesise**	4	Consider how the social construction of gender might influence access and equity in exercise, sport and physical activity.
	5	Produce a list of different sports and sort them into the following categories: 1 Sports played primarily by males 2 Sports played primarily by females What factors guided your decision making? What characteristics of the games make them more 'masculine' pursuits or 'feminine' pursuits? Are these stereotypes valid?

Glossary

abdominal (diaphragmatic) breathing	a relaxation technique aimed at controlling anxiety and reducing muscle tension
access	opportunity to participate
actin	a protein filament in the muscle fibre
active recovery	involves cooling down the body after exercise, reducing the intensity of the activity but remaining active submaximally
adenosine diphosphate (ADP)	one of the chemical products of the breakdown of ATP for energy production during muscle contraction
adenosine triphosphate (ATP)	the chemical that serves as the immediate source of chemical energy for most of the energy-consuming reactions of the body, especially for muscle contraction; it is split into adenosine diphosphate (ADP) and phosphate to produce energy
aerobic capacity	the ability to persist in physical activities that rely heavily on oxygen for energy production
aerobic steady state	reached after the first 3–4 minutes of exercise, when oxygen uptake meets the oxygen demand of the tissue, and heart rate, cardiac output and pulmonary ventilation have reached fairly constant levels
aerobic system	a method of resynthesising ATP in the presence of oxygen using carbohydrates and fats as fuels
alactacid debt	the amount of oxygen needed to replenish creatine phosphate and ATP stores in tissue cells during the recovery process after exercise
amino acid	compounds that are the building blocks of proteins; contain nitrogen, hydrogen and carbon
anaerobic capacity	the ability to persist at the maintenance or repetition of strenuous muscular contractions that rely substantially on anaerobic (without oxygen) mechanisms of energy supply
anaerobic glycolysis	is the conversion of glucose to lactic acid in the absence of oxygen
anecdotal	refers to short narratives of particular incidents or occurrences
anxiety	a subjective feeling of apprehension that is accompanied by a heightened state of arousal
Archimedes principle	states that the buoyant force acting on a body is equal to the weight of the fluid displaced by the body
arousal	a term used in psychology to describe the heightened sense of physical and mental alertness or activation
arteriovenous oxygen difference (a–vO_2 diff.)	the oxygen concentration difference between arterioles and venules; it shows how much oxygen is taken up by the tissues of a muscle
associative stage	the second stage in Fitts and Posner's model of motor learning; it is characterised by practice
autonomous stage	the final stage in the Fitts and Posner model of learning; it is characterised by automatic movement
balance	the ability to control your state of equilibrium
barriers	factors that restrict or prevent access to exercise, sport and physical activity
Bernoulli principle	explains the lift generated by an aerofoil: air moving at low speed under the wing generates a higher pressure than air moving at higher speed over the top of the wing
biological	concerned with the life and living matter in all forms

blocked practice a practice routine that involves the repetitious learning of one component of a multitask skill in order to refine and improve that component

blood lactate measure of the concentration of lactate in the blood formed from the salts of lactic acid

blood pressure the pressure of the blood in the arteries

body composition refers to the proportion of fat and lean (muscle and bone) constituents of the human body

body image the image you have of your own body and how you feel about it

buoyant force an upward force against the underside of an object in water

capitalism a system under which the means of production, distribution and exchange are largely privately owned and directed

carbohydrate loading a nutritional strategy to maximise muscle glycogen (carbohydrate) stores prior to endurance competition

carbohydrates chemical compounds that consist of carbon, hydrogen and oxygen atoms in specified arrangements; major components of foods such as bread, potatoes and rice

cardiac output (*Q*) the volume of blood pumped from a ventricle of the heart per unit of time; it is the product of heart rate and stroke volume

centre of gravity the point on a body at which the Earth's gravitational pull is concentrated

centre of percussion the 'sweet spot'; the impact spot on an implement where in a collision between bat and ball the hands will experience no jarring effect

choking a process of increasing anxiety due to the perceived importance of an event

clique a group of exclusive individuals

coefficient of restitution (of a ball) the square root of the rebound height divided by the drop height

cognitive stage the first stage in the Fitts and Posner model of motor learning; it is characterised by frequent errors in performance

competence belief a belief in your own ability or competence in an activity

concentration the ability to maintain attentional focus to relevant environmental cues

concentric force a force applied through the centre of gravity of an object causing it to translate

conservation of momentum is the preservation of momentum, e.g. in any collision between two objects, momentum cannot be created or destroyed, but it can be transferred from one body to another

conservative to be cautious or moderate, traditional in style or manner, and to preserving existing conditions

constant practice a practice routine in which only one class of skill is practised in the session

constructionist view one in which the human body is considered both biological and social in function; the body exists both within society and nature, concurrently

consumer someone who uses a commodity or service

context the circumstance or facts that surrounds a particular situation

cool-down the combination of activities (walking, static stretching) done at reduced intensity to help the body return to the pre-exercise state and aid recovery after the conditioning phase

coordination the ability to control motor movements and patterns with either the hands or the feet

creatine phosphate (CP) a chemical stored in the muscle fibre that can donate its phosphate to ADP to rapidly replenish tissue stores of ATP; also called phosphocreatine

creatine phosphate system an anaerobic method of resynthesising ATP using creatine phosphate as the fuel

detraining the physiological adaptations that occur when an individual stops training

dextral	pertaining to the right-hand side of the body
diffusion	the net movement of chemicals such as oxygen, carbon dioxide and sodium from an area of high concentration to an area of lower concentration
distributed practice	a training routine that involves short, frequent practice sessions interspersed with rest intervals
division of labour	how roles and tasks might be allocated to individuals or groups
duration	the length of time that something takes
eccentric force	a force applied to one side of the centre of gravity causing the object to rotate; if the axis is not fixed, the object may both rotate and translate
ectomorphy	a tendency towards slenderness, the body component relating to thinness
effective base of support	the distance between the gravity line and the pivot point over which the body destabilises
effective mass	involves bracing a body part to ensure maximum transfer of force
efficacy belief	a belief in your own effectiveness when completing a task
elastic	material that would rebound/return to its original shape/height
electrocardiograph	measures the electrical activity of the heart
electroencephalogram	an instrument that measures brain wave activity
electrolyte	a substance that dissociates into positively and negatively charged ions in water and conducts electricity; it aids in a number of vital bodily process, e.g. muscle control, absorption of fluids
electromyograph	measures electrical activity in muscle
endomorphy	the body component related to levels of fatty tissue within the body
energy	the capacity or ability to do work
enzymes	proteins that function as catalysts, which act to increase the speed at which chemical reactions occur
epinephrine	a synthetic form of adrenaline; relaxes the airways and constricts blood vessels
equality	the state of being equal in some respect
equity	concerned with giving value to, and celebrating, social and cultural differences of individuals and in society
ergogenic aid	a substance used to enhance performance
ethnicity	groups of individuals sharing common characteristics that differentiate these individuals from other groups in society
excess post-exercise oxygen consumption (EPOC)	the total amount of oxygen required during the recovery process after exercise, to replace ATP, restore CP, remove lactic acid in the working tissue and return all body systems to their pre-exercise resting state; also referred to as oxygen debt
exercise recovery	a combination of active recovery and post-exercise stretching
extrinsic (augmented) feedback	feedback that is received at the completion of a movement; it is divided into knowledge of results and knowledge of performance
fatigue	the diminished capacity for work as a result of prolonged or excessive exertion
fitness	the ability to carry out everyday activities without fatiguing and having enough energy left over to deal with emergencies or participate in leisure activities
Fitts and Posner model	describes the different stages of learning a motor skill
flexibility	the range of motion of the body's joints
force	that which causes a change in a body's motion or shape; force gives a mass a given acceleration
frequency (of an event)	the number of times it occurs within a certain period

games analysis a method of gathering data about the performance of an individual athlete or team to identify areas of strength and weakness and target training to ensure it is effective

glycemic index (GI) a way of ranking carbohydrates according to their effect on blood glucose levels; foods with a high GI cause a greater increase in blood glucose and insulin levels

glycogen the form in which digested carbohydrates are stored in the muscles and liver

goal setting a means by which individuals and teams direct their focus

gravity line indicates the direction of the gravity force passing through the centre of gravity of a body

heart rate the number of beats of the heart in one minute

hydrodynamic drag the sum of the resistive forces in water

hypertrophy an increase in cell size leading to an increase in tissue size

ideology the process by which people use images, symbols and ideas to represent and understand social conditions

imagery a psychological term that uses all the senses to create or re-create an experience in the mind

impulse the product of a force and the time interval over which the force acts

individuality acknowledges that no two athletes respond to training in the same way, therefore to be truly effective a training program or session must consider the individual's needs, goals, fitness levels, motivation and skills

inelastic material that would not rebound at all

intensity in relation to exercise it is the degree of difficulty or the amount of strength and/or energy required

internal distractor thought that distracts attention from the present attentional cues

intervention a certain program or practice administered to a population and the resulting outcomes observed

intrinsic feedback information that comes from the senses both during and after a movement pattern

inverted-U theory also known as the Yerkes–Dodson law, describes the relationship between performance and arousal

kilojoule (kJ) a unit of energy used to refer to the energy content of food or drink (1 kilojoule ≈ 24 calories)

kinaesthetic sense the ability to sense the position, movement and weight of the body by receptors in the muscles, joints and tendons

knowledge of performance a form of extrinsic feedback (usually verbal) that indicates the technical correctness or quality of the movement; may include identification of the parts of the skill that were performed correctly or incorrectly

knowledge of results a form of extrinsic feedback that indicates the outcome of the performance (e.g. 5.6 m in long jump) rather than the movements that brought about the performance

lactacid debt the amount of oxygen needed during recovery after intense exercise to remove lactic acid that has accumulated in muscle tissue and blood during the exercise period

lactate threshold 1 the first intensity at which there is a sustained increase in blood lactate concentration above resting levels

lactate threshold 2 the intensity indicating the upper limit of equilibrium (balance) between lactate production and lactate clearance (also referred to as anaerobic threshold)

lactic acid the by-product of the anaerobic metabolism of glucose in muscle; salts of lactic acid are called lactates

lactic acid system an anaerobic method of resynthesising ATP using glycogen or glucose as the fuel

lever a rigid rod or body segment that rotates around an axis

lift force	force due to the development of high pressure under the hand and low pressure above it when the hand is pitched to the water at around 40°
linear momentum	the product of the mass and velocity of an object travelling in a straight line
long-term memory	a system of permanently storing and managing information for later use
Magnus force	a force effect using the Bernoulli principle which causes a spinning ball to swerve in the air
massed practice	a training routine in which a skill is practised continuously and consistently
maximum heart rate (MHR)	the theoretical maximum rate (not intended as an exercise rate) at which a person's heart can beat at a given age; the formula used to calculate the maximum heart rate of a healthy individual is 220 – age in years
maximum oxygen uptake VO_{2max}	the level of oxygen an individual can consume and utilise to produce energy in one minute; also called maximal oxygen consumption
mediasport	the product transmitted to viewers, through selected images and descriptions
mesomorphy	the body component related to muscularity
metacentre	the intersection of the weight and buoyancy lines in aquatic craft
microcosm	a miniature representation of society that shares a feature of society on a smaller scale
mitochondria	the structures located within cells that contain the enzymes responsible for the generation of ATP by aerobic mechanisms
moment of force ($T = Fd$)	equal to the force applied to an object multiplied by the length of the moment or turning arm
momentum	a quantity of motion equal to the mass of a body multiplied by its velocity (momentum = mass × velocity)
motivation	the direction and intensity of effort
motor learning	change in the capability of a person to perform a skill as a result of practice or experience
motor neuron	a nerve cell that conducts an impulse from the central nervous system to muscles or glands
motor program	the set of instructions held in memory that is sent to muscles and results in movement
motor skill	that which involves a muscular movement to complete a predetermined task
muscular endurance	the ability of a muscle to perform repetitive work over a prolonged period of time
muscular power	the ability to utilise strength in rapid, explosive muscle contractions
muscular strength	the capacity to apply force against a particular resistance
mutual support organisation	one formed 'of, by and for' the membership of a club
myosin	the contractile protein making up the thick filament in the muscle fibre
nationalism	the sentiment, aspiration and consciousness of the value of a nation-state
naturalistic view	one in which the human body is viewed only in terms of muscle, bone and various tissues
negative reinforcement	an increase in the future frequency of a behaviour when the consequence is the *removal* of an aversive stimulus
neuron	nerve cell, consisting of cell body, axon and dendrites that sends electrical impulses via neurotransmitters
neurotransmitter	a chemical that carries messages between nerve cells
Newton's Law of Acceleration ($F = ma$)	the acceleration of an object is proportional to the applied force and in the same direction
Newton's Law of Action and Reaction ($F = -F$)	every force produces an equal and opposite force

Newton's Law of Inertia ($\sum F = 0$)	a body will continue at rest or in uniform motion unless acted upon by an applied force, i.e. if there are no forces there is no change in movement
norepinephrine (noradrenaline)	a neurotransmitter that increases blood pressure, rate of breathing and blood sugar levels
norms	structured rules that govern the way a group is organised and maintained
optimal level of arousal	the level at which an athlete performs at their best; different sports have different optimal levels of arousal
outcome goals	goals that focus on the result of a particular event, e.g. finishing 5th
overlearning	learning a skill in which practice proceeds beyond the point at which a skill can be performed with a high degree of precision
oxygen debt	the oxygen uptake during recovery from exercise that is in excess of the normal oxygen uptake during a rest period of similar duration
oxygen deficit	the period during exercise when the oxygen consumption is below that necessary to supply aerobically all the ATP required for exercise
oxygen uptake	is the ability to consume oxygen to produce energy
part practice	a practice routine that involves learning a skill in its component parts
patriarchy	a form of social organisation in which males have significant control
peaking	the optimum state of readiness for an athlete coming into a major competition or performance
peer group	a set of individuals who share certain common characteristics, such as age, ethnicity or interests
performance goals	goals based solely on comparing the individual's performance with their own previous performance
performance indicators	measurable indicators that demonstrate whether a goal has been achieved; standards are used as a benchmark for future performance goals, e.g. time in possession, race times and rate of improvement
performance routines	routines established by the athlete in order to maintain focus
periodisation	the process of structuring training in phases or cycles
plyometric	exercises that develop strong fast movement by stretching muscles to their fullest extent and then suddenly contracting them
politics	the processes and procedures of making decisions that affect people, from small groups to societies and even multiple societies that are unified for certain purposes
positive reinforcement	an increase in the future frequency of a behaviour due to the *addition* of a stimulus immediately following a response
post-performance debriefing	the process of providing feedback on performance in a supportive environment
power	the control or influence over others
pressure	a feeling that is created by an athlete in response to performing in a sporting situation
process goals	focus on the technique rather than the performance result
profile drag	the resistive force in air or water caused by the size and shape of the body
progressive muscle relaxation	technique uses the alternate tightening and relaxing of muscles in order to heighten an athlete's awareness of tension within the body
progressive overload	the gradual increase in the load of training to ensure that fitness continues to improve
proprioception	the ability of the body to sense stimuli from within the body; e.g. knowing that your hand is in the air when your eyes are closed
psychological recovery	the process whereby an athlete incorporates psychological skills into their recovery plan
psychological refractory period	the delay in processing a signal while the preceding signal is processed

psychology	the study of the human mind and mental states
psychoneuromuscular theory	theory that by imagining performing a skill an athlete stimulates the same neural pathways as when actually performing the movement
pump propulsion	due to a pressure gradient, pumping water down the arm and forming a low pressure area behind the hand
punishment	a term used in behavioural psychology to describe the process of adding a negative consequence to a behaviour in order to extinguish that behaviour
pyruvic acid	a three-carbon molecule produced by the breakdown of glucose
racism	the belief that human races have distinctive characteristics that determine their respective cultures, usually involving the idea that one's own race is superior
random practice	the practice routine in which all components of a multitask skill are practised in random order within each practice session
rate of perceived exertion	a scale developed by Borg to describe how an athlete felt when completing the exercise or training
reaction time	the amount of time between a stimulus and the first movement initiated in response to it
recovery	the overcoming of the effects of fatigue induced by an activity program
relative-age effect	term used to describe the trend of players born in the early months of the year to be disproportionally represented at elite level sport
relaxation	the state in which an individual is psychologically and physically free from uncontrolled tension, anxiety and negative thoughts
resistance	in water it is the sum total of skin friction, profile and wave drag
rotational inertia	a body's resistance to change due to the magnitude of the mass of the object and its distance from the axis of rotation
rotational momentum	the product of rotational inertia and rotational velocity
selective attention	the ability to filter out irrelevant background information
self-esteem	the feelings you have about yourself
self-monitoring	a means by which athletes match emotions with performance
self-talk	a technique used to improve concentration; based on the theory that what people say to themselves has an affect on the way they behave
short-term (working) memory	the temporary storage site in the brain for managing information
simulation training	training that mimics the competition environment as closely as possible
skin friction drag	is the resistive force in water caused by water flowing along the surface of the body
social construction	the process by which individuals are influenced by various aspects of culture and subcultures of society
social facilitation theory	seeks to explain the change in player's performance when in front of an audience
social institutions	social practices that are regularly and continuously repeated and legitimised by social norms
social norm	a form of behaviour that is usually accepted as correct and 'proper' by the majority of members of the society
socialisation	the ongoing process by which individuals learn and are taught to conform to existing norms and values
socialising agent	a catalyst for compliance with social norms and values
sociocultural	social and cultural factors combined to influence participation
somatotype	classification of body types according to physique; there are three somatotypes: ectomorph, mesomorph and endomorph
specificity	refers to practice being close to the context in which the skills are performed

specificity of training the principle underlying construction of a training program for a specific activity or skill, and the primary energy system(s) involved during performance, e.g. a training program for sprinters would consist of repeated bouts of sprints in order to develop both sprinting performance and the ATP–PC system

speed the rate of travel of a body without regard to direction

spirometer an instrument for measuring the capacity of the lungs

sport psychology the study of the psychological and mental factors that influence and are influenced by participation and performance in sport, exercise, and physical activity

stabilisation refers to the setting of the body's base of support so that it can act as a foundation for the generation of momentum of body segments

steady state the point reached after the first 3–4 minutes of exercise, when oxygen uptake meets the oxygen demand of the tissue, and heart rate, cardiac output and pulmonary ventilation have reached fairly constant levels

stereotype the fixed, narrow views of individuals' characteristics; a set form or convention

stigma a characteristic mark or a sign of a defect; a stain on reputation

stimulus–response compatibility the degrees of correspondence between a stimulus and its correct response

stroke volume the volume of blood ejected by a ventricle of the heart during systole, the period of a single cardiac contraction

submaximal exercise usually refers to exercise at less than maximal intensity; may also refer to exercise of less than maximal duration

symbiotic relationship that is an interaction of two agencies that is advantageous or necessary for both to function

tapering a reduction in training before a major event to allow for complete recovery and optimal performance due to reduced fatigue and maximum strength or endurance

target heart rate (THR) the heart rate the athlete is aiming to work at to achieve the correct intensity for the energy system(s) being targeted

tidal volume the volume of air breathed in or out with each breath

training principles the rules that an athlete should follow to ensure that individual training sessions and whole training plans are effective in targeting performance goals

values culturally prescribed criteria by which humans evaluate people, beliefs, ideas, symbols and artefacts

variability (of practice) refers to practice sessions that incorporate a variety of movement options and context changes

varied practice a practice routine in which there are variations within the one class of skill

VARK a questionnaire designed to identify a learner's predominant learning style: V = visual, A = aural, R = read/write, K = kinaesthetic

ventilation the movement of air in and out of the lungs

visual occlusion training a method of training an athlete's visual ability to detect cues; involves blocking the pertinent visual stimuli in order to identify key performance cues

vitalisation the process by which sports clubs and managers consciously deal with social changes and changes in the ways that sport is perceived by its members

warm-up the combination of activities (jogging, dynamic stretching, skills) done at a low intensity to prepare the body for more vigorous exercise

wave drag caused by moving along, through or near the water surface

whole practice a practice routine that involves learning a skill in its entirety

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