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NELSON Physical Education Studies FOR WA 3A, 3B

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Amanda Telford

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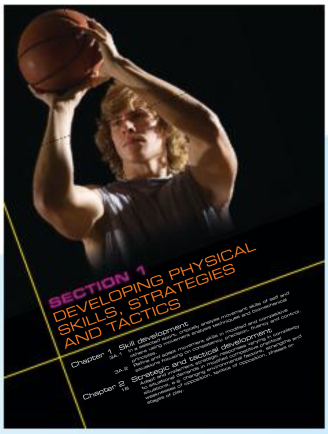
CONTENTS

About this book

Each section of *Physical Education Studies for WA 3A, 3B* lists the chapters and outcomes



In the chapters, you can find the following features.

- Clear, easy-to-read text, with plenty of illustrations, tables and graphs to explain concepts.

- Tactics used in all 14 Curriculum Council sports are discussed in Chapter 2. There are set play examples, interviews, practical activities and websites for further information.
- **Keep it Real** case studies, articles and interviews throughout the text relate theory to real-life situations and real people.

- **Margin definitions** help students learn new terms on the spot. These definitions are collected in the **Glossary** at the back of the book.

DOMS
delayed onset of muscle soreness; soreness as a result of taking part in unaccustomed exercise

- **Checkpoints** activities help students to summarise and review the section they have just completed.

- **Coursework** activities and Labs throughout the chapters provide perfect homework or assessment tasks. It is not expected that all students will do all of the Coursework activities.

> **Coursework**
>
> ## Coaching in practice
>
> **Aim:** Observation of coaching styles
>
> **Procedure:**
>
> Observe two training sessions with two different coaching styles. Record your observations. Your observations should include:
>
> - the sport being played
> - the participants' age group

- **Test your knowledge** sections at the end of chapters provide multiple-choice, short-answer and essay-style questions. Answers are on the book's website: **www.nelsonnet.com.au.**

TEST YOUR KNOWLEDGE

- **Catchy facts** and quotations are sprinkled though the book to make reading this book a lively reading experience.
- Margin icons alert students to direct weblinks and to material on the NelsonNet website.

> **Catchy fact**
> The fastest softball pitchers throw the ball at about 130 km/h. This equates to a reaction time for the batter of 0.341 seconds.

Pineapplehead

Interview with Kay Terry

On the NelsonNet website

The NelsonNet website has:

- written interviews with elite athletes or coaches in all 14 Curriculum Council-assessed sports
- blank templates of all the sporting fields and courts
- an example of an annual training plan
- podcast interviews
- weblinks
- a weblink to the Dartfish website with a 30-day free trial, which you can use with the Dartfish activities in Chapters 1 and 6 of *Physical Education Studies for WA 3A, 3B*.
- references and further reading.

Visit **www.nelsonnet.com.au.**

We hope you enjoy this great book!

Please note: All resources listed throughout the book as available on the student DVD can now be found on the NelsonNet website.

About the authors

Darren McPartland has been teaching since 1990, and has been a Head of Department in Western Australia, the Northern Territory, Victoria and the ACT. He is currently Head of Physical and Health Education at Christ Church Grammar School. Darren has been a strong advocate of the new Physical Education Studies Course in Western Australia, where he has had a number of roles with the Curriculum Council, including moderator and marker. In 2007, Darren organised a very successful professional development day at Christ Church for teachers of the new course, bringing over experts from Melbourne to speak as well as presenting a number of sessions himself.

Adrian Pree has taught Physical Education for 19 years, with 18 of those years spent teaching and developing Physical Education Studies in its various forms. He has also been involved in writing assessments for the Secondary Education Authority (now the Curriculum Council of Western Australia). Adrian has been Head of Physical Education at St Mark's Anglican Community School for 13 years, and has also taught in the United Kingdom. Adrian has been heavily involved in developing local resources for the students in his care in the areas of Outdoor Education, Risk Management, Sport and Martial Arts.

Rob Malpeli has been teaching senior Physical Education for more than 20 years. He has been involved in national professional development and co-authored or produced numerous texts and resource packages for Years 11 and 12 Physical Education. He is a senior teaching fellow at the University of Ballarat and currently teaches at Balwyn High School in Victoria.

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Rob

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Amanda

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SECTION 1
DEVELOPING PHYSICAL SKILLS, STRATEGIES AND TACTICS

Chapter 1 Skill development

3A.1 In a selected sport, critically analyse movement skills of self and others using movement analysis techniques and biomechanical principles.

3A.2 Refine and adapt movement skills in modified and competitive situations focusing on consistency, precision, fluency and control.

Chapter 2 Strategic and tactical development

3B.1 Adapt and implement strategic responses varying in complexity to situational demands in modified competitive practical situations; e.g. changing environmental factors, strengths and weaknesses of opposition, tactics of opposition, phases or stages of play.

1 Skill development

> Strategies and Tactics – measure these in terms of five things, use these assessments to make comparisons, and thus find out what the conditions are. The five things are the way, the weather, the terrain, the leadership, and the discipline.
>
> **Sun Tzu, about 500 BC**

Introduction: Advanced tactics, strategy and skill

Figure 1.1 A star: Cathy Freeman

Strategy

A strategy takes a long-term view of a team and its overall plan. The strategies developed by a team should always look at the big picture. Strategies are normally prepared before a competition starts, and may need to be adjusted by the coach as the circumstances of the competition change

Differences in strategy are quite evident in international soccer: the Brazilian team strategy is based on attack, whereas the Italian teams base their game on defence. Some teams, such as England, have never totally committed themselves to either an attacking strategy or a defensive strategy, and this could be one of the reasons for their poor performances at international level. In recent times, the AFL has followed the strategy of recruiting players whose dominant asset is speed. To detect speed, important measures are the 20-metre and 40-metre sprints and the vertical jump tests performed at the draft camp.

Some coaches use the notion of a 'game plan' to describe their strategy. A game plan is more than just a strategy: it includes tactics, goals and team rules. Once a strategy has been decided upon, the coach or the team need to develop a range of tactics to help them implement it.

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Tactics

Tactics are the methods or actions a team or player uses to help move towards success and achieve their desired goal. Tactics vary with circumstances, and will often change over time and due to different environments. A tactic can be implemented as one or more tasks.

tactics
methods or actions used to achieve a goal

Keep it real: Attack or defend?

The Italian National Soccer Team will set up a defensive formation, take very few risks and often only play a lone striker. They attempt to score goals on the counter attack.

In contrast, the Brazilian National Soccer Team plays a more free-flowing style, with up to three forwards up front. They take more potential risks defensively because of the space available on their backline. Both teams have had success as World Cup champions; however, Brazil has been more successful.

Checkpoints

1. Think of an elite sport that you are familiar with, and describe two teams that have opposite strategies.
2. What tactics do think each team would need to use to help them make their strategy successful?
3. Describe the strategy that you believe would be successful in a sport you are currently involved with.
4. What are the main tactics you would use to help this strategy become successful?
5. Watch a sport that you are unfamiliar with, then discuss who are the most skilful athletes. Possible sports include European handball, table tennis and lacrosse.

Skilled athletes

Skilled athletes often look as though they are playing or performing in a different time continuum. People who have been in car accidents often report that time 'slowed down' just before the accident. Scientists believe that the speed of the brain has sped up to such a point that it seems that time has become relatively slower. Some people believe that skilled performers may have a similar brain response when they are playing sport.

Advanced skills

There are various factors that make up a skilled performer. The abilities that skilled performers elicit are a type of intelligence, just like the ability to do mathematics, learn a foreign language or play music.

A skilled performer exhibits these traits. They:

- are not affected by environmental influences
- perform well under pressure
- execute simple skills perfectly on a regular basis
- execute complex skills to a high level when others falter
- make appropriate decisions about which skills to use
- time their movements so that they always seem to be in the right place at the right time; they are able to read the play.

It is quite easy to identify a highly skilled performer. The way someone looks and moves is often a good guide to determining whether or not they are skilful. Even if you had never seen an elite volleyball game, it would not take very long to determine who were the most highly skilled athletes. Looking at each player's ability to jump, spike, block and defend would help you determine how skilful each player is.

lockout
when media and the public are not allowed into a training venue

full-ground rolling zone
when a team moves as a whole to have more players near the ball, but with players maintaining their positions

Advanced tactics

Coaches in elite sport spend a lot of time, energy and resources developing tactics that will help their team gain an edge over their competitors. Coaches develop defensive and offensive tactics. Lockouts in Australian Rules football are designed to stop opposition teams gaining access to training sessions where a team is refining its tactics.

In 2008, Hawthorn won the AFL premiership using several tactics that had taken them four years to develop. One of these tactics was a full-ground rolling zone. However, the best tactics in the world will not be successful unless the athletes have a skill level that is high enough to carry them out effectively.

Figure 1.2 Manchester United in the Champions League

Classifying sports

In order to group strategies and tactics into similar groups, it is necessary to classify them. The criteria used for classification might differ significantly depending on the observer's opinions.

One simple classification system would be: ball sports versus non–ball sports. This system defines only two categories, with little in common between the activities. Soccer and squash are two ball sports identified in this simple system; they are both ball sports but they have little in common and very few transferable tactics.

Table 1.1 contains several sports that are difficult to categorise. For example, water polo is an evasion/invasion sport, but it is predominantly aquatic in nature. Skill at water polo and the ability to swim competently are connected, and this makes the decision about categorising the sport open to interpretation. Other examples in Table 1.1 that are difficult to categorise are marked like this: **.

The classification allows us to group similar activities, so that inferences can be made on the transfer of strategies and tactics. This may be helpful for performers hoping to draw on tactical knowledge from a sport that they know, and utilise it in a new sport in order to fast-track their progress.

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Table 1.1 Classifying sports

General category	Examples	The 14 Curriculum Council sports	Sample tactical problem
Evasion games	Australian Rules football	Yes	Set plays from restart Set plays in offence; open plays in offence Set plays in defence; open plays in defence Pressuring the ball carrier to force a turnover One-on-one pressure Playing formations
	Soccer	Yes	
	Hockey	Yes	
	Netball	Yes	
	Touch	Yes	
	Basketball	Yes	
	Rugby league		
	Rugby union		
Net/wall games	Tennis	Yes	Starting Attacking from set and open plays Defending from set and open plays Playing formations
	Badminton	Yes	
	Squash	Yes	
	Volleyball	Yes	
Aesthetic sports	Gymnastics		Starting Gaining position Finishing Transitions Wave selection
	Surfing**		
	Diving		
Aquatics	Swimming	Yes	Starting Finishing Transitions Attacking Defending Turns
	Water polo**		
	Rowing		
	Kayaking		
	Sailing		
Combat sports	Boxing		Attacking Defending Scoring points versus gaining advantage Negating opponent
	Wrestling		
	Martial arts		
Cycling	Road racing		Starting Mid race Finishing
	Track cycling		
	Mountain biking		
	Triathlon**		
Target sports	Golf	Yes	Beginning Sequences Recovery Conservative
	Archery		
	Ten-pin bowling		
	Lawn bowls		

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General category	Examples	The 14 Curriculum Council sports	Sample tactical problem
Striking and fielding sports	Cricket	Yes	Fielding: attacking
	Softball	Yes	Fielding: defending
			Batting: attacking
			Batting: defending
			Last ball of innings in special circumstances
Athletics	Track events		Starting
	Field events		Mid-race
			Finishing
			Field event planning
Extreme sports	Rock climbing		Speed
	Skateboarding		Technical sections

General tactical principles

The information in Table 1.1 summarises tactical problems that may be common to the sports in each category. The list is not exhaustive, but it does provide a framework that can be used to start planning which tactics to use in order to achieve a specific strategy.

We need to look at some of these tactics in more detail to grasp the key concepts.

1 Evasion and invasion games

Evasion and invasion games usually have large numbers of competitors occupying the same area, sometimes with restrictions, in order to score in a designated area.

They are based around similar core principles, including pass and move, maintaining possession, controlling the space and penetrating a designated area. The large number of competitors make strategising and responding to the opposition a complex task. Outscoring the opposition is the main focus, although in some sports on certain occasions the key is to minimise the damage.

KEEP IT REAL!

In the case of a soccer team playing a home-and-away leg of a cup game, such as the Champion League Knockout phase, the coach might decide that a draw in the away fixture is as good as a win. This is because if both legs leave the teams even on aggregate, then the away goal rule comes in, effectively doubling any away score. If the away score is a 1–1 draw, and the home is a 0–0 draw, the away goal rule is applied and the team who scored away from home in the draw moves through to the next round.

Evasion and invasion games make up the majority of team sports, so these will be looked at in more detail.

In evasion games, opposing teams need to possess the ball and invade each other's space to score. In looking at the tactics and strategies of evasion games, it is useful to categorise the structure of the game into three parts: attack, defence, and when possession is in dispute. In other words, either *we* have the ball, *they* have the ball or *no-one* has the ball.

Attack principles

Creating space

Space is created by holding width or staying well forward or back. The objective is to spread the defence, creating spaces that your team can attack through. Having attackers spread across the field provides opportunities to switch the angle of attack.

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Holding players behind the ball
Having players behind the ball when in attack serves several purposes. These players are:
- in an outlet position should the ball player or carrier get into trouble
- able to quickly move to an appropriate defensive position if the ball turns over
- able to move into spaces created by other players.

Taking a defender out of play
This is done to provide the attacker with an extra player. It can be achieved by:
- screening a defender
- passing the ball past a defender
- performing a 'scissor' move, by running forwards and then doubling back behind the defender.

Motion offence
Motion offence involves the attacking team moving the defenders around, either as the result of a set play or as an intuitive move. Motion offence attempts to:
- make the defenders move, creating space behind them. If the defender does not follow the moving attacker, then they are in an open position to receive the ball
- make the defender 'lost' from their direct opponent
- force the defenders to adapt to different positions and situations.

Defence principles
Depth
Depth in defence means trying to get as many players as possible between the goal and the ball to protect the goal. The aim is to limit the amount of space the opposition can move into. It is important that the defending team is appropriately spread out, as it is easy to pass defenders who are in a straight line.

Zone defence
Spreading players across the major attacking areas helps to limit space, and is also effective against a motion offence. Players tend to look after an area on the field, rather than being responsible for a direct opponent. A zone could include all players or just some players. Some sports, such as Australian Rules football, refer to zone defence using all players as a 'flood'.

Delay
By slowing the attacking team, a defender provides time for their team to set up an appropriate defence structure. Delaying can be achieved by:
- sending the ball over the sideline, or as far as possible downfield
- getting one or more defenders directly in front of the ball to force the attackers to go wide.

One-on-one defence
In one-on-one defence, every player has a responsibility to oppose one other player. Everyone knows their specific defensive role. This system can be very effective if, player for player, one team is superior to the other in the majority of positions. The brief to players in a one-on-one defence is simple: cover your direct opponent when the other team has possession.

One disadvantage is that players can become less team-oriented and solely concerned with negating their direct opponent. This can discourage players from leaving their player to go to a direct contest where the ball is in dispute.

2 Net and wall games
Net and wall games are characterised by smaller numbers of players. The key principle is to get the ball to ground on the other team's court. In tennis and squash, the ball must bounce twice to be deemed indefensible. In badminton and volleyball, the aim is to get the shuttle or

ball to ground in the opposing court. Forcing the other team to hit the object out of court will achieve the same result.

Tactics revolve around defending your own court when the other team is in possession, and setting up suitable attacking plays in order to get the object down in the opponents' court.

KEEP IT REAL!

Tennis players can be generally categorised into baseliners, serve-and-volley specialists, or all-court players.

The baseliner's tactic is to move their opponent around the court until they can use a short or angled ball to create an opening to win the rally. This is more a war of attrition.

The serve-and-volley player is attempting to reduce the time their opponent has to react by running in behind a serve in order to take the return as a volley and create an instant opportunity. This is a good method to shorten points, and can be beneficial if a player has an injury.

Roger Federer is a great example of an all-court player. He has the necessary skills to rally from the baseline, or he can move in behind a serve to force quick results. This means he can respond to players who are continually slicing slow returns by putting instant pressure on the next stroke. This has allowed Federer to dominate men's tennis, amassing some 14 Grand Slam titles. Pete Sampras was the dominant player prior to Federer, and he was also an all-court player.

Coaches should consider which category their players fall into when devising a game plan.

Figure 1.3 Roger Federer and Pete Sampras, two all-court players

3 Aesthetic sports

Aesthetic sports are characterised by external subjective judgements on performance. The criteria for each activity are analysed by experts in the field, who then give an instant response. The subjective nature of the judging often creates controversy.

Tactics are usually very specific to the timing of the performance. For example, in gymnastics or diving the difficulty of a routine might be changed in response to an opponent's performance. An ice skater may decide not to go for a triple spin in their

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final pass if they do not require the highest number of points to win. However, if they are behind on the scoreboard, their only tactical option is to go for a difficult, highly risky routine.

KEEP IT REAL!

Surfers make instant decisions based on the wave they are riding and the tactics they are going to employ. If the wave becomes hollow and allows tube riding, surfers have the option of going into the tube or riding on ahead to perform re-entries and cutbacks. Tactics may have been thought about before paddling into the wave, but often the shape of the wave determines the decision. Professional surfers can sometimes choose the wrong option – resulting in severe injury or death.

Figure 1.4 The shape of a wave often determines a tactical decision

4 Aquatics

Aquatics refers to water-based sports. This environment is unique, as water creates unique obstacles that performers need to overcome. It can be argued that surfing belongs in this category, but because of the aesthetic nature of the judging at surfing competitions, the strategies are fundamentally different.

Aquatics can be divided into sub-categories that help define tactical differences. Kayaking, rowing, sailing and swimming are race-based activities; their tactics revolve around having a race plan aimed at minimising time and maximising speed.

Sprint events focus purely on good preparation, fast reactions and the correct arousal levels. Distance events rely on all of the above, plus a comprehensive race plan. The race plan must include 'what if' scenarios, in case the race follows a totally unexpected format. In a sailing event, if some yachts head out to an unusual part of the course looking for wind shifts, then all crews could be advised to cover the move, regardless of their own race plan. This could be especially true if the wayward yachts are all crewed by locals with specific knowledge.

Water polo, which also fits the category of an invasion sport, is simply about pass and move to create space in order to outscore the opposition. The usual principles of evasion and invasion games apply, such as tactics from stoppages, with the added complication of swimming to generate all tactics. There is very little transfer in tactics for a netball player or soccer player who takes up water polo.

5 Combat sports

The tactics in combat sports are based on outscoring or rendering unconscious the opponent by striking to legitimate areas of the body. Physical conditioning is crucial in being able to execute tactics, as the physical punishment received is unique to these sports. Combat sports are often seen as the ultimate test of character: they pit two people against each other in a confined space, with the aim of beating the opponent.

Tactics revolve around using set combinations and movements in response to the opponent's position. The wrong decision will sometimes be instantly painful.

KEEP IT REAL!

Tactics

In the 1987 America's Cup between Australia and America, wind shifts during the seventh and deciding race were the deciding factor in ending the 132-year unbeaten record of the New York Yacht Club.

After initially going to a 3–1 lead, the Americans looked set to hold the title, raced in the fickle winds off Rhode Island, New York. The famed *Australia II*, with its mystery winged keel, fought back to level at 3–3.

In the deciding race, the Americans were in front. Then, surprisingly, Australian skipper John Bertrand headed out wide on the course, looking for more wind. The tactic was risky, but when the boats came back together, *Australia II* was in front. All that was left for the Australians to do was to cover the Americans' moves to make sure that both yachts received the same amount of wind. *Australia II* held on to make history.

Figure 1.5 *Australia II* skipper John Bertrand

Catchy fact

The Australian Prime Minister at the time of the 1987 America's Cup victory, Bob Hawke, said the day after the race that 'any boss who makes his employees go to work today is a mug'. This may have been because the race finished in the early hours of the morning.

6 Cycling

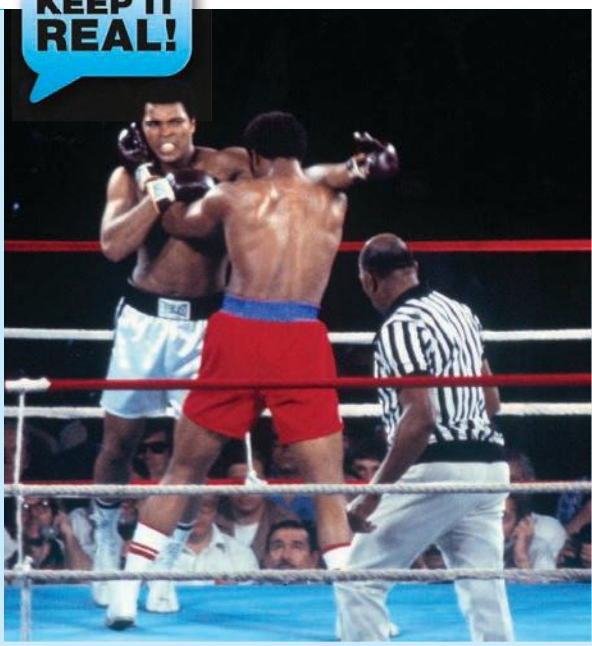
There are many tactics involved in elite road cycling and often tactics, rather than strength, decide the winner. Because of the high drag forces, most cycling tactics involve sheltering from the wind or forcing other riders to ride in the wind. Following are some of the common tactics.

Lead-out rider

The speeds in elite-level cycling sprints exceed 60 km/h, so having a team mate to shelter you and put you into good position is invaluable. Top-level sprinters like Australia's Robbie McEwen use a lead-out rider to shelter them until they launch their final sprint for the line. Having a lead-out rider in front allows them to save their energy until the end of the race.

KEEP IT REAL!

Muhammad Ali



Ali used rather extreme tactics in his efforts to defeat George Foreman in the famous 1974 fight known as the 'Rumble in the Jungle'. Foreman was famous for being the hardest body hitter of all time, so most fighters used tactics to avoid his blows. In pre-fight conferences, Ali spoke of using his famous 'dancing' tactics to escape his opponent. This influenced Foreman's training, as he was expecting a fast-paced fight.

When the fight started, Ali didn't dance: he went straight to the ropes and stood there, absorbing all of Foreman's blows. The tactic was called 'rope a dope', and Ali managed to exhaust Foreman after several rounds. Then Ali moved in and knocked out Foreman, winning against the odds. This was at great personal cost for Ali, as he took severe punishment in the fight and was never quite the same again.

Figure 1.6 Muhammed Ali (facing) and George Foreman

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False Tempo

If a rider is struggling or cannot climb very well, they will often ride at the front of the bunch, but at a slower pace than a stronger rider would ride. This is a bluffing tactic, used in the hope of getting the whole bunch to slow down. The same slowing tactic is used to protect a team-mate in a breakaway; the breakaway rider's team-mates will pretend to be helping with the chase while doing their best to slow it down.

Leaving a breakaway to fry

Often sprinters' teams will leave a breakaway group dangling just a few minutes ahead of the peloton, in the hope of avoiding the counter-attacks that follow the capture of a breakaway. This allows sprinters' teams to ride a steady tempo at high speed, and prevents other riders from surging ahead and spoiling the chance for a bunch sprint.

Cross winds

In crosswinds, strong teams decide which side of the road to ride on; this determines if they give shelter to any other riders. If a strong team masses at the front of a race in a crosswind, they can rip the peleton apart. Many races have been lost because riders were caught at the back of the peloton when the course turned a corner and hit a crosswind.

Counter Attacking

Launching a counter-attack just after a breakaway has been caught can be a very successful tactic. Often the sprinters' teams will be tired from chasing or riding tempo; they will be slowing down and looking for someone else to take the responsibility of chasing. This hesitation can give a rider the gap needed for a winning move.

KEEP IT REAL!

In 1988, the average golf handicap in the United States was 18. With all the advances in technology and widespread knowledge of coaching principles, strategies and tactics, you would expect this handicap to have come down significantly. However, the average golf handicap in the United States is still 18.

Some professional golfers argue that coaches are too focused on the mechanics of the swing, and not focused enough on course management. The great golfers have the ability to achieve low scores even when they are not hitting the ball at their very best. They are able to minimise the damage on the course by using conservative strategies when times get tough.

Maybe you are aware of Greg Norman 'choking' during the 1996 US Masters, when he took a seven shot lead into the final round. He still had all the swing capabilities that had taken him to such a lead, but he allowed his rivals to catch up to him because of poor course management. Unbelievably, after hitting one ball into the water, Norman attempted an almost identical shot as his recovery, with the same result. This poor tactical decision in the heat of battle will always cloud public perception of the golfer known as the 'Great White Shark'.

Nick Faldo chased down the score and, with nothing to lose, took risks at the appropriate times. The pressure mounted during the round as Faldo closed in. The rest is history, as Greg Norman succumbed to Faldo and lost the 'unlosable'. See p. 306 for more about choking.

7 Target games

Target games involve being the closest to a specific target. In golf, a lower score is the key component. Sports such as ten-pin bowling and lawn bowls involve getting the correct length and accuracy in order to succeed. Archery and shooting are an objective measure of accuracy, although sometimes time constraints will change the tactics.

8 Striking and fielding

Striking and fielding activities focus on striking a projected ball in order to redirect it away from fielders. The fielding team aim to keep the opposition's innings as short and low-scoring as possible. The batting team is aiming to either maximise the score or maximise the time spent batting.

Fielding and batting can be done defensively or offensively, depending on the stage of the competition, and tactics need to be constantly adjusted to accommodate this.

KEEP IT REAL!

In the 2005 Ashes Tour of England, there was very little difference between the two teams. English bowlers were consistently able to make the ball swing traditionally in the first ten overs, and then reverse swing after 15 or 20 overs.

Reverse-swing bowling was popularised by Pakistani bowler Imran Kahn in the mid-1990s.

English batsman Marcus Trescothick later revealed in his biography, *Coming back to me*, that it was well known in English County Cricket that the reverse-swing process could be improved by chewing mints and using the sugar-soaked saliva to speed up the effect. He had even experimented with different brands of mint to find which were most effective. Tactics can be obvious, or devious. (See Chapter 8 for more on the biomechanics of swing.)

Figure 1.7 Marcus Trescothick with the English cricket team

9 Athletics

Athletics events are characterised by maximal athletic performances with a highly specific end result.

Field events emphasise maximising distances; track events aim to maximise speed. Events with a limited number of possible attempts require specific tactics regarding when to focus on a legal scoring effort and when to attempt an all-out maximum.

In high jump and pole vault the number of attempts is unlimited, but fatigue can be a factor if the competitor enters the competition too early. Knowing when to 'start jumping' becomes the key tactic.

Track events have their own specific race tactics. In a marathon, the main tactics are knowing what pace to set and when to break away from the field. These are also referred to as a 'race plan'. Drafting other runners is commonplace; this is a tactic aimed at gaining an advantage by sitting in the disturbed air of the runner in front, thus encountering less air resistance and using less energy.

KEEP IT REAL!

Mary Dekker and Zola Budd

In the 1984 Olympic Games 3000-metres final, Zola Budd tangled with American runner Mary Decker, putting Decker out of the race. Replays showed that Budd and Decker bumped into each other twice, but on the second encounter Decker's spikes caught Budd's heel. Budd used the unusual tactic of running bare foot.

What made Budd's stumble more unusual was that as she fell, her left leg shot out and tripped Decker. Decker was unable to continue and was carried from the track. Budd kept running but was booed by the largely American crowd and finished well down in the field. Decker claimed that Budd had cut in front of her, but this was overturned after Budd's initial disqualification.

The tactic of drafting another runner to reduce wind resistance is common in many sports. In this case, aggressive running by Budd and Decker cost them both the chance of a medal.

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Sprint racing is generally a completely maximal event, although running in heats and semi-finals before the main race requires conservation of energy measured against ensuring qualification.

10 Extreme sports

Extreme sports are characterised by perceived and real risk that is beyond what is normally deemed acceptable.

Rock climbing comes in many forms, with some emphasising speed and others emphasising the most difficult route. In an 'on-sight' climb, the competitor is only allowed to view the climbing route seconds before attempting it, and is given no time to select the simplest route.

Skateboarding also has many different forms, with some emphasising speed and others using judgement based on aesthetic criteria.

Checkpoints

Important tactical traits in Australian Rules football are:

- high skill level
- willingness to follow team tactics
- decision-making ability – choosing the appropriate tactic at the appropriate time
- being a team player
- ability to withstand pressure
- ability to stay composed
- flexibility
- ability to play within the rules of the game and not give away free kicks
- ability to read the opposition's strengths
- ability to read and anticipate the opposition's tactics
- good communication with team and coaches
- ability to adapt to different environmental conditions.

1 In a sport of your choice, outline a set of traits that you consider would be beneficial to a potential player. Use the list above as a guide.

2 Do you think there is a generic list of skills that is unique to all sports? What are they?

3 From the different classifications of sports, identify two highly specific traits for each; for example, Invasion Games, Net or Wall Games, etc.

4 Compare these six players on their skill level:

Buddy Franklin (Australian Rules football)
Matthew Pavlich (Australian Rules football)
Chris Judd (Australian Rules football)
Tiger Woods (Golf)
Ronaldo (Soccer)
Serena Williams (Tennis)

a List the special skills they possess.

b Use a highlighter to show any skills that all six players have in common.

c Which skills are specific to their particular sport?

Sport-specific advanced tactics

In this section, we examine specific advanced tactics across a range of sports. Interviews with highly experienced coaches are included to give you further insight into the use of tactics in elite sport. The more variables within a sport, the more tactics can influence the outcome of the competition.

The first column in Table 1.2 lists the sports we are going to examine in detail in Chapter 2. The second column ranks each sport in terms of the number of variables, from highest to lowest. The variables include number of players, rules, field size and the number of substitutions available. Read through the rankings carefully, keeping the number of variables in mind. Do you agree with the ranked list? What order would you place the sports in?

Table 1.2 Sport rankings in terms of the number of variables

Sports examined	Ranked list
1 Australian Rules football	1 Australian Rules football
2 Badminton	2 Hockey
3 Basketball	3 Soccer
4 Cricket	4 Basketball
5 Golf	5 Cricket
6 Hockey	6 Netball
7 Netball	7 Volleyball
8 Soccer	8 Softball
9 Softball	9 Touch football
10 Squash	10 Tennis
11 Swimming	11 Golf
12 Tennis	12 Badminton
13 Touch football	13 Squash
14 Volleyball	14 Swimming

Other sports:
15 Cycling
16 Athletics
17 American football

Coursework

Enhancing your performance

In this assignment, your goal is to improve your performance of the skills associated with tactical problems in a physical activity.

In Task 1, you will be demonstrating the execution of the skills, tactics and strategies in a tournament situation.

In Task 2 you will use video analysis to reflect on your performance, using your experiences and the information collected to complete a reflective analysis relating to movement, skill and strategic and tactical development.

Task 1

First, select and perform the skills and strategies associated with tactical problems in your sport of study. You will be assessed on your ability to perform effectively in an authentic competitive situation. Your teacher will judge your achievement. To achieve this, you must:

a participate in a series of development lessons

b participate in a doubles tournament or work with a partner as a mentor, applying a range of movement skills, strategies and tactics

c apply communication and cooperation skills in making decisions and taking actions.

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Task 2

Based on your experiences in Task 1, complete an analysis reflecting on your performance.

Stage 1

a Select your **tactical problem**, determine the skills that are required and video your performance.

b Provide a description of the tactical problem and the core skills you selected, then select one skill and carry out the following tasks.

- Analyse and reflect on how it was performed and when it was used in a game, including both offensive and defensive examples.
- Identify why you decided to concentrate on this skill.
- Identify aspects of your technique that require improvement, and describe the changes that need to be made to move into the next phase of learning.
- Identify any strategies that were taken into consideration, e.g. position on the court, your opponent's skill level.

Stage 2

View the video of yourself executing your chosen **skill**, and describe what you looked like. Include:

a the major phases of the action in relation to the range of motion

b how knowledge of this information was used to improve performance.

- Identify how concentration and arousal affected your performance, both positively and negatively.
- Identify evidence that shows skill improvement.

Figure 1.8 Video of a learner practising bowling

Coursework

Observation and analysis of skill development

Refer to the Dartfish video demonstrations on the student DVD in the back of the book; they show two athletes performing their chosen skill.

1 Compare the two videos provided in the Dartfish analyser. Which action would enable the person to perform more efficiently, if all other factors were constant?

2 With reference to the videos, identify and explain three biomechanical principles that apply to the successful demonstration of the skill for maximal performance. Create Key Positions to highlight the principles, and annotate your answer.

3 Identify four stages in the observation and analysis process for skill development.

This assignment can be completed in conjunction with the sample Dartfish trial on your DVD.

Activities above thanks to Dartfish

www

Dartfish

TEST YOUR KNOWLEDGE

>> multiple-choice questions

1 The global outlook from a coach regarding a game plan is known as:

A creating and denying space
B strategy
C tactic
D offensive and defensive synergies.

2 Invasion sports have very complex strategies and tactics because of:

A the large number of participants on the arena
B constantly reviewing the zone and one-on-one defence needs
C players continually making decisions that are not controlled by the coach.
D All of the above.

3 Maximising your performance in the eyes of external subjective judges is a characteristic of:

A combat and aesthetic sports
B aquatics and aesthetic sports
C target games and combat sports
D net games and target games.

4 One-on-one defence is very effective if:

A your players are better than the opposition players
B your players are weaker than the opposition players
C the field is smaller
D the opposition has a height advantage.

>> short-answer questions

1 In a team sport of your choice, outline different tactics for defensive, offensive and midfield players.

2 Using an example, explain the difference between a zone defence and a one-on-one defence.

3 Imagine that you are a talent scout at the national championships, in a sport of your choice. What characteristics are you seeking in the players you are recommending?

4 What impact has technology had on tactics? Provide some examples.

>> essay questions

1 In a sport of your choice, design a strategy for your team at a major tournament. Assume this will involve a state championships round-robin format. You will be playing numerous opponents over a number of days. Consider the following in your strategy.

a Recovery between games
b Tactical variations, taking into account opposing teams who are attacking; defensive; have a star player; have a very tall player; and who have won the tournament many times before
c The characteristics your players would require in order to achieve your tactics

2 Many coaches now use regularly timed substitutions in sports that have an interchange bench. Discuss and debate the benefits of using this system. Explain how this could be used to extend the effect of your overall tactics.

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2 Strategic and tactical development

Specific strategies and tactics

> Leaders establish the vision for the future and set the strategy for getting there; they cause change. They motivate and inspire others to go in the right direction and they, along with everyone else, sacrifice to get there.
>
> **John Kotter, 1999**

Figure 2.1 Two West Australian athletes: Jamie Harnwell and Steve Hooker

In examining skills, strategies and tactics in your sport, you will spend a lot of time on the court, at the oval, or down at the pool, etc. It is also important to spend time examining the successful strategies and tactics that are being utilised at the elite level. Many high-level coaches adapt strategies and tactics from other sports in an attempt to gain a competitive edge.

In this chapter, we have enlisted some of Western Australia's top-level coaches and players to provide an insight into the specific strategies and tactics they utilise in their particular sports.

For each sport, there is an interview, an example of a set-play and a discussion of the environmental influence on tactics for each of the 14 Curriculum Council examinable sports. There are also blank fields for each sport on the DVD so that you can develop your own specific tactics.

set play
a series of pre-practised movement patterns typically used by sporting teams that follow a set sequence

Interview with John Worsfold

Australian Rules football

See the student DVD at the back of this book for an interview with John Worsfold, current coach of the West Coast Eagles. Worsfold was a dual premiership player and club captain in 1992 and 1994. He coached the Eagles to two Grand Final appearances, including the 2006 Premiership. Worsfold attended South Fremantle Senior High School.

Set-play example

Ruckman running forwards after the centre bounce

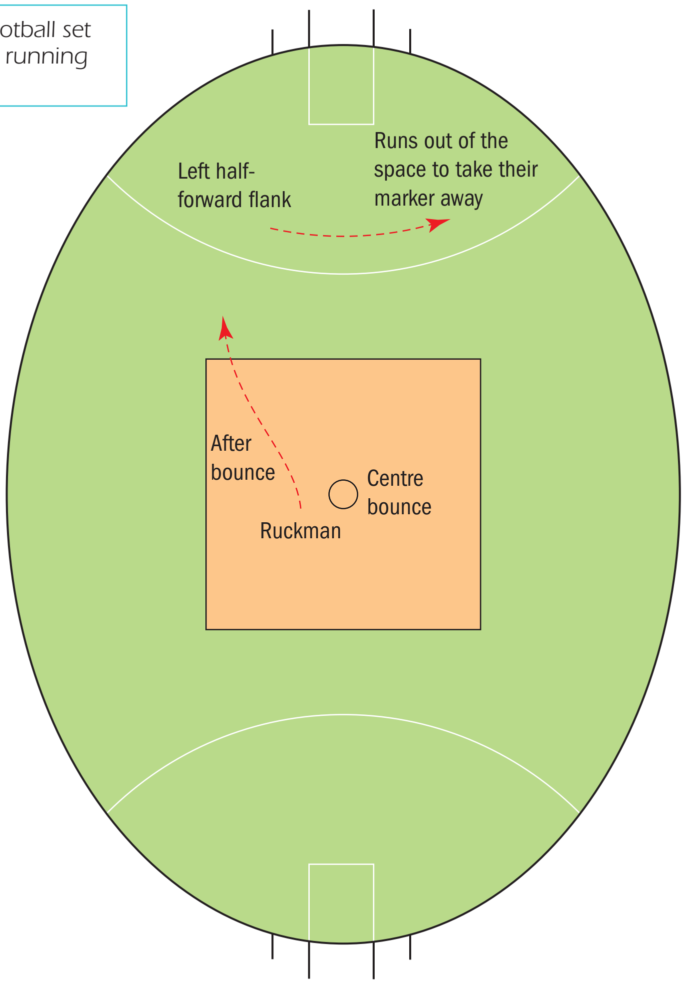
The ruckman is less likely to influence the play after they have tapped the ball. One attacking tactic is to have the ruckman run forwards immediately after the bounce. Both Dean Cox (West Coast Eagles) and Aaron Sandilands (Fremantle Dockers) do this.

Players on the half-forward line need to move out of the space on one side. If a team gets the ball, they know their ruckman is free at half forward. The opposition ruckman often gets caught watching the ball in the middle of the ground.

Things to consider with this tactic:

- It is a gamble, as the other team may get the ball, and then the ruckman is out of the play.
- The opposition ruckman may do exactly the same thing.
- The tactic can be nullified by teams that play a spare man in defence.
- This can also be used at a stoppage around the ground; your team needs to clear space for the ruckman to run into.
- It is most successful when the opposition team is playing a man-on-man defence.

Figure 2.2 Football set play: Ruckman running forwards



Catchy fact

The 'zone defence to kick out' tactic was first used by the Brisbane Lions, under coach Robert Walls. This then evolved into a flood-defensive system by the Western Bulldogs (under coach Terry Wallace) and Sydney Swans (under coach Rodney Eade). In 2008, Hawthorn won the AFL Grand Final using a full rolling-ground zone defence.

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How the environment changes the tactics

Weather

Now that some Australian Rules football games are played 'indoors' on occasions, the impact of weather has been reduced. Also, the grounds are very well looked after, so the effects of water and mud are not as great as they once were.

Wet conditions

During wet conditions, it is important to limit the number of possessions. Teams must not let the ball get behind them in defence, as it takes a long time to turn the ball around.

High winds

In high winds, keep extra players in defence when your team is kicking against the breeze.

AFL football field diagram

Checkpoints

Describe one defensive and one offensive strategy used in this sport. Use the blank diagram provided on the DVD to supplement your answer, or draw one yourself.

The AFL website is a good place to look for more information on Australian Rules football. You can link directly to the website via the weblinks on the student DVD.

Australian Rules football

Badminton

See the student CD at the back of this book for an interview with Kay Terry, a former state, national and international badminton player. She is the current coach of the Western Australian Under-17 Badminton Team.

Interview with Kay Terry

Set-play example

Playing short and long in singles

With the rear tramlines 'in' for service in singles badminton, the logical set play to use extends that principle. When serving to the backhand court, place the shuttle deep into the corner inside the tram lines.

This gives your opponent two options. They can either:

- run around the service and take it on the forehand side for a powerful, clear shot or drive, leaving them exposed to a cross-court winner on the next shot
- play the shuttle on the backhand side and risk a weak, shallow return that will allow you an easy put-away smash.

After serving the shuttle deep to the backhand side, it is important to close on the net and intimidate your opponent.

Catchy fact
The best shuttlecocks are made from feathers from only the left wing of a goose.

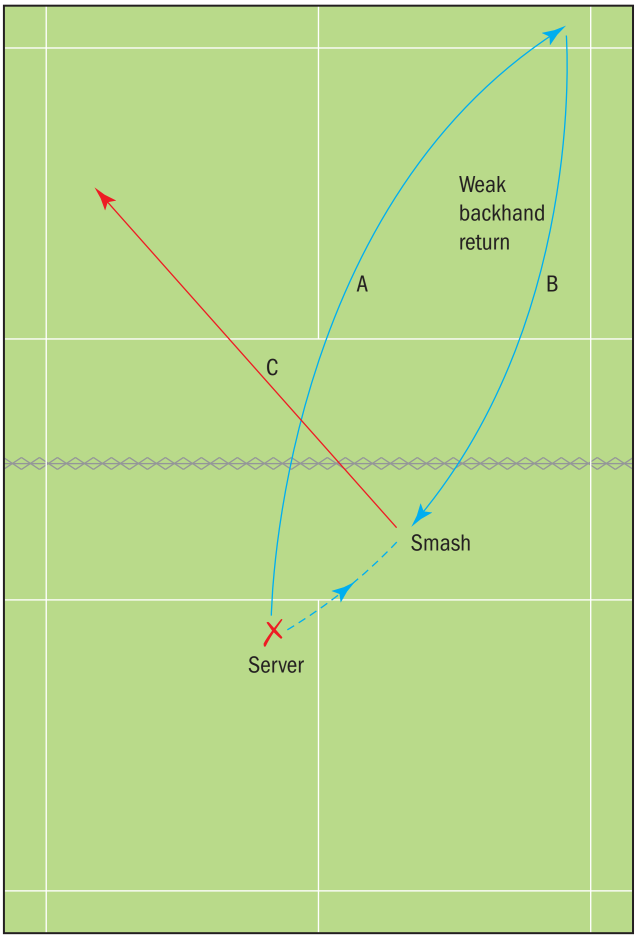
Figure 2.3 Maria Kristin Yulianti of Indonesia playing the shuttle on the backhand side

How the environment changes the tactics

Playing against a left-hander

Defensive shots in badminton are generally sent deep into the court on your opponent's backhand side. (Or to the right of your opponent as you face them.) If you are playing a left-handed player, this would place the shuttle on their forehand side and give them an opportunity to attack. Changing to hit the shuttle to the other side of the court will require concentration and practice; in a fast-moving game such as badminton, much of the movement and skill execution is done almost by reflex.

Figure 2.4 Badminton set play: Deep serve to backhand court



Badminton

The *Badzone* website is a good place to look for more information on badminton. See the weblink table on the CD at the back of your book for more detail.

Badminton court diagram

Checkpoints

Describe one defensive and one offensive strategy in badminton. Use the blank diagram provided on the DVD to supplement your answer, or draw one yourself.

Basketball

Interview with Andrew Vlahov

See the DVD at the back of this book for an interview with Andrew Vlahov. Andrew is in his 18th season with the Perth Wildcats as both a player (including captain) and administrator. He is a four-time Olympian, a Perth Wildcats legend, and he is currently the team's managing director. Andrew attended Kent Street High School, then Stanford University in the USA.

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Set-play example

Box-and-one defence

A box-and-one defence is an extension of zone defence, where one defender plays a one-on-one defence on the opposition's best player. The defensive team sets up a 2–2 zone defence, protecting the key way with the other four players. This defence is used to try to limit the impact of one player, usually a player who is a good outside shooter and play-maker.

For box-and-one defence, you need to consider the following

- You need to have a great defender to play this role.
- The remaining defenders will be under a lot of pressure on the base line and low post.
- This defence is very susceptible to outside shots.
- Zone defence is illegal in the NBA.
- It is unlikely you would use this defensive system for the entire game.

How the environment changes the tactics

The type of defence and offence your opponents are running is probably the single biggest influence on the tactics you choose. With many time-outs and substitutions in basketball, it is relatively easy for a coach to change or adapt the tactics they are using. Also the coach is so close to the play that they can yell instructions to their players even at NBA games.

Things that necessitate immediate tactical changes include the following

- A star player being injured or taken out of the game after too many fouls
- A player getting 'hot' when shooting. If the player is on your team, you would set up plays to get the ball to them; if you are trying to defend such a player, you need to limit their shooting.
- A team with bigger and stronger players. This may force you to shoot more from outside the key way.

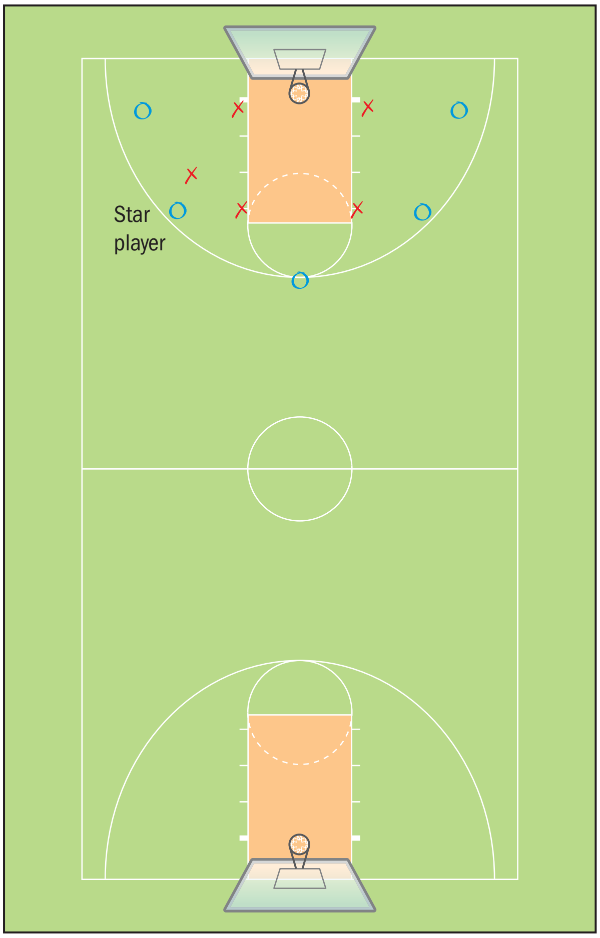

Figure 2.5 Basketball set play: box-and-one defence

Catchy fact
Kenny George was the 2008 University of North Carolina centre. He was 2.37 metres tall, weighed 163 kg and wore size 28 shoes. His best weapon was blocked shots, averaging 5.3 per game. George suffers from acromegaly, caused by excess production of growth hormone.

Basketball

- Playing a team that has played a number of games in a row. If you think your team is fresher, play a running game to fatigue the opposition more quickly.
- The stage of the game. You may need to foul to try and win back possession and limit the time running on the clock. Alternatively, passing the ball quickly and spreading out will make it difficult for the opposition to foul you.

The *Guide to Coaching Basketball* website is a good place to look for more information on basketball. You can link directly to the website via the weblinks on the student DVD.

Basketball court diagram

Checkpoints

Describe one defensive and one offensive strategy in basketball. Use the blank diagram on the DVD to supplement your answer, or draw one yourself.

Cricket

Interview with Tom Moody

See the DVD at the back of this book for an interview with Tom Moody. Tom Moody is the coach of the Western Australian cricket team, the Western Warriors. He also coaches the Punjab Kings in the Indian IPL Cricket League. Before this appointment, he coached Sri Lanka and Worcestershire in English County Cricket.

Tom went to school at Guildford Grammar. As an Australian player, he played in eight Test Matches and 76 one-day games, including the 1987 and 1999 World Cup victories.

Set-play example

Bowling to an off-side field

Batsmen have strengths in playing shots to various areas. Great batsmen such as Mark Waugh, Simon Katich, Zoe Goss and Sachin Tendulkar are masters at taking a ball off the stumps and playing it into the onside field.

A team can employ one of two set plays against this type of player. They can either set a tight leg-side field and then try to negate the strength by blocking scoring avenues, or they can set a strong off-side field and try to tempt the player into hitting across the line. Let us look at the second option.

1. The incoming batsman is identified as a strong leg-side player.
2. The field is set with three slips, a gully, point, cover, mid off, bat pad and third man. By leaving a gap at mid on and on the leg-side boundary, it tempts the batsman to take a ball from outside off stump and hit it into the leg side, where there are many scoring opportunities. However, leaving the bat pad in place casts doubt in the batsman's mind; they could be expecting the odd bouncer. This will make them indecisive.
3. The bowler is required to bowl in a zone just outside off stump, just short of a length. Away-swing bowling is encouraged, and occasionally taking a chance by bowling an off-cutter.

This set play is aimed at taking away the strengths of a player and forcing them to take unfamiliar shots.

How the environment changes the tactics

In this case we will consider a major environmental factor: the effect of the wind. Bowling teams need to consider wind direction when considering bowling changes and field placement.

If an off-spin bowler is bowling to a right-hander and the wind is blowing from behind the batter towards mid-wicket from one end, the fielding team would be wise to do one of two things:

- Move fielders into the deep mid-wicket region right on the boundary.
- Change the off-spin bowler to the other end.

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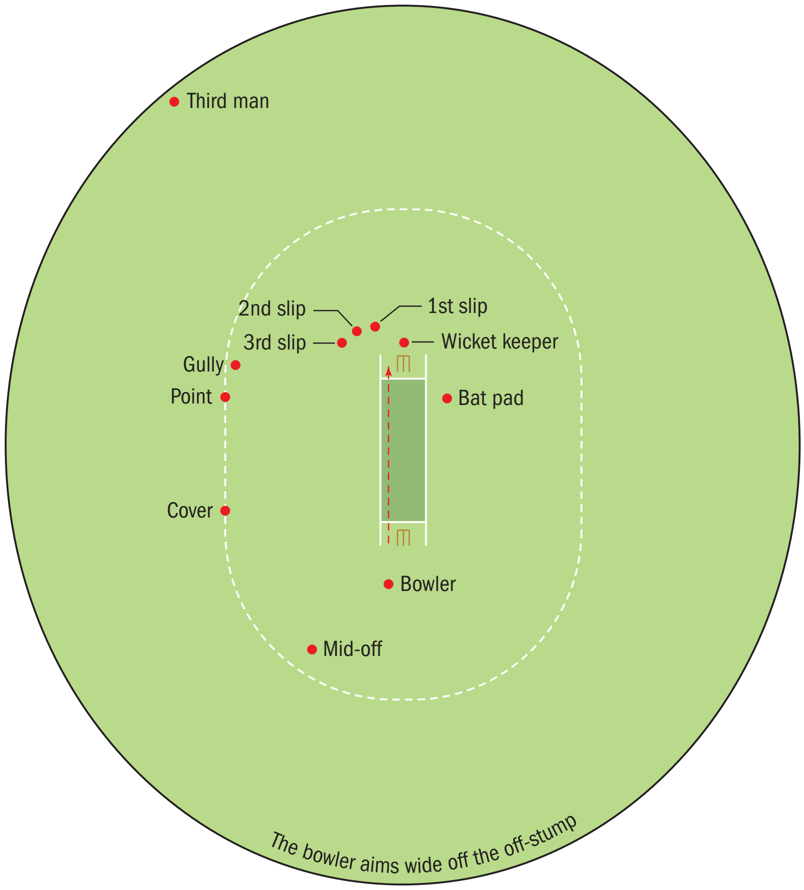

Figure 2.6 Cricket set play bowling to a strong onside player

This is because the batter will be hitting the ball a long way as a result of the wind and the spin on the ball. By switching the bowler to the other end, the batter will be forced to hit into the wind, and will have less chance of clearing the boundary.

An attacking captain may allow the off-spin bowler to continue from the 'dangerous' end, and place an extra few players in the deep, to encourage the batter to take a chance. A clever off-spin bowler may also bowl more topspinners, aimed at hurrying straight on at the batsman and looking for a bowled or lbw decision.

Response to a specific situation

In this example, the batting team has changed the batting order in response to a slow-scoring start by the openers.

The fielding team has identified a weakness: the batter is hitting the ball into the air when it is wide of off stump, and they regularly score many runs in that region. The bowler can deliberately bowl wide of off stump to encourage the stroke, then pack many fielders in the point, gully and cover regions.

This tactic has been used against former Australian great Damien Martyn. Martyn was an excellent player square of the wicket, and this tactic slowed his run rate and led to many dismissals.

The WACA, *Cricket* and *Baggy Green* websites are good places to look for more information on cricket. You can link directly to these websites via the weblinks on the student DVD.

Checkpoints

Describe one defensive and one offensive strategy used in cricket. Use the blank diagram provided on the DVD to supplement your answer, or draw one yourself.

Cricket field diagram

Interview with Drew Dubberlin

Golf

See the DVD at the back of this book for an interview with Drew Dubberlin. Drew is currently head golf professional at Champion Golf Academy, Sembawang Golf Club, Singapore. He attended St Mark's Anglican Community School in Hillarys, Western Australia.

Set-play example

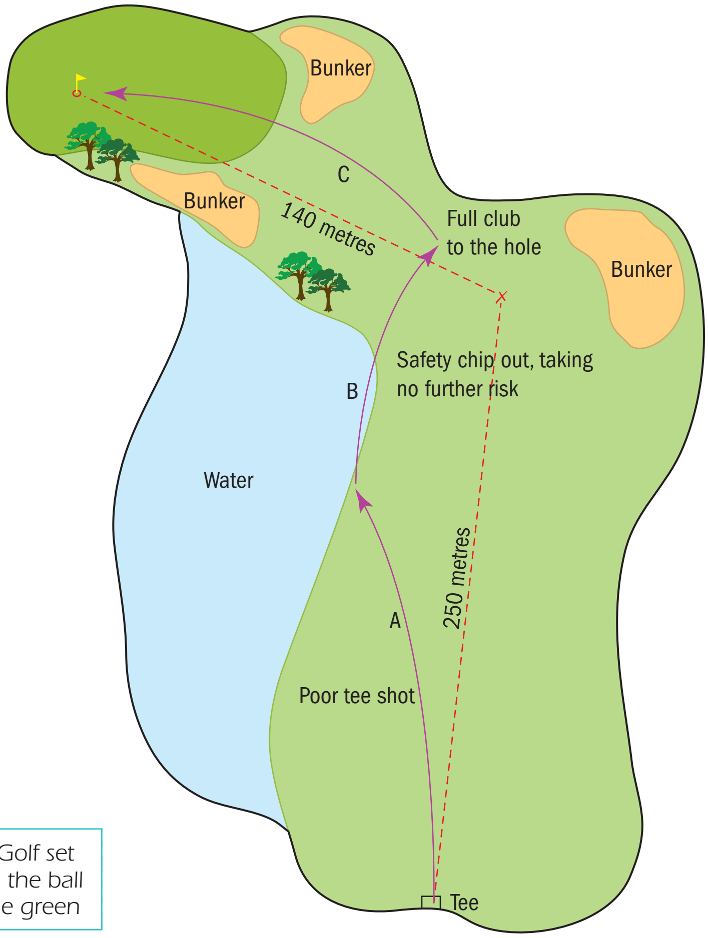

Figure 2.7 Golf set play: getting the ball in sight of the green

Every stroke in golf is essentially a set play. The loft in each club is designed to change the distance and height of the hit; all the player needs to do is execute the swing and select the correct club for the distance.

Imagine that a player has hit a poor tee shot and is off the fairway with no clear path to the green for the next shot. A simple set play is to use a lofted club to chip out and leave the ball in sight of the green, a full club length away. This will mean that when the golfer plays the next shot, they will be able to accurately select, say, a nine iron to hit the shot from 120 metres out, and complete a full swing. This is less likely to result in an error than trying to hit a low percentage recovery shot in an attempt to get near the green, leaving a short 'feel' chip in order to get near the hole.

Catchy fact
The world's highest golf course is the Tactu Golf Club in Morococha, Peru. It is 4370 metres above sea level at its lowest point, which is almost half the height of Mt Everest!

How the environment changes the tactics

Hitting over a water obstacle

Few things are more challenging to a novice golfer than hitting over water, especially on a short par three hole with no option to lay up or hit around the obstacle. However, the problem is purely mental, as the hit relies only on a well-executed swing with the

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correct club, aimed in the correct direction. Thinking about the water before, during or after the swing will lead to useless information cluttering the mind. This is the difference between amateurs and professionals (except, perhaps, Greg Norman in the 1996 US Masters).

Response to a specific situation

Putting to force a playoff on the last hole

In this situation, the player hitting the critical last putt must have one thing clear in their mind. They must choose the correct line, and then make sure the putt does not finish short of the hole. Regardless of the lie of the green, any putt that does not roll past the hole doesn't have a chance to make it into the hole. The old saying 'Drive for show, putt for dough' applies here.

The *PGA* website is a good place to look for more information on golf. You can link directly to these websites via the weblinks on the student DVD.

Golf

Golf diagram

Checkpoints

Describe one defensive and one offensive strategy used in golf. Use the blank diagram provided on the DVD to supplement your answer, or draw one yourself.

Hockey

See the student DVD at the back of this book for an interview with Ric Charlesworth. Ric is a former Australian Women's Hockey Coach, former Australian Men's Hockey Team Captain, former high-performance coach of the Fremantle Dockers and a former West Australian Sheffield Shield cricketer. He is currently the coach of the Australian Men's Hockey Team.

Interview with Ric Charlesworth

Set-play example

Many set plays in hockey are used when the attacking team has a free hit inside their 25-metre line. This could be from a free hit in field play or from a penalty corner.

Free hit just outside the 'D' on an angle

An attacker gives the ball a hard hit a couple of metres short of the near goal post. A player stationary near the goal post deflects the ball away from and across the goal towards the centre of the D. The striker has already moved from the top of the D into this position and flicks the ball over the goalie.

It is important that attacking players try to take the defenders out of the centre of the D. Many defensive systems try to zone this area, to stop set plays of this type. It is important to have players who can quickly adapt to the changing game environment they find themselves in.

Catchy fact

A ball hit from a short corner can travel at 160 km/h. Players defending the short corner wear face masks, groin protectors, shin pads and cricket gloves. They remove the face masks and gloves after the short corner is completed.

How the environment changes the tactics

The change to Supergrass synthetic-turf pitches has made hockey pitches all over the world very similar, although playing in different cities and countries has a large impact.

The Olympic Games hockey matches are often held in quite hot environments, so most countries prepare themselves for playing in the heat.

European hockey players use a more defensive style than the Australians. Australian teams use the change in interchange rules to their advantage by having many substitutions, which allows the players to perform at higher intensities for longer periods of time. The Australian substitutions also make it difficult for other teams to know who their direct opponent is.

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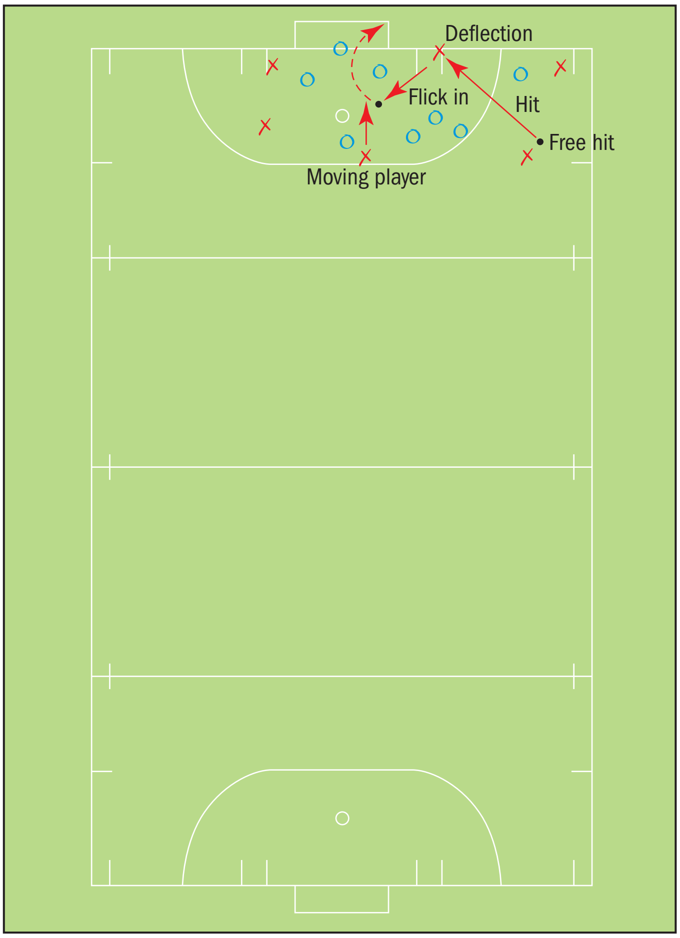

Figure 2.8 Hockey set play: free hit outside the 'D'

Hockey

Hockey field diagram

The *Hockey* and *World Hockey* websites are good places to look for more information on hockey. You can link directly to these websites via the weblinks on the student DVD.

Checkpoints

Describe one defensive and one offensive strategy used in hockey. Use the blank diagram provided on the DVD to supplement your answer, or draw one yourself.

Netball

Interview with Jane Searle

See the student DVD at the back of this book for an interview with Jane Searle. Originally from Melbourne, Jane was a student at Our Lady of Mercy College in Heidelberg. She is a former Australian player and was 1986 captain of the Victorian team who became National Champions. She played primarily as a defender, playing goal defence,wing defence and centre. Jane is the former coach of the Melbourne Kestrals.

Set-play example

Create space play out of defence

When the goalkeeper inbounds the ball from the baseline, the other players are trying to create space for the pass to go into. It is important that players don't lead into the space too early, as this could allow their opponents to cover the space and intercept the ball.

The goal defence and wing defence work together to create the space. They can:

- use body position to hold their opponents out of the space
- lead forwards towards the goalkeeper, then double back into the

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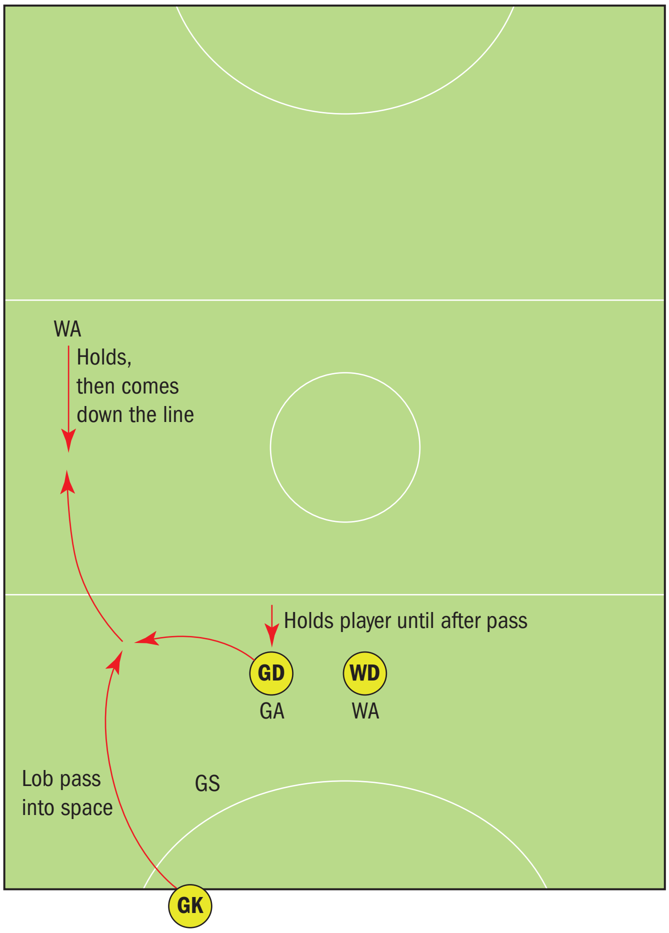

Figure 2.9 Netball set play: creating space

Key
WA wing attack
GA goal attack
GS goal shooter
GD goal defence
WD wing defence

Catchy fact
Netball was invented almost immediately after basketball, when James Naismith's basketball sketches were misinterpreted as zones that players were to stay within. Netball was originally known as women's basketball.

space split from each other and go wide
- cross over, hoping that their opposition players get caught in 'traffic'
- screen one of the players, then move into the space.

If both the goal defence and wing defence are well covered, the centre will need to get involved.

Things to consider with this set play:
- The goalkeeper has only three seconds to inbound the ball.
- Passing into the goal circle is dangerous; a turnover here will allow the opposition to have an immediate shot at goal
- The opposing goalshooter may double-team either the goal defence or wing defence.
- The opposing centre might move into the defensive third to zone off.
- The goalkeeper can come back into play after inbounding the ball and be an outlet for the second pass.
- The wing attack should be holding position so that they can run into space for the second pass.

How the environment changes the tactics

National variations in umpiring

Umpires in New Zealand are much stricter on the contact rules than their Australian counterparts, especially if the defender is behind their opponent. Australian umpires tend to let the game flow a little more. With the introduction of the ANZ League, players need to adjust on a week-by-week basis. Over time, the umpires will find common ground in their interpretation of the rules.

Floor differences

Some floors are harder under foot than others, which may cause minor injuries to some players. This can be an issue during tournaments, where players play games with only a couple of days' rest in between.

Defensive structure

In New Zealand, players tend to use a zone defence and look to intercept the higher lob passes, whereas Australian players traditionally favour a one-on-one defence.

Flexibility of posts, how far the ball rebounds

Defenders and attackers both need to adjust for small changes in post flexibility and ball rebound.

The *Netball* website is a good place to look for more information on netball. You can link directly to the website via the weblinks on the student DVD.

Netball

Netball court diagram

Checkpoints

Describe one defensive and one offensive strategy used in netball. Use the blank diagram provided on the DVD to supplement your answer, or draw one yourself.

Soccer

Interview with Jamie Harnwell

See the DVD at the back of this book for an interview with Jamie Harnwell. Jamie attended Carine Senior High School, Western Australia. He now plays with the Perth Glory A-League Soccer Club, and runs Jamie Harnwell's Soccer Academy.

Set-play example

Long throw in to near-post header

Jamie Harnwell

Many sports have great opportunities to set up routine plays from inbounding the ball. In soccer, the long throw can be effectively used to create a scoring opportunity. If a team has a player who can accurately throw the ball 20 metres, this play can been highly successful.

In the 2008–09 season, Stoke City used this play with Rory De Lap, who was able to throw the ball 45 metres with extreme pace. The flat trajectory of a thrown ball is ideal, as it allows pace to be generated from the first header at the near post. Stoke City used this tactic to score crucial goals against the top teams, even after the tactic was heavily publicised. Rory De Lap could actually throw the ball so far that Stoke City even employed the tactic from the half-way line.

The great advantage of this play is that there can be no offside immediately from a throw in. This spreads the defence, and allows depth in attack. It also takes away the empty area that is normally in front of a goalkeeper, caused by defence players pushing the forwards out by using the offside trap.

The main principles are as follows.

1 The thrower holds the ball until all players reach their set positions. They usually set up a tall player at the front post, then have several players positioned for incoming runs for the second ball. The thrower aims the throw at the target player at the front post. Then one of two things can happen.

2 The goalkeeper can be drawn to the front post in case the forward decides to head the ball directly at the goal. If so, the target player should redirect the ball back across the goal to the hot spots that players are running into. Generally one of these players will be directly in front of goal, and another is running towards the rear post for a longer flick. Teams use a signal to indicate which option they will use.

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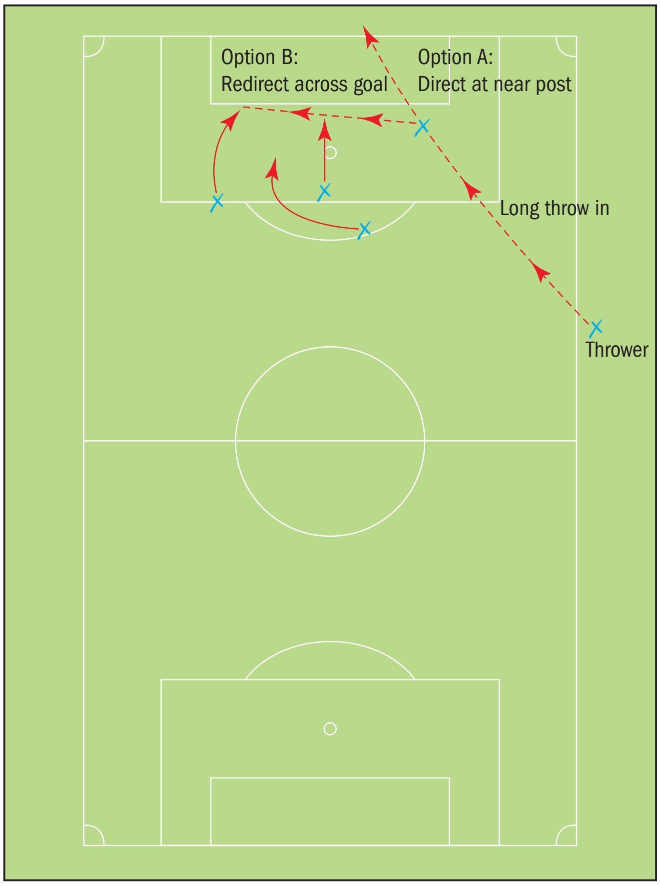

Figure 2.10 Soccer set play: the long throw

Catchy fact
The 1979 Scottish Cup tie between Falkirk and Inverness Thistle was postponed 29 times because of bad weather.

3 If the goalkeeper does not cover the front post direct attack, the target forward needs a call, or perhaps decides that the speed and trajectory of the throw will allow a powerful header. In this case, the forward should go directly at goal.

In general, the idea is to create a chance by using the rules to extend field position. Also, if the first ball is played across the goal face, confusion is created by attackers making staggered runs into the danger areas created. Some teams have refined this strategy further by setting screens to allow attacking players a clear run without a defender checking them closely.

How the environment changes the tactics

Extremely poor pitch condition

The general principle in soccer is to 'play the ball to feet'. This ensures that the ball is easy to control and pass without needing to calculate bounce. When the surface of the pitch is uneven, playing the ball along the ground, especially in defence, may cause the ball to bobble or skip over the foot of the player attempting to trap it. Attackers will encourage midfielders to play long balls in the air into dangerous attacking positions, to increase the chance of a fickle bounce causing a mis-trap by a defender. Defenders should clear the ball rapidly from defence in a more direct route, to quickly improve their field position.

The *Expert Skills* website is a good place to look for more information on soccer. You can link directly to the website via the weblinks on the student DVD.

Soccer skills

Checkpoints

Describe one defensive and one offensive strategy used in soccer. Use the blank diagram provided on the DVD to supplement your answer, or draw one yourself.

Soccer field diagram

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Softball

See the student DVD at the back of this book for an interview with Kere Johanson. Kere was WAIS softball head coach 2002–2009, 2004 Olympic Games assistant Australian coach for the silver-medallists, and Western Australian head softball coach. He played in four world championships with the New Zealand Men's Softball Team.

Interview with Kere Johanson

Set-play example

Using a bunt to advance the runner on first base

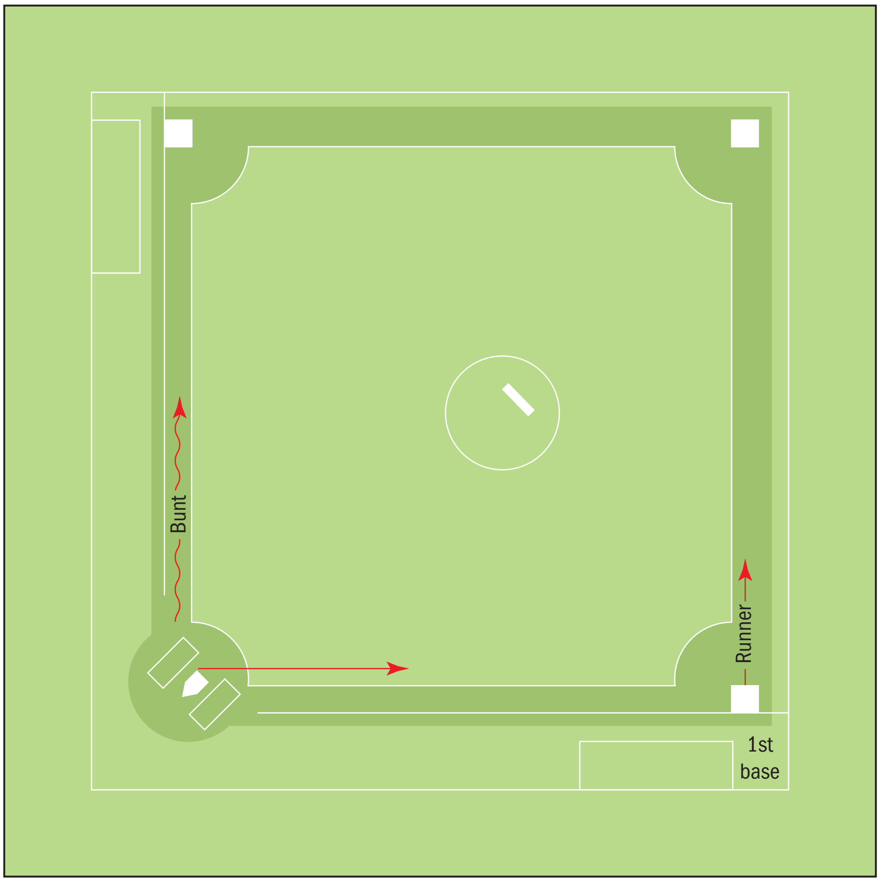

Figure 2.11 Softball set play: using a bunt to advance the runner on first base. If the bunt is perfect, the batter will also make first base.

The batter hits a bunt along the line towards third base, ideally travelling halfway down the line. This should allow the runner at first base to easily make second base. If it is a perfect bunt, the batter might even manage to reach first base. This tactic is often used against a pitcher who is hard to get a safe hit on, or if you are hitting into a very strong breeze.

Things to consider before using a bunt:

- How close the third base is to the infield
- The ability of the batter

If it is not a forced play, i.e. there is a runner on second base but no-one on first base, the batter can bunt down the first-base line and sacrifice their own position to advance the runner to third base. Bunting the ball along the line towards third base often ends with the batter out at first base, as the first-base player collects the ball and throws it to the pitcher, who is covering first base.

Catchy fact

The fastest softball pitchers throw the ball at about 130 km/h. This equates to a reaction time for the batter of 0.341 seconds.

How the environment changes the tactics

The pitcher

The greatest environmental influence is the pitcher: are they pitching a certain type of ball?

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The state of the game

The second influence is the state of the game, as it will dictate if a player steals, bunts or hits. The dimensions of the diamond are always the same; however, the distance to the home-run fence can vary considerably. This influences the success of particular hitters. It certainly dictates the direction of any hit, depending on which runners are on the bases.

The *Softball* website is a good place to look for more information on softball. You can link directly to the website via the weblinks on the student DVD.

Softball field diagram

Softball

Checkpoints

Describe one defensive and one offensive strategy used in softball. Use the blank diagram provided on the DVD to supplement your answer, or draw one yourself.

Squash

See the DVD at the back of this book for an interview with Mike Cornish. Mike is state coaching manager with Western Australian Squash, and high-performance coach for the National Talent Squash Program. Mike was a student at Applecross Senior High School.

Interview with Mike Cornish

Set-play example

Using the side walls and establishing front position

Once a rally is underway, elite players tend to keep driving the ball down the side walls and relatively deep. It is crucial to gain front position and try to maintain it until your opponent drops a line drive a little short. It is then easy to boast the ball off the side wall into the front

boast
a shot that hits a sidewall or backwall before hitting the front wall

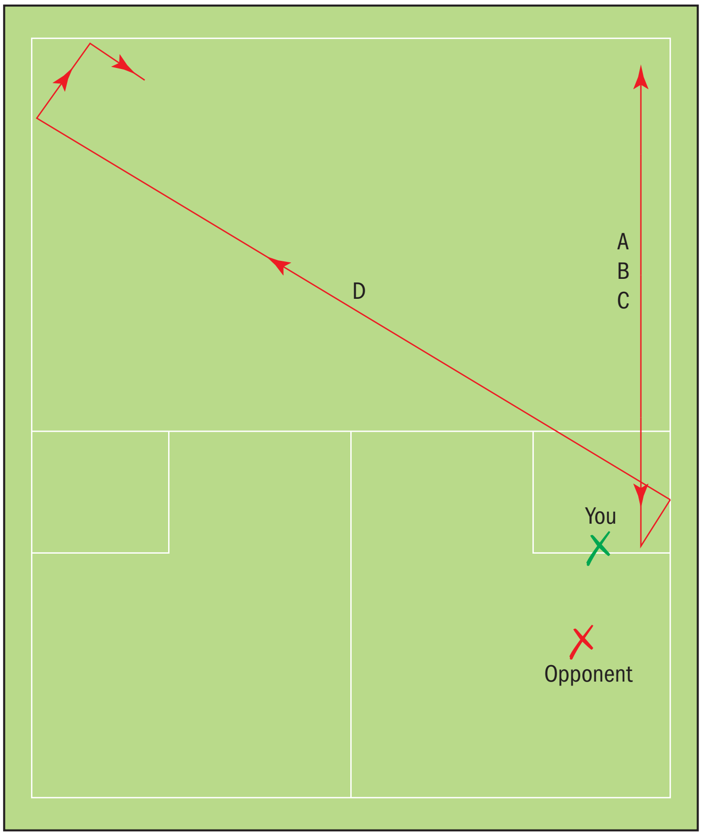

Figure 2.12 Squash set play: boast the ball off the side wall to make your opponent run further A, B and C are drives down the line in a rally. Once you have secured the front position, boast the ball off the side wall into the front court. This obstructs your opponent's vision and presents the longest diagonal to run to retrieve the next hit.

Catchy fact
Heather McKay enjoyed a period of unparalleled squash dominance. In a career lasting 20 years, where she was Australian champion 14 times and British Open champion 16 times, she only ever lost two matches.

opposite corner. This creates the longest possible distance for your opponent to cover to retrieve the ball from the front court. Hopefully this will set up the winner!

How the environment changes the tactics

There are a few environmental considerations:

- The air temperature and bounce height of the ball
- The size of your opponent (a physical obstacle)
- The humidity in the court
- The lighting
- Your opponent's tactics

The *Squash Game* and *World Squash* websites are good places to look for more information on squash. You can link directly to these websites via the weblinks on the student DVD.

Squash

Squash court diagram

Checkpoints

Describe one defensive and one offensive strategy used in softball. Use the blank diagram provided on the DVD to supplement your answer, or draw one yourself.

Swimming

See the DVD at the back of this book for an interview with Bill Kirby. Bill Kirby currently runs his own swim school business, named Kirby Swim, which has three metropolitan centres and one in Mandurah. Bill was a student at Prindiville College and Christ Church Grammar School. He also has a Bachelor of Science in Human Movement from the University of Western Australia.

Bill was a gold medallist in the 4 × 200-metre relay at the 2000 Sydney Olympic Games. He broke six world records in various 4 × 200-metre teams, spent nine years as a national swimmer, and was Australian Butterfly Champion three times.

Interview with Bill Kirby

Set-play example

Swimming is a sport where each athlete generally swims their own race. Sports such as swimming, which have a limited number of variables, often use simpler tactics based on physiology. Following is an example for backstroke.

100-metres backstroke

Backstroke involves the following elements:

1. Push of the wall, then swim 15 metres underwater holding a strong streamlined position and doing hard, powerful kicks.
2. Build pace through the first 50 metres, making sure not to go so fast that you will fatigue on the return lap. Although this is a sprint, the pace for the first 50 metres still needs to be controlled. The energy system used in this race is very similar to that used in a 400-metre race on an athletics track.
3. Turn hard and explode off the wall.
4. Sprint home!

Catchy fact
Between 1938 and 1952 many breastroke swimmers swam using a butterfly arm stroke. Butterfly became a stroke of its own in 1952 and breastroke rules were changed.

How the environment changes the tactics

The environment has little impact on swimmers, as all pools at international level are designed to the same standards. At the Bejing Olympic Games, the swimming finals were held in the mornings, and this could have influenced the pace some swimmers swam at during the previous night's heat.

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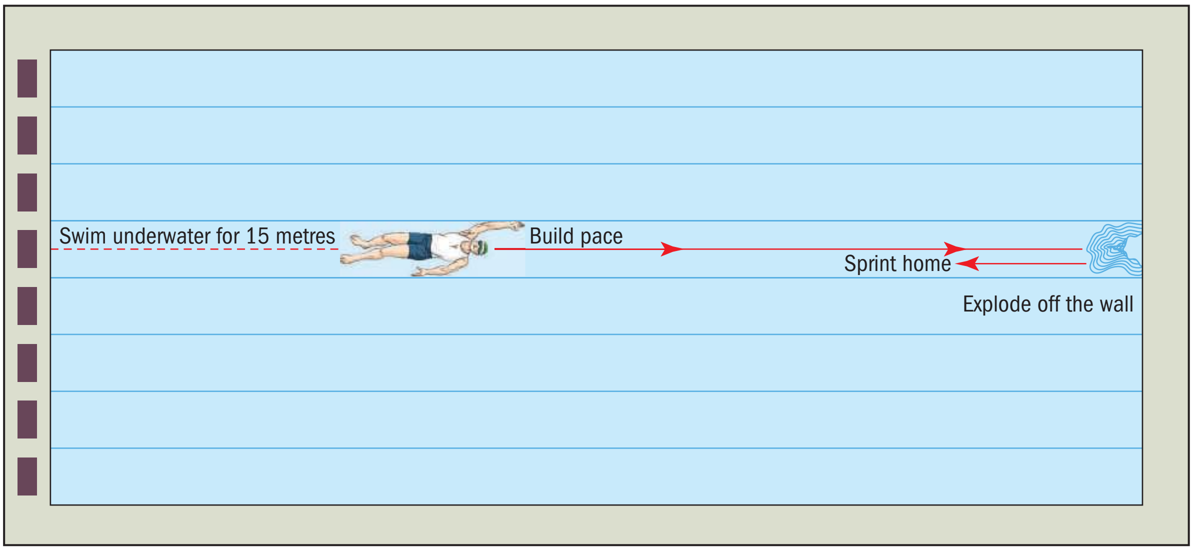


Figure 2.13 Swimming set play: 100-metre backstroke

Swimming

The *Swimming Western Australia* website is a good place to look for more information on swimming. You can link directly to the website via the weblinks on the student DVD.

Checkpoints

Describe one defensive and one offensive strategy used in swimming. Use the blank diagram provided on the DVD to supplement your answer, or draw one yourself.

Swimming pool diagram

Tennis

See the DVD at the back of this book for an interview with Dave Culley. Dave was a student at Christchurch Grammar School. He is a former state number one player and tennis professional. He is currently the coach at Cottesloe Tennis Club, and president of Tennis Coaches' Association of Western Australia.

Interview with Dave Culley

Set-play example

If your opponent has a big serve but is not particularly mobile, chip the ball and charge the net, forcing your opponent to make the play.

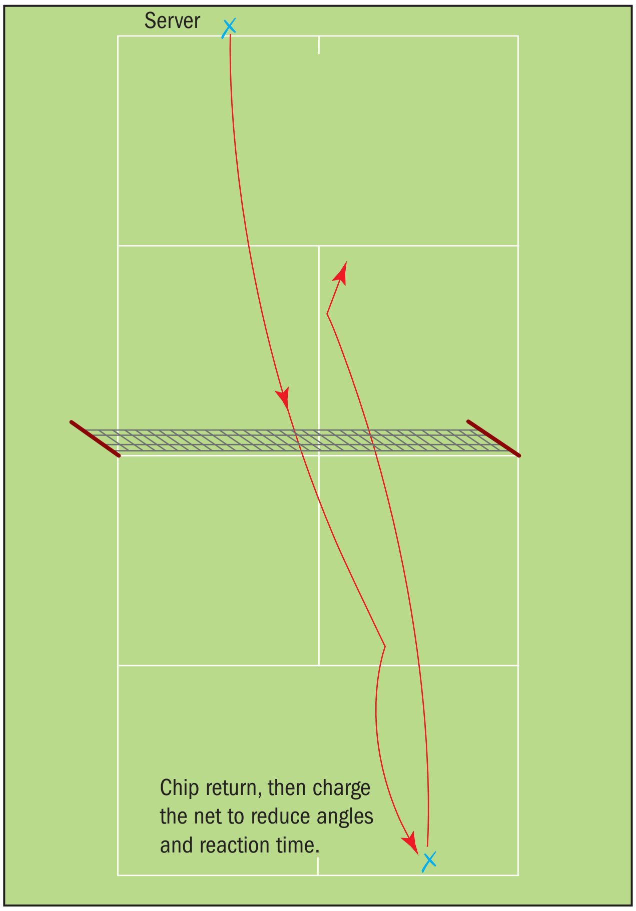
This tactic is good against a serve that is difficult to return. By concentrating on just getting the ball back to the middle of the court, you are not trying to win the point on the return of service.

Aim to hit the ball into the middle of the court and to the feet of the opposition player as they approach the net. By placing the ball in the middle of the court, it limits the angles your opponent has to hit the ball past you. If you get the ball to your opponent's feet, you can then become the aggressor and charge the net. Because the ball is low at their feet, they will hopefully will hit a high volley or half-volley.

Things to consider before using this tactic:

- The volleying ability of the opposition.
- The playing surface. On a clay court, the ball will most likely bounce up and sit there waiting for your opponent to smash it back at you, so it might not be a good tactic. On a grass court, it can be an excellent tactic as the bounce is quite variable, thus making a half-volley more difficult.
- It can be an excellent tactic if your opponent is a weak at volleys, as they probably feel uncomfortable playing at the net.

Figure 2.14 Tennis set play: chip and charge



Catchy fact
Australian Todd Perry is in the record books for the longest tennis match held at Wimbledon. The match lasted 6 hours and 7 minutes. The score was 5–7, 6–3, 6–7, 6–3, 23–21. Todd Perry and his partner were on the losing end after having six match points.


Tennis court diagram

Tennis


Interview with Matt Bramford

How the environment changes the tactics

Tennis is an interesting sport when we look at the environment. The court surfaces of the four Grand Slam tournaments are all different:

- Australian Open – Flexicushion
- French Open – clay made from crushed bricks (hence the colour)
- Wimbledon – grass
- US Open – hard court (Deco Turf)

The court surface has an enormous impact on the strategies and tactics required for each event. From 2003 to 2008, Roger Federer dominated men's tennis, winning 14 Grand Slams. However, he was unable to win the French Open until 2009, as it requires a different style of game.

Each player has different strengths and weaknesses, so this is the major factor in deciding which strategies and tactics to use. Tennis players are not permitted to be coached during the game, so they need to be adaptable in their thinking.

The *Tennis* and *Tennis Coach* websites are good places to look for more information on tennis. You can link directly to these websites via the weblinks on the student DVD.

Checkpoints

Describe one defensive and one offensive strategy used in tennis. Use the blank diagram provided on the DVD to supplement your answer, or draw one yourself.

Touch football

See the DVD at the back of this book for an interview with Matt Bramford. Matt played touch football at a state level from 1994 to 2005. He is currently the Barbarians' mens' open coach in the National Touch League. Matt attended McCarthy Catholic College in Tamworth.

Set-play example

Making ground

Touch football is a game of field position, so most teams use the first three touches to gain as much ground as they can as quickly as possible.

The first three touches involve using a pass and running straight forwards, with the attacker initiating the touch on the defender and playing the ball as quickly as possible. This is in an attempt to get the defenders offside. Because the defenders are running backwards, it

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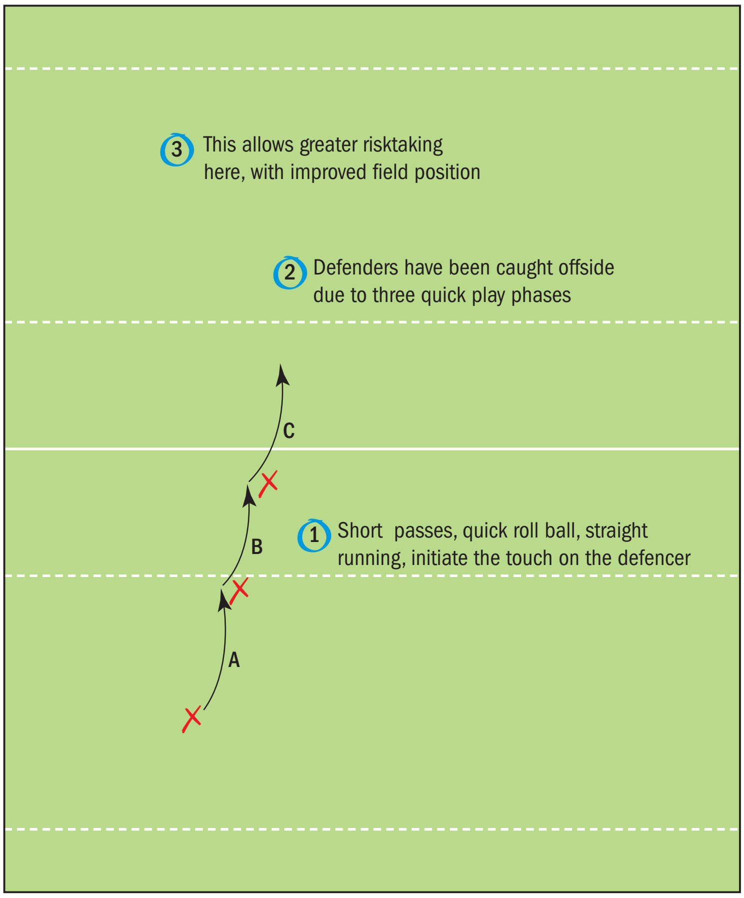

Figure 2.15 Touch football set play: speed attack

is more difficult for them to move back into line. After gaining some ground, teams become more inventive with their tactics, using wraps, switches, draws, crossovers, etc.

Things to consider before using this tactic:

- Defensive teams will try to slow down this type of attack by having one defender (a 'bullet') charge out of the line to limit the ground made.
- This 'bullet' defence can also open up holes in the defensive line.
- The speed of the of play of the ball is critical.
- Short passes are needed so that the ball is not in the air for too long.
- The attackers must hit the ball at pace.

Catchy fact
Touch football was originally used as a training technique for Rugby League players. Competitions began in the late 1970s, when people were looking for safe rugby competitions. Touch football in Australia has over 500 000 registered players.

How the environment changes the tactics

- Running into or against the wind is a key factor in how quickly you can get a team offside.
- A team that attacks the line quickly will have large holes, and you might need to have a specialised attack to work against this tactic.
- Limit the number of passes on a wet day to reduce the chance of error and the likelihood of a turnover.
- Use the interchange more on hot days, so that players have an opportunity to recover and cool down. This is particularly important in tournaments, where athletes will be backing up and playing each day.
- Different surfaces require different footwear. Agility games require good balance, so different footwear might be required for different types of grasses. This is very important in the wet. Remember, you should not have footwear with too much grip, as this can result in injury – especially at the knee joint.

The *Touch West* and *Touch New Zealand* websites are good places to look for more information on touch football. You can link directly to these websites via the weblinks on the student DVD.

WWW Touch football

Touch football field diagram

Interview with Gavin Lewis

Checkpoints

Describe one defensive and one offensive strategy used in touch football. Use the blank diagram provided on the DVD to supplement your answer or draw one yourself.

Volleyball

See the student DVD at the back of this book for an interview with Gavin Lewis. Gavin has been the coach of various Western Australian women's volleyball teams. He attended Corpus Christi College.

Figure 2.16 Spiking in volleyball

In its simplest form, volleyball is about either getting the ball to ground on the opponent's side of the net, or forcing the opposition to put the ball out of court. Everything else stems from these two ideas.

In volleyball it is necessary to look at the known strengths and weaknesses of the opposition. Consider questions such as the following.

- Do they have one or more tall, powerful hitters?
- Do they have specialist setters?
- Do they use a libero effectively, or at all?

libero
a specialised defensive player who always stays in the back row

Set-play example

Using a specialist back-court spiker

The standard play in volleyball is to receive the serve using a dig, then forearm pass the ball to the player in position three, who sets it to either position two or position four. In the majority of cases, the setter will play the ball to the forehand hitter in the front row.

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The forehand hitter is the player who receives the ball from the preferred hitting side of their body. This will mean that the ball does not have to cross the hitter's body before they can spike it, and makes execution of the skill slightly easier.

Most teams aim for 50 to 70 per cent of all sets to go to the player in position four, provided that all players are right-handed. This is especially true if there is a power hitter in position four.

This standard offensive set play is predictable, and allows the opposition to set up regular effective blocking defence. There is the need to have a variety of set plays to negate this. For example, the back-court spiker can be used in a set play to provide variety in attack. This will be even more effective if there is a power hitter in the back court in position five or position one.

The basic play remains the same initially:

1 The dig from service reception is still played to position three, in the centre of the front court.
2 The setter at position three is then provided with two dummy-run hitters coming through in the first wave of hitters, in order to distract the blockers.
3 The setter will set the ball further off the net than usual, and generally a little higher. If the opponents have big solid blockers on that side of the court, then the setter should keep the ball even further off the net to take away the blockers' effective angles, and make it more difficult for them to time their jumps.

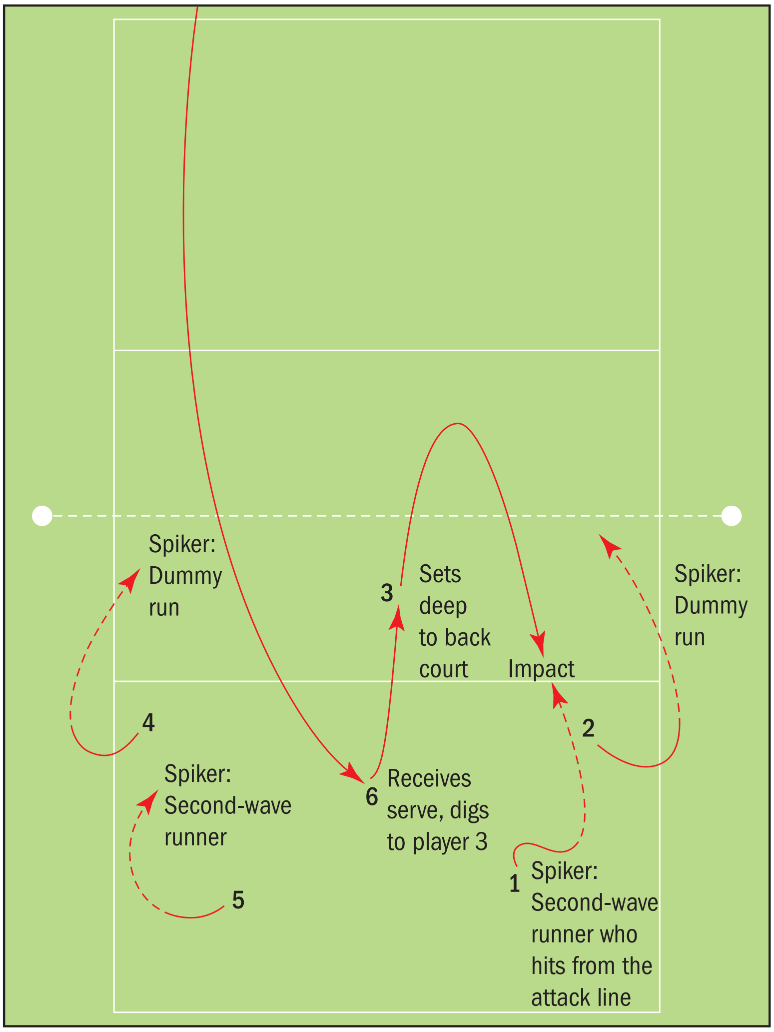

Figure 2.17
Volleyball set play: second-layer back-court spiker

Catchy fact
Cuban volleyball star Leonel Marshall has a vertical jump of 127 centimetres. Check him out on YouTube!

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4 Meanwhile, the outside back-court players in positions five and one circle around behind the first-wave hitters and jump from behind the attack line to offer second-wave back-court hitters.

The preferred option is position five, if all hitters are right-handers with similar spiking ability. If position one has a big spiker, then they can be an excellent option – and a little unexpected.

How the environment changes the tactics

Volleyball

Volleyball is mostly an indoor game, so environmental conditions are normally limited to factors other than weather or heat.

The opposition

The environment includes the opposition. If the opposition has a power hitter in position four hitting on their forehand side, a different blocking set-up might be preferred, such as using 'read blockers'. This involves using three blockers who attempt to watch the ball as it comes off the setter's hands, to predict where the spike is coming from. Where there is a probable hitting option for the opposition, designated blockers may be used. This is when the blockers are simply assigned a place to go to in response to a predictable pattern. This means the blockers do not need to read the set, they simply run to pre-determined positions.

The *Volleyball WA* and *Volleyball Australia* websites are good places to look for more information on volleyball. You can link directly to these websites via the weblinks on the student DVD.

Volleyball court diagram

Checkpoints

Describe one defensive and one offensive strategy used in volleyball. Use the blank diagram provided on the DVD to supplement your answer, or draw one yourself.

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SECTION 2
MOTOR LEARNING AND COACHING

Chapter 3 — Transfer of learning

3A.3 Define and understand transfer of learning and identify the different categories, i.e. skill to skill, theory to practice, training to competition.

3A.4 Explain the effects of transfer of learning, i.e. positive effects, negative effects, zero effects and their impact on improving skill execution and movement efficiency.

Chapter 4 — Analysing movement skills

3A.5 Analyse movement skills of self and others to identify errors, provide feedback, and suggest corrections to improve performance.

3A.6 Design coaching and training activities to improve performance in selected skills, including shaping, chaining, static-dynamic, simple-complex.

Chapter 5 — Leadership in sport

3A.7 Evaluate the use of different leadership styles to suit audience needs.

Chapter 6 — Reflective learning and participation

3B.2 Explain the process of using tools such as checklists and video to analyse and reflect on self and others' performance in physical activity; e.g. strengths and weaknesses, mental versus physical performance, error correction.

3B.3 Analyse learning and skill development in relation to correction and improvement of self and others; e.g. use of video analysis, reflective journals, peer/mentor/coach feedback, questionnaires.

.3 Transfer of learning

> A sportsman's night is when a whole lot of people who aren't any good at sport come to listen to people who used to be good at sport.
>
> **Damian Callinan, 2001**

transfer of learning
transfer or shift learning or training from one task to another

motor pathway
the course followed by a nerve impulse from the brain to an organ or muscle

kinaesthetic awareness
an individual's awareness of their body parts in relation to each other and space

What is transfer of learning?

Transfer of learning refers to the relationship between skills from different types of sporting activities. If coaches are aware of the skill transfer between specific sports, they can streamline the learning process using motor pathways that are already well established. However, the amount of skill transfer can also be negatively affected by contrasting motor pathways, and by ingrained movement patterns that prevent a new skill from being learnt easily.

Transfer of learning, according to the traditional view, can only occur when the new activity and the old activity are almost identical in nature. There will be transfer of learning if a tennis player who can hit a topspin forehand is then taught to hit a topspin lob. As you will discover later in this chapter, a tennis player attempting to learn a squash or badminton forehand will not gain the same benefit from established motor pathways. Research indicates that there is little transfer between some skills that appear to be very similar. The actual motor pathway for hitting a baseball and a cricket ball are quite different. Would we expect a cricketer to hit a baseball well? Not from a technical point of view, but findings from some more modern theorists suggest that the cricketer would still hit the baseball successfully.

The idea that skills need to be almost identical before they can be transferred would appear to be at odds with many of our sporting beliefs. For example, the boy who is good at Australian Rules football and adapts quickly to playing soccer; or the girl who is a state-level netballer and also a highly skilful squash player. In truth, their general level of skill, game play and kinaesthetic awareness is so much higher than the average person that their competitive spirit and desire to win allows them to get involved in the play of any game. They know where to go on the field or court to maximise their possessions. The skill transfer is not direct, as the skills of soccer and football are so different, as are the skills of netball and squash.

Historical perspectives

Thorndike's identical elements theory (1901)

The Theory of Transfer of Learning was introduced by Edward Thorndike and Robert S. Woodworth in 1901. They explored how individuals would transfer learning in one context to another context that shared similar characteristics. Their theory suggested that transfer of learning depends on the learning task and the transfer task being identical. Thorndike felt that just because a person had a skill in one area, there was no reason to suggest that they would have skills in any other area.

Catchy fact
Golf is the only sport that has been played on the moon. On 6 February 1971, astronaut Alan Shepard hit a golf ball.

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Schmidt and Wrisberg (2004)

Schmidt and Wrisberg (2004) proposed that the 'identical' elements between activities can be either:

- movements
- perceptual elements
- conceptual elements.

This is an extension of Thorndike's theory, as it is not just observable movements that we must consider. The perceptual mechanism of recognising information, relevant cues and having all the necessary information to respond effectively is also very important. Schmidt and Wrisberg were moving on from Thorndike's original proposal that transfer of learning can only take place between identical movements. Sports performance is so much more than just the technical execution of the correct skill.

> **perceptual**
> receiving information with the mind or senses
>
> **conceptual**
> being able to cognitively link similar movement concepts

Current directions: Abernethy, Farrow and Raub

Transfer of pattern recognition in team sports

Recent studies have drawn more attention to pattern recognition. Pattern recognition is a player's ability to see similar game-play characteristics between sports, and be in a better position to respond in a new sport. For a netball player playing soccer for the first time, there are notable similarities in patterns of play.

In both games, a 'pass and move into space' strategy will allow the ball to be moved successfully towards the opponent's goal. This is fundamental to both games. The netball player would execute the soccer pass, and then move out from behind their marker into a space where they could receive the ball back again. The transfer of learning has been enhanced by pattern recognition. This is an obvious advantage in developing success more quickly in a new sport, as it allows 'anticipation' of a response, based on previous similar experience.

This progression from Thorndike through to the current skill-acquisition theorists, reinforces the need for looking beyond the 'observable', and delving into the cognitive processes that underlie every movement. Unfortunately, it is easier to measure only the output, as early researchers tended to do.

Modern theories offer up some excellent methods to help extend sports performance using than just physical means. Let's look at some of the more recent research.

> **pattern recognition**
> a player's ability to see similar game play characteristics between sports
>
> **execute**
> complete; carry out
>
> **cognitive**
> the process of knowing, understanding and learning something

Some interesting findings

Farrow, Baker and McMahon (2007) came up with some interesting findings regarding birthplaces and birthdates.

Rural environments provide an ideal setting for giving young athletes a broad exposure to many sports. This provides a greater possibility of the young athlete developing into an elite athlete, especially in invasion games and net games. Exposure to a wide range of activities with similar movements allows these individuals to acquire the skills needed to quickly excel at new sports.

Elite performers are over-represented in birthdates in the first three months of the year related to age cut-offs. This has real implications for administrators deciding on age cut-offs in junior sport.

What researchers found is that individuals from the country are more likely to have been involved in a wide range of activities prior to the age of 12. This means that they established more motor pathways than children who participated in a narrow range of activities, increasing their ability to solve future movement problems, even in totally new activities.

From this finding alone, primary-school students should be exposed to a wide range of movement patterns if they are to maximise their sporting ability.

Skill to skill

Transfer of learning is traditionally referred to as 'skill to skill'. Most coaches and athletes are convinced that the links between sports are much closer than research has revealed.

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Abernethy et al (2006), discussing players' ability to locate team-mates, opposing players, the ball, etc., reported that 'experts characteristically outperform non-experts on tasks that require specific patterns of play to be recognised or recalled'. Abernethy also said that 'skilled athletes in many sports act rather like intuitive biomechanists in their understandings of the inherent relationships and predictabilities that exist within an opponent's movement pattern'. Put simply, this means that individuals who are good at sport have the ability to quickly recognise familiar patterns of play; they have more options for responding, because of the breadth of their previous experience.

Elite decision makers were interviewed on the types of activities they completed in their childhood and adolescent years. Farrow and Raab reported that recent research involving elite decision makers found the following:

'It is thought that such information may shed some light on the types of activities that should be practised if one wishes to become an expert decision maker.

'The same athletes Abernethy and colleagues tested on pattern-recognition skills also completed developmental history profiles. Of particular interest was that the athletes accumulated far less sport-specific practice (less than 4000 hours on average) prior to reaching expert levels than the 10 000 hours that would be deemed necessary by the theory of deliberate practice. In explaining this finding, it is critical to note that the number of different sports these athletes participated in as a junior was inversely related to the number of practice hours required to become an expert player. For example, one netball player only detailed 600 hours of netball specific practice before being selected for the Australian team. However, she participated in 14 other sports as a junior.

'Based on such findings, it has been reasoned that participation in a variety of sports before specialising can be advantageous to one's development of expert decision-making skills. Importantly, as highlighted in some research on Australian football, it's not just any sport. Rather, participation in sports that are conceptually similar to the one in which a child wants to excel is more likely to generate the transfer of pattern recognition skill previously described (as well as other capacities such as physical fitness). For example, expert decision makers in Australian football were found to participate in a significantly greater number of secondary invasion sports relative to non-expert decision makers. Invasion sports are those much like Australian Rules football, which involve players running freely on a field or court and being able, in some way, to directly challenge their opponents for possession of a ball. This includes sports such as soccer, hockey and basketball.'

Farrow and Raab 2006, p. 140

Checkpoints

1 After reading the above information from Farrow and Raab, design a brochure encouraging parents to get their children involved in community sport. Focus on Farrow and Raab's key findings.

2 Copy the following table and fill it in, using a list of ten of your classmates. Attempt to categorise whether the sports listed would have a high, medium or low transfer to the primary sport that each student normally pursues. (A primary sport is considered an athlete's main sport.)

Name	Primary sport	Volleyball	Basketball	Australian Rules football	Golf	Other
	Soccer	Low	Low	Medium	Low	Futsal

a Did you rate more sports as high, medium or low in terms of transfer of skill?

b In the final column, select a sport that *does* have a high transfer of skill for that student's primary sport.

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Transfer of learning through patterns of play recognition

'Recent research has revealed that the ability to recognise patterns of play may transfer across team sports that possess a similar structure of play. Bruce Abernethy and his colleagues examined expert decision makers from the Australian basketball, netball and hockey teams and compared their performances on a pattern-recognition task with lesser-skilled athletes from the three sports. Consistent with previous work, the experts recalled patterns from their sport better than their lesser-skilled counterparts. However, when the experts from one sport, such as netball, were tested on other patterns, such as basketball patterns, their recall was still better than the non-expert basketball players. Such findings suggest that elements of pattern recognition are general in nature and can transfer between sports.'

'It has been reasoned that superior pattern-recognition skill provides a player with an awareness of what a team-mate or opponent is likely to do next. The outcome of effective pattern recognition is anticipation, or the capability to prepare a response in advance, based on the information provided early in an event sequence. The capacity to anticipate is particularly valuable in time-stressed sports for a number of reasons. First, in a situation such as the tennis return of serve, it may be necessary to begin moving before an opponent has even struck the ball in order to successfully intercept it. Second, it provides a player with more time to prepare a response, which may increase the likelihood of executing a successful response.'

'Finally, anticipation may also effectively reduce the expert's information-processing load. In summary, the net result of being an expert decision maker is to create the appearance of *having all the time in the world* with which to prepare and execute a response in time-stressed situations by efficiently travelling through some or all of the stages of the decision-making process previously described.'

Farrow & Raab, 2006, p. 140

Catchy fact
It takes about 3000 cows to supply enough leather for a year's production of American footballs to be used by the NFL.

KEEP IT REAL!

Saverio Rocca, the ex-Collingwood Australian Rules footballer, was drafted by the Philadelphia Eagles, an American NFL gridiron football team. Rocca had finished his AFL career, and been famous throughout his career for his huge kick; however, he was perceived to be an inconsistent goal kicker.

The similarities between gridiron and Australian Rules football are almost nonexistent. One isolated skill in the game is the high punt kick. The higher the kick, the longer the 'hang time' the ball spends in the air. This maximises field position and gives the team a huge advantage in the next play phase.

Rocca was successful in pursuing a gridiron career, and became a professional gridiron player, making a final in 2009.

Checkpoints

1. Why should a new coach collect data from the playing group to ascertain past experiences in sport?
2. List all of your previous sporting experiences and four core skills from each sport. Discuss which of the skills has a high or low degree of transfer between each sport and within each sport.

From theory to practice

Transfer of learning from theory to practice has become a significant tool in developing an athlete's ability to improve their decision-making skills. Elite sporting organisations recognise that there are huge benefits in spending time in the classroom attempting to streamline the learning process.

This is particularly important when it comes to developing strategies and tactics that are critical in achieving the team's goals. The main task for the coaching staff is to make sure the theory information is specific to achieving the desired outcome.

The Australian Cricket Team is famous for its use of theory discussions prior to play, as a way of formulating plans and specific tactics to achieve the desired outcome. At one stage the Australian Cricket Team was accused of deliberately leaving a game plan at the door of a New Zealand cricket official, in an attempt to confuse the opposition.

These theory sessions allow the team to discuss possible game scenarios that, should they arise, require specific responses known by the whole team. When the given situation arises in the game, the players in the key roles know the suitable response from their theory session. More importantly, the whole playing group knows the response, and they are one step ahead of the opposition in knowing what is going to happen next.

processing
taking in information

output
outcome, or action

strategy
overall plan for achieving success

Using the information-processing model, the team has reduced the number of options available at the processing stage, which allows them to focus on the predicted output. This allows them to attend to only the relevant stimuli. As with all strategies and tactics, the final controllable item for the team is the execution of the output. This is called the Input–Processing–Output–Feedback model.

If the player cannot 'execute' the strategy, then the transfer from theory to practice has actually reduced the effectiveness of their response.

Tennis players use the term 'execute' regularly in pre-game and post-game press conferences. They are acknowledging that they have a theoretical strategy, and provided that they can execute (or carry out) the skill as planned, they will have done everything possible to achieve the desired result. The player will then rely on the opponent's response to determine success or failure.

The transfer from theory to practice depends greatly on the way the information is delivered, and its specific application to the performance.

As with any teaching, the delivery will use multiple delivery platforms; for example, video footage of opponents, video of own performance, whiteboards, playing-field templates, Internet research, reading, discovery, etc.

Video training to enhance perceptual awareness and decision making

visual–perceptual training program
specific training to develop visual awareness of clues given by the opponent, to help streamline the decision-making process

Visual-perceptual training programs are designed to improve the athlete's ability to recognise key elements and cues that may improve performance. Experts and novices have different interpretations of the same situations and stimuli, so it is beneficial to target this area in order to improve performance. Video has become a powerful tool in attempting to have athletes identify critical postural cues and patterns of play. Sports-specific training attempts to replicate or simulate the decision-making conditions of the actual skill as it occurs in the game. Future directions of off-court training are somewhat experimental, and clear links have not yet been fully established. Only recently, research has focused on this issue and available evidence suggests transfer does occur.

The main findings of recent research are that off-court training of a non-physical nature can have a noticeable effect on performance. This suggests that when conditions set up by the coaching staff are correct, the transfer from theory to practice is another key tool to extending athletic performance (Farrow, Baker and McMahon, 2006).

KEEP IT REAL!

Excerpt from an interview with West Coast Eagles coach, John Worsfold.

What about transfer of learning and transfer between activities? Do you ever steal ideas or look at other sports and really go into detail about what their strategies and tactics are and talk to their people?

Yes, we do. Really just to get an understanding of why they do it, what is it about their game that allows them to do it, and can it be transferred to AFL. You spend a lot of time talking to them

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and researching it and it might not be relevant at all, or you might pick up bits and pieces. We try and research everything from the way they develop their players off field to their on-field strategies. Really anything that they're doing and we could do better, we try and find out if anyone is doing something that will make our program better.

Coaches crossing codes

by Paul Roos

KEEP IT REAL!

Basketball is a real passion of mine. I grew up playing the sport and I still watch it very closely. I'd love the opportunity to one day work with Brian Goorjian and the Boomers – post-football, of course.

I'm fascinated by American sport and have been fortunate enough to spend a little bit of time over there throughout my career, gaining an insight into how professional teams run their operations in the United States.

My wife is American and after I hung up the boots I lived in the United States for ten months. During brief visits to the Chicago Bears, Chicago Bulls, the San Francisco 49ers, the Denver Broncos and the LA Lakers, I was able to go through facilities and witness the professionalism of those organisations. It was fascinating stuff. At the Chicago Bears, I marvelled at the extravagance of the facilities as I wandered through an $80 million complex. I couldn't help but compare it to how we do things back home in our great game.

However, while most things in US sport might be bigger – especially the money involved and the media attention – the principles of each sport remain the same. That especially extends to the players and the coaches. During the week, they all prepare and plan to get the best out of themselves for every match. This has always been the case in the AFL, or VFL as it was many years ago.

What has changed in our game, however, is the amount of money and the level of professionalism. One only has to look at our own coaching structures – and the way the AFL has evolved – over the past 20 or 30 years to see what I am talking about.

The days of the senior coach, who maybe had one assistant helping him out, are long gone.

A quick glimpse in a coaches' box today shows the senior coach surrounded by three or four assistants. There might be also one or two others helping on match day. The senior coach's role – especially during the week – is more widespread these days than ever before, and he needs to have a variety of skills to be good at his job. It's easy to look at an AFL coach's resume and simply see 'senior coach'. I think a lot of people wouldn't know exactly what a coach does.

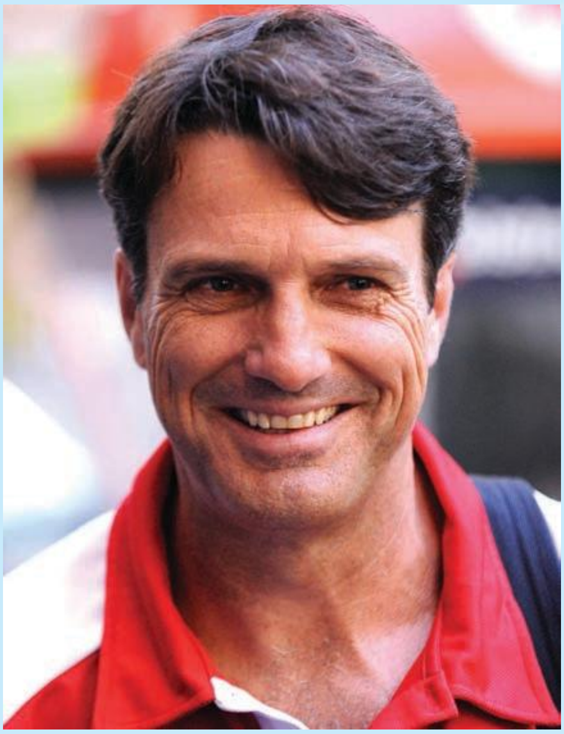

Figure 3.1
Paul Roos

But our roles extend to teaching, as well as promoting leadership and management, among other skills. While some of these skills might also make us suited to the corporate industry, I think it's also reasonable to suggest we'd be of use at other sporting organisations. We just happen to be coaching football. And coaching, after all, is about getting the best out of people.

It's for this reason I believe a good coach – either from the AFL, NFL or NBA – would have something to offer any other professional sporting organisation anywhere in the world. Yes, the game expertise would come from the coaches who have been around that particular sport their whole lives, but surely a successful suitably-qualified coach has the skill set to bring something to the table at any elite sporting organisation?

The sporting landscape is always developing and clubs are always moving with the times, looking to gain an edge over their rivals. In the future, striving for an advantage might be gained as much in intellectual talent as on-field.

What will the coaching structures look like in another ten or 15 years? Could a Phil Jackson type from the LA Lakers be helping out an AFL club? Or will a Bomber Thompson be asked to assist an NFL club? I think every AFL coach could offer something, whether it be in terms of leadership or management style. The opportunity for crossover, and for coaches to share their knowledge, is enormous.

www.afl.com.au

Coursework

1 Examine how pattern recognition in one sport can improve learning in a different sport.

2 Choose two other sports that you are familiar with, and explain cross-training potential in mixing skill sessions to gain suitable transfer.

From training to competition

In transfer of learning, specificity is the key to making the demands of training mirror the demands of competition. A coach must identify the key traits of successful performance in game play, then attempt to replicate this on the training track. The most effective way of developing an athlete's ability to improve on-field sports performance is to dissect the game and allow the athletes to develop their own strategies for decision making in a variety of game-like situations.

Research suggests that athletes who explore through self-discovery do better than those who are simply instructed how to solve a given problem.

Specific training is aimed at having the athlete develop a variety of movement responses to any given situation or stimulus. Transfer of practice from training to the game depends heavily on the similarity that exists between the two, so the coach must try to make training closely resemble a game. However, if training is simply game-play, there can be too many 'uncontrollables' to allow specific learning.

Most importantly, any improvements in decision making arising from training *must* translate to improved sports performance. Coaches must always have in their mind that athletes are all individuals, and they all have preferred learning styles. This is the difficult balance a coach must achieve.

As Farrow and Raab put it: 'The training principles of volume, frequency, intensity and overload are manipulated so that a progressive training effect is generated over time. The recipe of becoming an expert decision maker, in our opinion, is to systematically combine on-court training focusing on the execution of *what* and *how* decisions with off-court training. That is, all steps of the decision-making process, particularly the components of *generate*, *consider* and *select*, should be part of both types of training, though not necessarily presented in an explicit manner'.

Farrow & Raab 2006, p. 151

Farrow and Raab point out that real transfer gains can be made from training to competition in terms of improving decision making. Looking back at the Input–Processing–Output–Feedback model, we need to look at intervention at any or all of the stages if we are to maximise performance. The idea that significant gains can be made at the Input and Processing stages can be a huge benefit to forward-thinking coaches.

Catchy fact

At the 1993 American Basketball Conference playoffs, Michigan State Spartans were playing in the championship game against North Carolina. With 11 seconds left in the game, Michigan had the ball and was in position to tie or go ahead. Michigan's Chris Webber called a time-out to set up a last second play. It seemed like a good idea, except that the Spartans had no time-outs left. Webber was given a technical foul for calling a time-out his team didn't have. North Carolina sank the two technical foul shots and Michigan lost the championship.

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Checkpoints

1 Design a training session for a sport of your choice that would maximise transfer from training to competition. Describe how you would set up each activity and the outcomes you hope to achieve.

2 Select a sport and explain in detail how you could speed up cue detection in two vital skills.

The effects of transfer of learning

We have established that transfer of learning has the potential to fast-track an athlete's skill development. In other cases, it hinders progress significantly. There are three main aspects to this:

- Positive transfer
- Zero transfer
- Negative transfer

Positive transfer

Positive transfer occurs when two sports or skills have similarities in basic technique that would benefit a performer in each.

Football and soccer

Football and soccer involve similar skills, in kicking an object of similar weight. Some people argue that the swing pattern of the leg is different enough in each sport to cause some amount of negative transfer. However, if you were to compare the ability to impart maximum force on the ball at impact, you would expect that a player from either sport would have a considerable advantage over someone who was not from the background of a 'kicking' sport.

Former West Coast Eagle Peter Sumich is one elite-level AFL player who kicked with a soccer-type swing pattern, yet easily succeeded at the highest level. Although this resulted in a kick that bent in flight, it was generally consistent and could be allowed for when aiming.

Zero transfer

Zero transfer is when there is no relationship at all between the two sports or two skills.

Soccer and golf

Soccer is a basic kicking game, with foot–eye coordination and a relatively large object to be struck. Golf is one of the most difficult hand–eye coordination sports; it involves using a long, rigid-shafted club to strike an object that is only centimetres in diameter. Aside from a very loose connection between both sports relating to coincidence timing, a soccer player hoping to gain a skill benefit from being involved in golf would receive no perceived benefit.

coincidence timing
hitting an object with a body part or striking implement at the correct moment

KEEP IT REAL!

Michael Jordan, the greatest basketball player of all time, retired from the NBA to pursue a career in professional baseball. After spending a great deal of time and effort trying to make it to the big leagues, Jordan gave up. This failure was such big news that it became the theme for a book: *Why Michael couldn't hit*. But in reality, as all movement theorists agree, there is zero skill transfer between the two sports. One is an invasion game; the other is a striking and hitting game. The pattern recognition of similar situations in these sports is nonexistent.

Negative transfer

Negative transfer occurs between sports where there are fundamental differences in a key technical element, which might be considered critical to displaying good technique.

Tennis vs squash

An elite-level tennis player would have been taught from an early age to keep a firm wrist at impact in a traditional topspin forehand. This is partly due to the weight of the racquet and the ball, which is significant. If the same player was regularly playing squash with a friend and being coached, the teaching point for a squash forehand would be to roll or flick the wrist at impact on the forehand side. This extra segment of action helps impart maximum speed on the squash ball, and is mainly possible due to the lighter, shorter racquet and a lighter, smaller squash ball.

This direct contrast of fundamental movement patterns would indicate a negative transfer at the elite level, and most coaches would discourage the practice.

Cricket vs golf

In principle, cricket and golf have a lot in common, as they both require striking an object. However, cricket requires bent arms at the elbow in a cradling effect, to keep the front elbow high in a drive and present a suitable bat face to play the ball along the ground. The golf swing requires a very straight elbow in the backswing and at impact to maximise the chance of contacting the ball. The actual motor pathway of striking a cricket ball may be at odds with a golf swing, as the collapsing of the elbow in the cricket backswing would be difficult to eliminate from the golf swing.

Catchy fact
The Scottish government banned golf in 1647. Find out why.

Famous examples of zero transfer

During the 2005 tennis season, Australian tennis player Scott Draper proved that golf and tennis, although an unlikely pairing, could be played at an elite level – even on the same day! Draper won the Grand Slam Doubles Title and played in a professional golf tournament in the same week.

The skills of these two sports have an extremely loose link, with one being coincidence timing of a moving object, and the other being static timing in striking a stationary object. Transfer of learning would struggle to explain the reason for reaching such a high level in both sports.

Figure 3.2 Scott Draper: Tennis and golf professional in the same week!

Nova Perris-Kneebone made a more usual choice with her combination of sports at Olympic level. After winning a gold medal in women's hockey at the 1996 Atlanta Olympic Games, she then won two gold medals at the 1998 Kuala Lumpur Commonwealth Games

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in the 200-metre sprint. Her ability to strike a hockey ball had no direct relationship to performing at such a high level as a short-distance runner; however, her genetic makeup and work ethic could be key factors.

Figure 3.3 Nova Perris-Kneebone represented Australia in hockey and athletics

How does transfer of learning improve skill execution and movement efficiency?

If we have performed a similar skill in the past, we have the basic movement programs already established in our long-term memory. The research considered earlier in this chapter has made us aware of the need to use the transfer of learning to intervene in the Input–Processing–Output–Feedback model.

Consider the case of an AFL ruckman who has come from a basketball background as a junior. If he were also from the country, where he had a wide exposure to many sports, there are excellent transfer potentials. A coach would look at skill-to-skill training to competition and theory-to-practice in order to extend the ruckman's performance. The intervention from the coach could occur at any stage in our model

- **Input:** Training the body to be better equipped to identify correct stimulus. This would be enhanced by exposure to movement patterns from other sports
- **Processing:** Improved decision-making options available. The number of established motor programs in the long-term memory is greater because of movement patterns recognised from other sports
- **Output:** More available movement patterns to be drawn on and adapted

In essence, the athlete exposed to a broad range of prior movement experiences will have the advantage in recognising similar occurrences from other sports, allowing a less cluttered process of response.

Many of us think of Don Bradman as being only talented in the area of cricket. His batting average of nearly 100 runs per innings defies belief. Yet Bradman was also talented

> **Catchy fact**
> In the National Hockey League in the United States, home teams wear white jerseys and visiting teams wear dark jerseys. That's because back in the 1960s, the league figured it would be more difficult to keep white uniforms clean while players were on the road.

at many other sports, including tennis, golf and billiards. Farrow and Kemp (2003) reported Bradman's greatest advice on transfer of learning to be:

'I would counsel every child who is interested in batting to play with a ball at every opportunity. Whether it be a golf ball, tennis ball, baseball or any other kind doesn't matter. It will help train the eye and coordinate brain, eye and muscle movement.'

Farrow & Kemp 2003

It's ironic that after so many years of scientific research into improving human performance, the modern-day movement experts still agree with Bradman's advice!

Crossover between sports

Table 3.1 shows data on players involved in multiple sports at junior level. This data shows us the total number, as well as the percentage of children playing no sport, and the percentages of children playing one, two or more than three sports.

Table 3.1 Number of organised sports played, by gender (2006)

Number of organised sports played, by gender	Males ('000)	Females ('000)	Persons ('000)	Males %	Females %	Persons %
0	425.4	548.2	973.6	31.1	42.2	36.5
1	440.6	425.6	866.2	32.2	32.8	32.5
2	314.2	222.9	537.1	23.0	17.2	20.2
3 or more	186.4	101.4	287.8	13.6	7.8	10.8
Total	1366.7	1298.0	2664.7	100.0	100.0	100.0

ABS 49010, April 2006 ' Children's Participation in Cultural and Leisure Activities, Australia' © Commonwealth of Australia, 2006

Checkpoints

1 What conclusions can you draw from this data regarding the state of our sporting nation?

2 How could you use this data to argue your case for helping to promote junior sport?

3 Does this data predict good or bad numbers of prospective elite athletes, based on your understanding of transfer of learning?

Coursework

Equipment

Basketballs, bucket or hoop, tennis balls, markers, medicine ball, cricket bat, tennis racquet

Procedure

1 Students set up markers and a bucket or hoop five metres apart, then have **ten** trials at each of the following:

- **a** Using the cricket bat and attempting to hit the tennis ball on the full into the target
- **b** Using the cricket bat and attempting to hit the basketball on the full into the target

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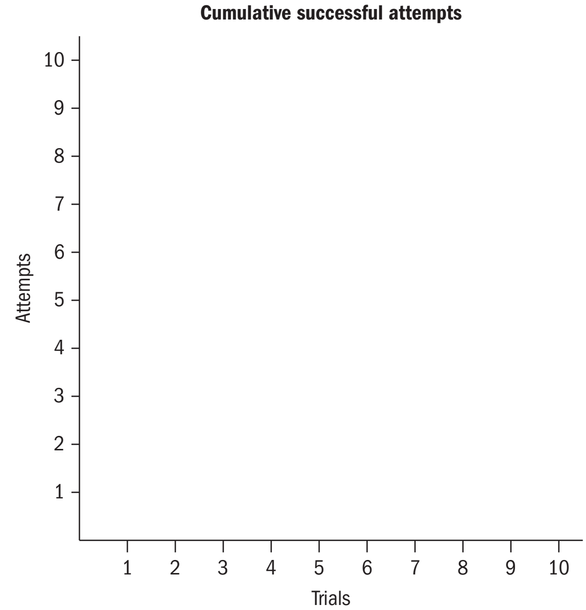
c Using the tennis racquet and attempting to **flick** the tennis ball on the full into the target: no hitting allowed

d Using the tennis racquet and attempting to **flick** the basketball on the full into the target: no hitting allowed



2 Graph the results on a trial-by-trial basis, using a colour code for each trial. Each successful attempt is added to the previous attempt, to create a cumulative total.

3 What trends regarding transfer of learning can you draw from this data?

4 From your knowledge of transfer of learning, use a sport of your choice to suggest and justify three types of cross training you would recommend to a coach for gaining maximum benefits.

TEST YOUR KNOWLEDGE

>> multiple-choice questions

1 A tennis forehand and a squash forehand drive would have:

A positive transfer
B zero transfer
C negative transfer
D bilateral transfer.

2 Don Bradman believed that:

A specialisation in sport was needed at an early age
B variety in ball sports would maximise sporting progress
C being ambidextrous would help skill development
D cue detection would not improve a batter's reflexes.

3 Farrow and Raab found that skilled athletes could generally reach elite levels with only _________ hours of sport-specific practice, due to transfer of pattern recognition.

A 1000
B 4000
C 10 000
D 12 000

4 Abernethy found that expert athletes in one sport were:

A more likely to have better pattern recognition in another sport than even a lower-level player in that sport
B less likely to have better pattern recognition in another sport than even a lower-level player in that sport
C more prone to error detection in irrelevant cues
D less likely to suffer kinaesthetic overload in zero transfer settings.

>> short-answer questions

1 Use an example to explain how skill-to-skill transfer could help a basketball player become a netball player.

2 Re-read the article 'Coaches crossing codes' on pages 45–46 of this chapter.

a Explain how this article relates to 'transfer of learning'.
b How could a junior coach benefit from Paul Roos' advice?

3 Explain, using the Input–Processing–Output model, how positive transfer of learning occurs.

4 Refer to data in Table 3.2 to answer these questions.

a Choose two sports from the table that you think would provide good transfer of learning for:
- European handball
- softball
- long jump
- diving.

b What do these statistics indicate about the popularity of sport in different states?
c How do you think this data could tell you why the level of sporting involvement and skill is dropping off in our population?

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Table 3.2 Summary of activities by states (2006)

	Victoria			Western Australia			Australia		
	Male	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**
	Number ('000)			Number ('000)			Number ('000)		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
	Proportion (%)			Proportion (%)			Proportion (%)		
Swimming	19.2	21.0	20.1	14.3	14.8	14.6	16.5	18.2	17.4
Soccer (outdoor)	8.9	2.1	5.6	13.1	4.3	8.8	19.6	6.4	13.2
Netball	0.2	16.8	8.3	**0.1	21.2	10.4	0.1	17.3	8.5
Tennis	10.4	8.5	9.5	9.3	5.6	7.5	8.0	6.6	7.3
Basketball	13.8	9.2	11.5	8.1	9.3	8.7	7.4	5.7	6.6
Australian Rules football	25.0	*1.5	13.6	25.3	**0.6	13.3	13.8	0.9	7.5
Cricket (outdoor)	11.9	**0.1	6.2	10.5	**0.3	5.5	10.1	0.4	5.4
Martial arts	6.6	2.6	4.7	7.0	*3.6	5.3	6.1	2.9	4.5
Athletics/track and field	2.0	3.5	2.7	**0.9	*2.4	*1.6	2.6	3.2	2.9
Rugby league	**0.3	**0.1	**0.2	**0.6	0.0	**0.3	7.9	0.3	4.2
Gymnastics	*1.8	5.7	3.7	*1.2	6.1	3.6	1.6	5.5	3.5
Hockey (outdoor)	*1.1	*0.9	*1.0	*3.7	4.9	4.3	1.7	2.2	1.9
Other organised sports	14.4	12.2	13.3	23.0	20.6	21.9	20.3	17.8	19.1
Total sport	69.2	56.2	62.9	68.5	61.8	65.2	68.9	57.8	63.5
Skateboarding or rollerblading	26.2	17.9	22.1	35.3	20.1	27.9	29.2	17.6	23.6
Bike riding	72.1	62.1	67.2	78.8	63.9	71.5	73.4	61.9	67.8
Watching TV, videos or DVDs	97.0	97.1	97.1	98.7	97.1	98.0	97.6	97.3	97.4
Playing electronic or computer games	76.9	47.6	62.6	75.1	49.4	62.6	76.8	49.8	63.6
Art and craft	32.5	57.1	44.5	39.7	67.7	53.4	37.4	61.4	49.1
Reading for pleasure	71.4	82.6	76.8	67.0	80.8	73.7	68.8	80.4	74.5
Homework or other study	81.0	84.4	82.6	73.6	79.0	76.3	81.0	84.9	82.9
Total leisure activities	99.7	99.6	99.6	99.9	100.0	99.9	99.7	99.7	99.7

Australian Bureau of Statistics, no. 4901.0 'Children's Participation in Cultural and Leisure Activities, Australia' © Commonwealth of Australia, 2007

>> essay questions

1 Present an argument to a group of local politicians that primary-school students should have specialised PE programs.

2 Imagine you are a newly-appointed elite coach. Outline the strategies you could put in place to maximise previous movement experiences of your playing group.

4 Analysing movement skills

> Insanity is doing the same thing you've always done and expecting different results.
>
> **Roger Milliken**

In order to maximise sporting performance, measurement and comparison before, during and after the event will provide the basis for future direction. This checkpoint helps determine a profile of player competencies. We have two main methods of analysis available to us:

- Qualitative analysis
- Quantitative analysis.

Qualitative analysis of movement skills

In order to guide performance for the future, it is necessary to go through a constant process of:

1. assessing athletes
2. identifying a profile of strengths and weaknesses for individuals and the team
3. amending the training program to correct these weaknesses.

This provides a baseline for a new coach to take stock of the resources at their disposal, allowing them to formulate a plan for the individuals and the team. Using this process ensures that training and skill development are not allowed to stagnate.

Qualitative analysis refers to an interdisciplinary approach to the process of assessing an athlete and plotting future improvement. This means looking at physical, mental and technical aspects as a whole, rather than looking at each aspect in isolation.

Several theories have been proposed to help build a framework for qualitative analysis. The most widely used framework was proposed by Knudsen and Morrison (2002).

profile
a collection of data that maps out strengths and weaknesses

qualitative analysis
examination of quality; analysis of fundamental variables that cannot be precisely valued

quantitative analysis
a direct measurable, numerical examination of specific variables

baseline
a standard that other measurements or facts can be compared with

interdisciplinary
drawing on more than one field

Knudsen and Morrison's model of qualitative analysis (2002)

Knudsen and Morrison's model of qualitative analysis is based on four distinct stages:

- Preparation
- Observation
- Evaluation
- Intervention

Catchy fact
The motto of the Olympic Games is *Citius, Altius, Fortius,* which is Latin for 'Faster, Higher, Stronger'.

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Stage 1: Preparation

During preparation, the coach gathers information on the key technical aspects of the activity. At this point, it is crucial to communicate with the athlete and become aware of their personal goals. For example, a soccer player may wish to move from defence to midfield to realise goal-scoring opportunities. When preparing to analyse such a player, the coach should allow them to complete activities that allow demonstration of midfield skills and goal-scoring skills.

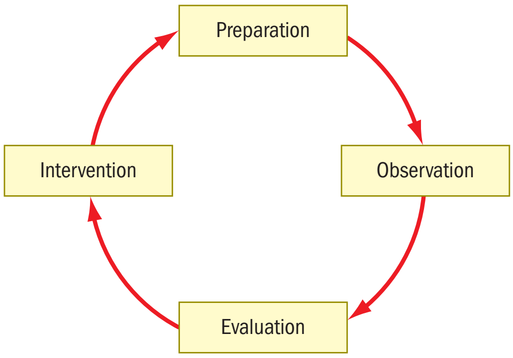


Figure 4.1 Knudsen and Morrison's model of qualitative analysis

Stage 2: Observation

Plan a suitable vantage point and a method of recording the observation. Will the view be front on, side on, rear view, top view, etc? Who will observe, who will record, what are the time frames? Will the analysis be a one-off? Or will it be over an extended time period?

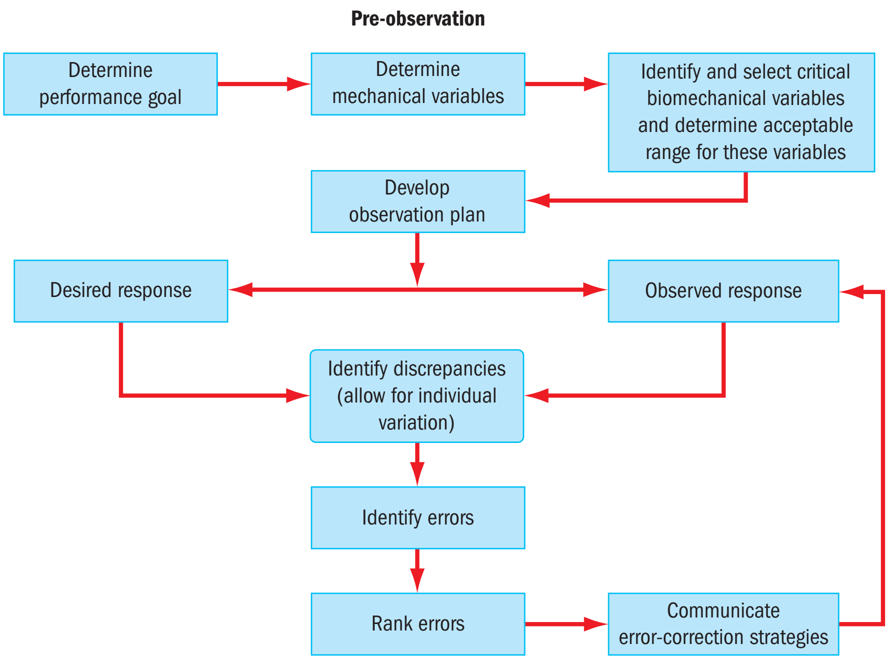
Stage 3: Evaluation

Review the analysis and ascertain the player's strengths and weaknesses. Then place the weaknesses into a priority list that has scheduled points for potential intervention.

intervention
a program or event designed to prevent or modify an outcome

Stage 4: Intervention

Discuss the weaknesses with the athlete. The methods for intervention will be based on the type of skill being considered. In reality, a professional basketball player with poor lay-up technique but who scores many points in competition, should not be interfered with in season. Any error correction should be timetabled for out of season, and probably would entail video-analysis software.



Adopted from McPherson 1996

Figure 4.2 McPherson's model of qualitative analysis

Other models have been proposed for guiding training and future athletic performance. McPherson (1996) used a more complex model for pre-observation. In essence, although the process looks more difficult, the desired outcome is the same.

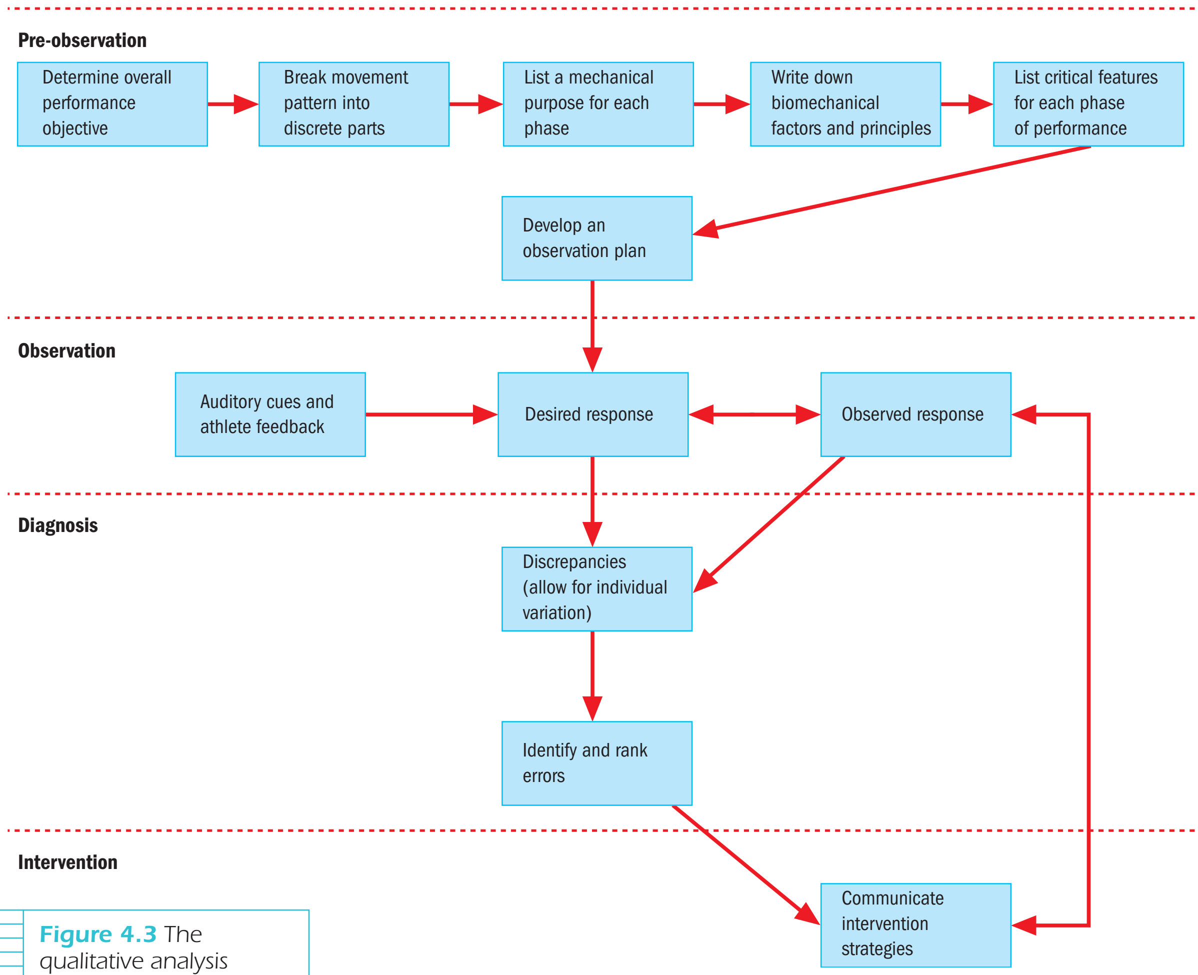


Figure 4.3 The qualitative analysis process

Adapted from Bloomfield, 1994

rubric
an assessment checklist, usually with numerical values, to help determine skill against designated measures

Examples of observation checklists

Observation of skills

Below are two examples of simple rubrics that could be used to help assess the current skill levels of a group of Year 10 students.

Table 4.1 Badminton skills checklist

Student's Name				
Recognise fundamental patterns of play or activity events and apply a range of actions in response:	High	Medium	Low	Not demonstrated
• Move to where the shuttle will be, two shots ahead				
• Read basic patterns of play: drop/drive smash – offence, drop/lob – defence				
• Read the opponent's ability				
• Make appropriate decisions in the game				
• Usually return to middle of court				

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Perform a range of specialised movement skills by adjusting the speed, force and direction of movement:				
• Ready position achieved most of the time				
• Usually get to shuttles in time				
• Vary speed, force and trajectory of shots to avoid moving opposition				
• Service, drop shots, drives and smashes are all demonstrated to a satisfactory level				
• Service is directed with accuracy				
Apply a range of activity specific strategies and tactics:				
• Use space, using convincing moves and a variety of forehands and backhands				
• Show offensive and defensive play				
• Show knowledge of predicting play				
• Usually return to middle of court				
• Maintain pressure on the shuttle and attempt to keep opposition moving				
Overall Rating: High/Medium/Low/Not Demonstrated				

Adapted from Curriculum Council of Western Australia

A simpler format such as that shown in Table 4.2 on page 58 could be used instead, to help establish a profile of strengths and weaknesses at a glance.

Checkpoints

Using Table 4.2 on page 58 as a template, design two rubrics aimed at assessing the skill level of your classmates in a sport of your choice.

1 The first of these should be qualitative, aimed at defining the observation of the performance or, to put it simply, 'How did it look?'

2 The second rubric should attempt to quantify the performance. In simple terms, 'What numerical values can we attach to the result or outcome'?

Qualitative analysis

Quantitative analysis

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Table 4.2 Sample volleyball rubric

STUDENT NAME:							
Defending Score ______	Does not demonstrate knowledge of basic mechanics of front-row play. /2	Periodically makes an attempt to block or stop the ball going to ground. /4	Makes regular contact with a blocked or dug ball so that team members can keep the ball alive. /5	Blocks or plays the ball into the opponents' court when it comes directly to them. /6	Consistently makes contact with a ball as a blocker and plays it over the net and moves to retrieve a spiked ball. /7	Consistently makes contact with a ball as a blocker, directing the ball into opponents' court and has some success retrieving a spiked ball. /8	Demonstrates ability to always be in the correct position to effectively block or retrieve a downward spiked ball. /10
Attacking Score ______	Does not demonstrate knowledge of basic mechanics of front-row play. /2	Periodically makes an uncontested attack over the net. /4	Hits the ball over the net when it comes directly to them. /5	Hits the ball over the net when it is set to him or her, occasionally moving to a set one or two steps away. /6	Consistently hits the ball over the net into the opposite court. /7	Consistently hits the ball over the net such that the opposing team cannot return. /8	Demonstrates ability to jump and attack the ball downward. /10
Communication Score ______	Does not communicate with team-mates or coaches. Does not make any motion towards the ball. /2	Does not communicate with team-mates or coaches; often runs into other players and takes balls called for by team-mates. /3	Responds to communications from team-mates and coaches by changing the way he or she plays on the court. /5	Calls for and aggressively pursues balls near their position and backs away from team-mates who call for a ball. /6	Encourages team-mates to communicate. /7	Helps guide team-mates on the court. /8	Strongly communicates with team-mates and coaches during play. /10
Game awareness Score ______	Sometimes confused on offence and defence; does not transition; stays in one place. /2	Can play a fixed position as instructed by coach; may go after an occasional loose ball. /4	Limited understanding of the game; performs basic skills and will run occasional plays if team prompts him or her. /5		Moderate understanding of the game; some offensive plays and solid defensive skills. /7		Advanced understanding of the game and mastery of volleyball fundamentals. /10
Movement Score ______	Maintains a stationary position; does not move to or away from the ball as necessary. /2	Moves only one or two steps towards the ball. /4	Moves toward the ball, but reaction time is slow and has intermittent transition from offence to defence. /5	Movements permits adequate court coverage. /6	Good court coverage, reasonably aggressive; good transition from offence to defence. /7	Excellent court coverage, aggressive; fast and accurate transition from offence to defence. /8	Exceptional court coverage, aggressive anticipation; great transition from offence to defence. /10

Total /50
(Maximum Score = 50)
Overall rating: ☐ A, B, C, D \

Adapted from St Mark's Community Anglican School, Perth

An alternative theory of qualitative analysis

Kreighbaum and Barthels (1996) suggest that knowledge of a few basic movement principles provides the necessary information for improving athletic performance.

What are coaches most concerned about when analysing activity?

Coaches need to consider a wide variety of collection methods when deciding which data will serve them best. Among these are:

- technique analysis
- energy-system requirements
- work–rest ratios
- dynamic-movement patterns
- team strategies and tactics
- recovery
- biomechanics
- their opponents' strengths and weaknesses.

Catchy fact
Since 1896, only two countries have participated in every modern Olympics Games: Greece and Australia.

Main methods for analysing performance

1 Visual observation

Visual observation by others or through the use of video footage allows for skill analysis using rubrics or checklists. Video footage can also be used to prolong viewing time, making the data more thorough.

2 Statistical analysis

Statistical analysis involves gathering objective data that can be viewed, if possible, by experts. This will also include direct testing, such as use of the vertical jump to assess injury recovery, or delayed onset muscle soreness DOMS. Weight can also be measured before and after competition to assess fluid loss.

3 Telemetry

Telemetry is having data electronically transferred to a recording device or computer. This could involve:

- heart-rate monitoring
- using the global positioning system (GPS) to track athletes
- joint-analysis software
- pedometry
- accelerometry.

DOMS
delayed onset of muscle soreness; soreness as a result of taking part in unaccustomed exercise

telemetry
transmitting data for recording and analysis

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4 Journal or log book

Keeping a journal or log book could involve:

- self-reporting by athletes (explained in more detail in Chapter 6)
- recall.

Table 4.3 Various methods for analysing performance

Type of analysis	Qualitative, quantitative or both	Methods available	Specific methods used in the field
Analysis technique	Qualitative	Visual	Rubrics, checklists, schedules
Energy-system requirements	Quantitative	Telemetry, visual	Heart-rate monitor, GPS tracking, observation checklist
Work–rest ratios	Quantitative	Telemetry, visual	Heart-rate monitor, GPS tracking, observation checklist
Dynamic-movement patterns	Both	Telemetry, visual	GPS tracking, observation checklist
Team strategies	Both	Telemetry, visual, journal	Journal, visual checklist
Recovery	Both	Visual, journal	Journal, visual checklist, testing
Biomechanics	Both	Statistical, visual	Joint-analysis software, observation schedule
Opponents' strengths and weaknesses	Both	Visual, statistical	Checklists, game analysis

The skill classification will determine the methods that will be most beneficial in mapping future direction. Some activities, especially if they are of a more continuous nature, will only really allow physiological performance measures, such as telemetry. For example, if you were measuring the performance of a cyclist, the absolute measures from Table 4.3 would provide the most information.

There is often debate about whether a recording method is purely objective (quantitative), or subjective (qualitative). In many cases, this depends on the skills of the observer. For example, in calculating the dynamic-movement patterns of a player, there may be components that are objective, such as where the player ran, as well as other criteria that are open to interpretation by the person recording.

A player who leaves his opponent to take on an attacking role and is then exposed on a turnover, allowing his direct opponent to score, may be perceived by some people as making the correct decision, and by others as having made a wrong decision.

KEEP IT REAL!

Thompson ready to smash 'em in 2009

Geelong coach Mark Thompson preached defiance, telling the AFL club's faithful he was determined to 'smash' next season.

Thompson, club chief executive Brian Cook and president Frank Costa urged Cats' fans to keep the faith at the official post-Grand Final dinner. It was a sombre event for several hundred guests at the National Tennis Centre as they lamented the 26-point Grand Final loss to Hawthorn [in 2008].

'Our guys will bounce back – we're taking it hard and I don't think you'd want us to take it any other way,' Thompson said. 'The fact is, this group is better than just winning one premiership and that's the challenge now.'

He pointed out that Geelong had enjoyed a near-perfect season and had most elements in place to continue as one of the AFL's top clubs. 'We just want to go home, but we can't do that. We have to face the music. Today we were beaten by a better team,' he said. 'But the core of our business, everything we believe in, is right. We actually know we've been the best team for the year and today didn't work for us.'

Cook, like every other Geelong fan, was bemused that the team seemed to have the measure of Hawthorn

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in most facets of the game – but still lost. He said it would be a waste if the club did not learn from what went wrong.

'We doubled the clearances, we took the ball into the 50 m 62 times, our average this year has been 45,' he said. 'It's just amazing that all of our KPIs [key performance indicators] were achieved, apart from one – the scoreboard. We have to learn from today. We have to take advantage and use it as a lever for next year because, if we don't, today is wasted.'

Cook, like Thompson, is already starting to think about next year and said it was vital that this current team make the most of their potential. 'To me, three Grand Finals in a row, if we win two out of three, (it's) not bad,' he said.

Excerpt from http://www.foxsports.com.au

What are KPIs?

In his article, Brian Cook referred to 'KPIs'. KPIs are key performance indicators; they are generally accepted areas that are recorded to allow statistical analysis; for example, the number of passes, intercepts and sprints in a game of netball. KPIs are different for each sport, as the specific nature of the sport will determine exactly which attributes are prized.

key performance indicators (KPIs). areas recorded for statistical analysis, e.g. number of passes

Framework for performance analysis

If a coach has recently taken over a new position, the four categories listed below would be an excellent starting point for reviewing the current situation and planning for the future.

- **Physical:** physiological fitness requirements
- **Mental:** psychological preparation and ability to cope with the pressures of competition
- **Technical:** the player's skill level, especially under pressure and when fatigued
- **Tactical:** the decision making of the athlete or coach, especially under pressure

Coach's resources

The coach needs to set up suitable structures beneath his overall position in order to methodically cater for all areas of preparation and planning. Table 4.4 outlines one structure that a coach may wish to establish, finances permitting. Data collection would often fall under the job description of assistant coaches, who very often enlist volunteers to obtain the raw data.

Alternatively, companies such as Pineapplehead and Champion Data specialise in data collection for sports analysis. The data is available on a user-pays system, and it is sometimes available to the public, who may wish to use this data to help predict winners.

The main problem with acquiring Champion Data, or similar, is that anyone can purchase it and everyone gets the same information. This has forced some elite sporting teams to collect their own critical data, even from the training track, in order to give them an added advantage regarding data collection and future directions.

Adapted from Brianmac.co.uk

Table 4.4 Network of coaches' resources

The Internet	Assistant or specialist coaches	Nutritional
Physician		Financial resources
Physiotherapist		Sports administrators
Physiologist	Coach	Masseur
Biomechanist		Specialists in rehabilitation and recovery programs, e.g. pilates, yoga
Manager		Officials
Psychologist	Career and education advisor	Strength and conditioning coordinator

Frank Pyke et al, 2001 p. 28

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Data collection

Champion Data

Champion Data is an Australian company founded in 1996 by former VFL player Ted Hopkins. Champion Data has become prominent in recent years as the source of statistical data for a range of sports, including cricket, soccer, rugby league, rugby union and Australian Rules football. Champion Data supplies TV and radio commentators and journalists, via a subscription service, with 'up-to-the-second' customised game-day statistics. Coaches receive the data in the coach's box instantly, via computer links. Statistics supplied by Champion Data are reported in newspapers the next day.

At every AFL game there are three or four trained 'callers' who identify and categorise the play into more than 70 different pre-determined categories: long kicks, short kicks, handballs, runs with the ball, kicks inside 50 metres, contested marks, 'hard-ball gets', 'clangers', etc. The 'calls' are recorded by one or two 'keyboarders' who enter the information onto laptop computers where it is instantly made available to subscribing customers: coaches, commentators and journalists. A live feed of the game is broadcast back to Champion Data headquarters where another analyst performs a quality check to make sure that the data is as accurate as possible. According to Hopkins, 'If we can't guarantee the quality and accuracy of the data to within 95 per cent or better, we don't record it'.

The advantage of collecting data on all players in every game is that analysis can be performed on recognising patterns of play. The computer package generates comparative data for every player, so that a player and their direct opponent can be compared. A player-ranking system, based on extensive research of winning and losing factors, has also been developed.

Player ranking system

The player, coach or team that makes better decisions is more likely to win. A player can expend a lot of energy running around, but their effort can be in vain if they are not making good decisions. The focus at Champion Data has been predominantly on team games, particularly Australian Rules football, as this is their most significant market; however, as more markets develop the potential for future growth is very good.

Pineapplehead

Pineapplehead

Pineapplehead provides an alternative to Champion Data. Pineapplehead provides everything from the graphics that we regularly see on TV to individual statistics – and even a virtual-spectator facility. This is all on a user-pays format. The skill classification used in the data can determine the methods that will be most beneficial in mapping future directions; for example, open or closed, discrete or continuous.

Observation

Observation is more difficult in sports with lots of players, large playing fields and unlimited substitutions. This is the reason that data-collection companies have become integral to assessing sporting performance. Indoor games with only a few players lend themselves to the collection of more data because of the ease of recording.

Quality of observations

If the observer is not skilled in the demands of the sport, they may overlook key statistics that are valued by the team. In Australian Rules football, the screen from another player to help leading forwards avoid heavy contact is a valuable statistic.

In netball, the defender who constantly zones out the shooter and prevents them from receiving the pass may not gather a statistic. The scoreboard may show that the other defender conceded more goals, even though they had many more plays to defend.

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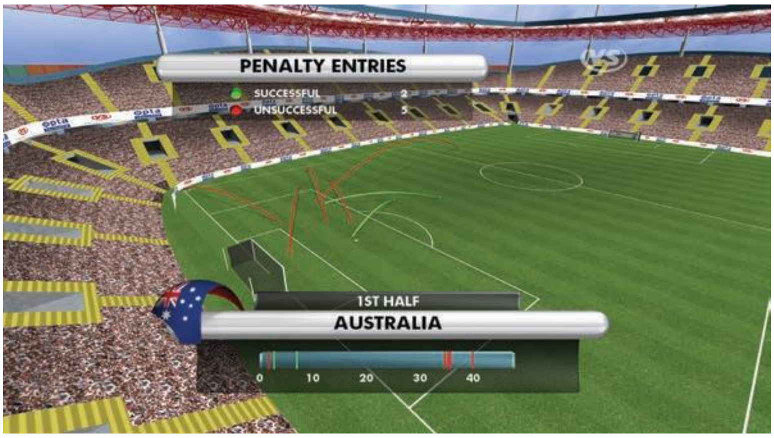

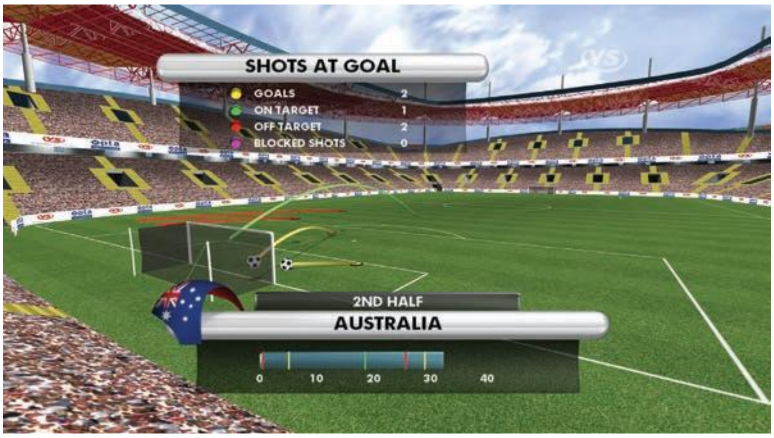

Figure 4.4 Examples of Pineapplehead data

Statistics in practice

The ratio of work to rest is an important statistic in determining how hard to make each training session. The work–rest ratio determines the number of repeated efforts, separated by recovery time. A work–rest ratio of 1:3 indicates that an athlete is working at physical activity for one minute for every three minutes that they are resting. Imagine that a training session lasts for 60 minutes, and that the physical-activity component of the session, or 'work', lasts 22 minutes in total. That leaves 38 minutes of recovery or 'rest'. The ratio of work to rest is approximately 1:3. This is a normal ratio for most team sports.

Work–rest ratios are specific to the type of activity, and vary with the ages and skill levels of the participants, and on the specific period in the training cycle. Work–rest ratios are only usually used in sports that are not continuous. However, there may be a case for the coach of a 5000-metre runner to use work–rest rations as a guide to how rigorous a training session should be when trying to develop an athlete's sprint finish.

work
the amount of time actively engaged in physical effort

rest
the time between physical conditioning, allowing the body to remove wastes and replenish muscle stores

Checkpoints

Watch a Physical Education class for a 20-minute period after the warm up is over. Design your own data collection sheet to determine time spent 'at work' and time spent 'at rest'. You might wish to expand your system of data collection to provide more meaningful information.

1. What work–rest ratio did your data uncover?
2. Is the Physical Education teacher working the class hard enough to gain a training benefit or physiological adaptation?
3. Why do you think a Physical Education teacher may have to set lower levels of activity than a coach?
4. What was the most difficult part of collecting the data?

Catchy fact
According to data published in 2001 by FIFA, the world football controlling body, more than 240 million people worldwide play football.

ISBN 9780170227124

Research throws light on an awkward fact

by Justin Kemp and Damian Farrow

KEEP IT REAL!

Figure 4.5 Is Muttiah Muralitheran a 'chucker'?

Ever since Australian Test bowler Ian Meckiff was unceremoniously chucked out of cricket for straightening the elbow in the 1960s, 'chucking' has been regarded as one of the game's biggest sins.

Several Test bowlers in recent times, including Pakistan's Shoaib Akhtar, Sri Lanka's Muttiah Muralitharan and Australia's Brett Lee, have had their actions put under the microscope. Last week, Bangladesh all-rounder Sanwar Hossain became the latest suspect in cricket's equivalent of the Salem witch-hunts.

Hossain played in the one-day series that finished this week, risking not just being no-balled for chucking, but effectivel y risking his career with every delivery.

It is interesting to note that Hossain was reported for throwing after Test umpires viewed video footage of his bowling action, despite common knowledge that our perception of high-speed sporting movements such as bowling is dependent on our viewing position.

This was highlighted in research undertaken a few years ago to analyse the suspect action of Muralitharan, who, like Hossain, is a spinner. Despite video allowing multiple slow-motion replays from a variety of angles, it was found that different viewing angles relative to the bowler told different stories. One particular camera angle gave the perception that Muralitharan's arm was straightening, while all other angles demonstrated this not to be the case. This particular view was located at a point similar to that of the umpire's position behind the stumps.

From a fast-bowling perspective, new research is now questioning the very definition of a fair delivery. A study conducted by scientists from Cricket Australia and the Australian Institute of Sport suggests that it might be a biomechanical impossibility for fast bowlers not to straighten the arm immediately before releasing the ball, as demanded by the laws of the game.

In the MCC laws of cricket 2000, Law 24, section 3, the definition of a legal delivery states: 'A ball is fairly delivered in respect to the arm if, once the bowler's arm has reached the level of the shoulder in the delivery swing, the elbow joint is not straightened partially or completely from that point until the ball has left the hand'.

The research, presented by Marc Portus (Cricket Australia's sports science officer) at the second World Congress of Science and Medicine in Cricket, revealed that if the present letter of the law is applied to the fast bowling techniques, many Test players might be chucking.

Thirty-four deliveries from 21 different bowlers in match situations underwent three-dimensional biomechanical analysis. Every ball analysed was bowled with some degree of elbow straightening, thereby making each delivery illegal under the laws of cricket. The average straightening about the elbow was 11 degrees, with only two deliveries showing elbow movement less than five degrees.

The International Cricket Council has stipulated a 10-degree tolerance threshold for changes in the elbow angle when analysing suspect fast bowlers. Of the 34 deliveries analysed, 14 exceeded this threshold. At the higher delivery speeds averaging 140 km/h, the amount of elbow straightening before ball release often exceeded 15 degrees.

Enhanced technology continues to provide enhanced understanding of the realities on the sporting field; in this case, that elbow straightening is a biomechanical reality for the world's elite fast bowlers. With this key criterion for chucking being so consistently broken, as highlighted by this recent research, perhaps it is time for a rethink by cricket law-makers as to what now should be deemed a fair delivery.

***The Age*, 9 August, 2003**

ISBN 9780170227124

Checkpoints

1 Discuss and debate the argument for and against using video-software analysis to disqualify players from competing.

2 Do you agree with changing the laws of cricket to accommodate technique variation in bowling? Using a sport of your choice, choose an activity where you think competitors ‘stretch’ the limitations of the laws.

3 Can you think of any other sports where players bend the rules to gain an advantage?

The following is typical data for a centre in a high-level netball game.

Table 4.5 Total skill frequency for the match

Skill activities	Total
Centre pass	42
Pass	127
Catch	138
Defend	160
Guard	172
Jump	47
Leap	39
Toss up	4

Table 4.6 Movement patterns: total numbers for the match

Movement patterns	0–2 m	3–5 m	6–10 m	11–15 m	16 m+	Total	Total distance	Average distance	Percentage of total
Stand still (no movement)						32			
Walk	31	81	36	21	2	171	1150 m	6.7 m	34
Shuffle	61	87	39	12	0	199	721 m	3.6 m	21
Jog	12	31	41	34	29	147	1037 m	7.05 m	31
Sprint	37	38	35	28	4	142	486 m	3.4 m	14
Change direction						223			
Totals	141	237	151	95	35		3394 m		100 %

Checkpoints

1. What information can be obtained by looking at the data in Tables 4.5 and 4.6 on page 65?
2. What is the purpose of a game analysis?
3. Using information from Tables 4.5 and 4.6 to support your response, discuss the use of the three energy systems in this particular game.
4. Review the statistics in Table 4.7. Is there such a thing as too many statistics?
5. What critical piece of information can you find in this data that doesn't support the team that won?
6. Would all this information help a coach to modify tactics at half-time?
7. Brainstorm all the statistics that you would require as a coach in the practical sport that you are completing for this course.
8. Can statistics be misleading? If so how?

Table 4.7 Australian Rules football match data

Geelong match statistics (sorted by disposals)														
Player	K	HB	D	M	G	B	T	HO	GA	GC	I50	FF	FA	DT	SC
Steve Johnson	21	13	34	6	1	1	1	0	0	1	6	2	0	120	98
Gary Ablett	12	22	34	3	2	1	5	0	0	2	8	2	3	115	141
Joel Corey	13	17	30	5	0	0	6	1	1	1	6	0	0	113	97
Joel Selwood	11	18	29	6	0	0	3	0	1	1	6	3	0	102	106
Corey Enright	11	14	25	6	0	0	2	0	0	0	1	0	0	87	98
James Bartel	12	12	24	4	0	0	3	1	1	1	4	2	3	78	81
Paul Chapman	14	8	22	5	1	2	4	0	0	1	4	2	0	99	103
Cameron Ling	7	13	20	3	0	0	2	0	0	0	4	1	0	65	55
Joshua Hunt	11	3	14	5	0	0	0	0	0	0	1	1	1	52	63
Cameron Mooney	9	5	14	8	2	3	0	0	0	2	3	0	1	73	74
Darren Milburn	9	5	14	6	1	0	2	1	0	1	1	1	0	71	91
Harry Taylor	4	9	13	1	0	0	0	0	0	0	1	2	0	35	51
Andrew Mackie	9	4	13	3	0	1	1	0	0	0	4	1	0	50	64
Max Rooke	5	8	13	3	2	0	7	0	1	3	4	3	4	71	67
Travis Varcoe	5	7	12	3	0	1	2	0	0	0	3	0	1	44	35
Tom Lonergan	6	6	12	5	2	1	1	0	0	2	0	2	3	55	35
Brad Ottens	7	5	12	2	0	1	4	22	0	0	2	1	1	74	93
Matthew Scarlett	5	6	11	1	0	0	2	0	0	0	0	3	0	41	77
Tom Harley	6	5	11	1	0	0	1	0	0	0	1	0	0	35	35
James Kelly	2	8	10	3	0	0	2	0	0	0	1	1	2	34	31

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Mathew Stokes	3	4	7	1	0	1	1	0	0	0	1	1	1	23	15
Mark Blake	1	3	4	1	0	0	0	20	0	0	1	1	1	30	42

GA - Goal Assists, I50 - Inside 50s, GC - Goals Contributed (Goals + Goal Assists)

Hawthorn Match Statistics (Sorted by Disposals)															
Player	K	HB	D	M	G	B	T	HO	GA	GC	I50	FF	FA	DT	SC
Xavier Ellis	21	7	28	14	1	0	2	1	1	2	5	2	0	136	110
Brad Sewell	10	17	27	7	0	0	5	0	0	0	1	2	1	104	113
Luke Hodge	20	6	26	9	1	0	5	0	0	1	1	3	1	125	155
Michael Osborne	15	11	26	8	0	0	3	0	4	4	3	3	1	103	121
Shane Crawford	12	13	25	4	0	0	3	1	0	0	2	0	1	84	79
Brent Guerra	15	10	25	12	0	0	2	0	0	0	1	1	2	104	78
Grant Birchall	13	10	23	12	0	0	4	0	0	0	1	1	1	109	100
Jordan Lewis	11	10	21	7	0	1	1	1	2	2	4	0	0	80	84
Clinton Young	14	5	19	8	1	0	2	0	0	1	6	1	1	88	43
Stuart Dew	10	9	19	3	2	1	5	0	1	3	4	0	0	90	134
Campbell Brown	11	5	16	10	1	1	1	0	1	2	2	1	1	82	94
Chance Bateman	12	4	16	4	1	1	2	0	2	3	4	1	2	66	64
Mark Williams	10	5	15	5	3	2	1	0	2	5	1	2	3	72	97
Rick Ladson	5	9	14	4	1	0	1	0	0	1	2	0	1	52	61
Stephen Gilham	10	3	13	10	0	0	2	0	0	0	0	0	0	74	82
Sam Mitchell	7	6	13	4	1	0	7	0	0	1	1	1	5	65	60
Lance Franklin	7	5	12	4	2	1	1	0	2	4	1	0	4	48	59
Cyril Rioli	6	4	10	2	2	0	3	0	0	2	2	2	1	55	85
Robert Campbell	5	5	10	3	0	0	1	14	0	0	0	0	0	52	54
Jarryd Roughead	4	4	8	2	2	0	1	1	0	2	1	0	1	40	53
Brent Renouf	3	2	5	2	0	0	3	7	0	0	1	1	2	33	22
Trent Croad	1	0	1	1	0	0	1	0	0	0	0	0	1	7	3

Head to Head		
Geelong	Statistic	Hawthorn
183	Kicks	222
195	Handballs	150
378	Disposals	372
0.94	Kick to Handball Ratio	1.48

Average Attributes		
Geelong	Attribute	Hawthorn
188.8 cm	Height	185.2 cm
91.3 kg	Weight	89.5 kg
25 yr 9 mth	Age	24 yr 7 mth
103.2	Games	87.0

81	Marks	135
49	Tackles	56
45	Hitouts	25
29	Frees For	21
21	Frees Against	29
11	Goals Kicked	18
12	Behinds Kicked	7
11	Rushed Behinds	0
34	Scoring Shots	25
32.4%	Conversion	72.0%
34.36	Disposals Per Goal	20.67
11.12	Disps Per Scoring Shot	14.88
62	Inside 50s	43
1.82	In50s Per Scoring Shot	1.72
5.64	Inside 50s Per Goal	2.39
37.1%	% In50s Score	58.1%
17.7%	% In50s Goal	41.9%
4	Goal Assists	15
36.4%	% Goals Assisted	83.3%

Total Players By Games		
Geelong	Games	Hawthorn
4	Less than 50	3
3	50 to 99	8
6	100 to 149	7
9	150 or more	4

Goals Analysis		
Geelong	Goals From	Hawthorn
4	Mark	10
4	Free Kick	0
1	50 m Penalty	1
3	Play	8

Quarter by Quarter Scoring Breakdown

Geelong	First Quarter	Hawthorn
5.3 33	Score	5.2 32
8	Scoring Shots	7
62.5%	Conversion	71.4%
Won quarter by 1	Result	Lost quarter by 1
Leading by 1	End of Quarter	Trailing by 1

Geelong	Second Quarter	Hawthorn
1.9 15	Score	3.1 19
10	Scoring Shots	4
10.0%	Conversion	75.0%
Lost quarter by 4	Result	Won quarter by 4
Trailing by 3	Halftime	Leading by 3

Geelong	Third Quarter	Hawthorn
3.6 24	Score	6.2 38
9	Scoring Shots	8
33.3%	Conversion	75.0%
Lost quarter by 14	Result	Won quarter by 14
Trailing by 17	End of Quarter	Leading by 17

Geelong	Final Quarter	Hawthorn
2.5 17	Score	4.2 26
7	Scoring Shots	6
28.6%	Conversion	66.7%
Lost quarter by 9	Result	Won quarter by 9
Lost game by 26	End of Game	Won game by 26

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Scoring Breakdown For Each Half

Geelong	First Half	Hawthorn
6.12 48	Score	8.3 51
18	Scoring Shots	11
33.3%	Conversion	72.7%
Lost half by 3	Result	Won half by 3
Trailing by 3	Halftime	Leading by 3

Geelong	Second Half	Hawthorn
5.11 41	Score	10.4 64
16	Scoring Shots	14
31.2%	Conversion	71.4%
Lost half by 23	Result	Won half by 23
Lost game by 26	End of Game	Won game by 26

http://www.footywire.com/afl/footy/ft_match_statistics?mid=4134

KEEP IT REAL!

Becoming a better bench coach

by Alan Launder and Wendy Piltz

Match analysis 'during the game' is a significant component of bench coaching. There is vast difference between pre- or post-match analysis and match analysis in the 'cauldron' of a crucial game. Match analysis during a game is far more than the collection and interpretation of statistics, however valuable that may be. It is a complex process involving specific skills in observation and analysis.

The coach must be able to:

- watch the players of both teams in a relatively calm manner, even under intense pressure
- discern patterns of play
- identify the manner and contributions of individual players on both sides amid the apparent chaos of the game
- see whether or not your team is attempting to carry out its game plan, and if not, why not?
- remain composed to decide what changes can be made and then act with confide ce to make them
- gain maximum value from timeouts and substitutions, and make the best use of quarter and half-time breaks.

This form of match analysis is multi-layered and, as with the appreciation of anything complex, the layers are usually only peeled away through thoughtful experience over many years.

www.afl.com.au, 28 January 2002

Checkpoints

Read the article above, then design a generic table that could be used in any sport, taking into account:

- biomechanical principles
- technique
- physical capacities
- psychological capacities.

Training to improve performance

This topic could fill a book on any given sport, and would require detail specific to the actual sport being considered. A coach needs to follow a framework for implementing a suitable training program in order to cover all of the necessary aspects. The framework in Figure 4.6 outlines one common plan.

Types of practice

In observing several coaches in action, you would witness many different formats for training the same skill. There are limitless ways of setting up an activity; however, they all fall loosely into several main categories. Some methods will reflect a number of practice types integrated into one.

In simple terms, we can identify several different types of practice:

- Massed practice
- Distributed practice
- Variable practice
- Fixed practice

Massed practice

A skill is practised continually until it is developed, without any noticeable breaks. A short pass in soccer would be well suited for this type of practise. As martial artist Bruce Lee said, 'I fear not the man who has practised 10 000 kicks once; I fear the man who has practised one kick 10 000 times.'

Figure 4.6 Framework for implementing a training program

1 Analyse the activity and its requirements
For example, fitness components, priority-energy systems, skills.

↓

2 Fitness test the entire playing group
This could be pre-season or in-season.

↓

3 Decide on appropriate training methods
For example, continuous training, fartlek, supplementary weights, cross-training, etc. Information from Stages 1 and 2 should be used to decide on the training methods.

↓

4 Design the training program
Use the periodisation schedule, including macrocycles, mesocycles and microcycles. The detail should allow a large overview matrix to be made of the entire year.

↓

5 Line coaches design individual sessions
Elite teams map out daily or weekly session-by-session outlines at the start of the pre-season, although these are flexible.

↓

6 Playing list summary spreadsheet
Use this list to keep track of all players, including priority programs and specialised interventions. (See Chapter 6 for more detail.) This also must be tied into the overall periodisation schedule.

periodisation
breaking up a training program into blocks of time

macrocycle
the large block of training, which can be several months or a year

mesocycle
a block of weeks in a training cycle, usually 4–12 weeks

microcycle
training unit that repeats itself; usually a week, but can be 4–10 days

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Distributed practice

The training is broken up to allow intervention from coaches, or to relieve boredom. The skill is developed gradually, particularly if it is difficult; for example, a volleyball player trying to learn a jump spike serve.

Variable practice

The skill is practised in the variety of situations that could be experienced in game or competition; for example, a defender in Australian Rules football learning how to read a specific attacking play.

Fixed practice

A fixed practice is a drill in which a specific movement is practised repeatedly; for example, a golfer hitting drives for distance and accuracy.

Other descriptions of types of training may include:

- training for accuracy
- mental vs physical training
- training for speed.

Which practice works best?

Practice methods need to align with the desired outcome of practice. If the goal is long-term retention, then the practise needs to focus on changing techniques over a period of time; this is the opposite of practise that focuses on short-term performance gains. Trying to maximise learning in a practice session often conflicts with the goal of performing as well as possible in a practice session. A coach must always remember the distinction between learning and performance.

Checkpoints

Tailoring practice to skills

Copy and complete Table 4.8, placing ticks in the appropriate columns to show which types of practice would be most suited to each activity.

Table 4.8 Practice and skill types

Activity	Massed	Distributed	Variable	Fixed	Reason
Taking a corner kick in soccer					
Sprint cycling					
Defending the goal shooter in netball					
Catching a wave in surfing					
Kicking a goal in Australian Rules football					
Improving the effect of breastroke kick in swimming					
Javelin throwing					

Defining skills: simple vs complex

Before we can consider the type of practice that would be most suitable for the activity being coached, we need to understand more about the broad classification of motor skills. A simple skill must be able to be learned quickly and easily so that it is repeatable. This can vary from individual to individual.

simple skill
a motor skill that an individual can perform with very little practise

Coaching a simple skill involves repeating the core movement, in what is called 'massed practice'. This means that performers must persist in completing the basic skill over and over in order to help define and refine the motor pathway. Once the motor pathway is almost automatic, the athlete is then able to focus on other external cues that may help guide improvement in performance.

Standard methods of teaching a simple motor skill

1 Imitation

The athlete is asked to copy a video or a demonstration by another person. In tennis, serving is traditionally introduced by copying the coach. However, if a skill cannot be copied easily, the athlete may not find it a simple skill.

2 Demonstration, explanation, practice, coaching

This is the preferred method for most Physical Education teachers. When sports were first introduced to you, it was probably using the 'demonstration, explanation, practise, coaching' method.

Examples of a simple skill include:

- kicking a soccer ball
- throwing a chest pass in netball
- catching a basketball.

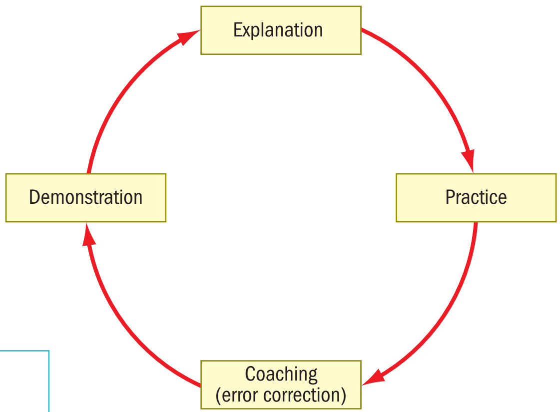

Figure 4.7 The 'demonstration, explanation, practise, coaching' method

The individual's skill level will influence whether or not they perceive an activity as simple or complex, so the examples above are not true in all cases.

A complex skill is a motor skill that cannot easily be performed using this method. It usually involves complex temporal patterning, advanced timing and excellent stability and balance to perform a complex skill repeatedly with success.

complex skill
a skill that cannot be performed after simple demonstration or explanation

Whenever you are attempting to decide whether a skill is complex or simple, remember that a simple skill to one athlete may be complex to another; as a coach you must determine how each athlete perceives the skill. If you teach overhead serves in volleyball to a group of 15-year-olds, some may quickly master the basic technique. For them, it is simple. However, another group of students may struggle with the coincidence timing, and will need to have the skill broken down into simpler parts before they can master the skill. This leads us to the notion of how to teach a complex skill.

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Checkpoints

1 Give examples of these training types in a sport of your choice.
- Training for accuracy
- Mental training as opposed to physical training
- Training for speed

Catchy fact
Manchester United were first known as Newton Heath. They changed their name in 1902.

KEEP IT REAL!

Lena is a 15-year-old girl who is developing her soccer skills in her school PE class. She has informally kicked the ball around with friends and in primary school, but she has never closely been coached.

First, Lena must learn not to kick the ball with her toes, as she has been doing for many years. She is instructed to turn her toes out, and focus on striking the ball with her instep.

Lena finds this awkward at first, but is given many varied drills to give her the opportunity to develop the correct technique using massed practice. Once Lena has mastered this basic movement, she can begin integrating it into game play, where there are many constantly changing external factors. This can only really be done once the basic skill is mastered, and Lena's mind is not continually cluttered with the task of performing the movement.

Teaching a complex motor skill

Complex motor skills require a sequential method, generally introducing one piece of the skill at a time. The actual movement itself may incorporate several simple skills that require integration into a complex motor program. Each part in isolation may be simple, but when combined they become extremely difficult; for example, a spike serve in volleyball.

There are two main recognised methods for teaching a complex skill. They are shaping and chaining. Both methods achieve the same outcome: a re-assembled, efficient, complete movement pattern.

Shaping

Shaping involves the following steps.

1. Demonstration
2. Perform a simple, incomplete version of the skill
3. Error correction of simple version
4. Add components to increase complexity
5. Focus on accuracy and increasing speed
6. Perform entire skill and refine
7. Integrate the skill into small game play

In summary, shaping is the process of simplifying a complex skill into its main component, and then adding on the missing pieces.

shaping
simplifying a complex skill into its main components, then adding on the missing pieces

chaining
breaking a complex skill into its components, practising each part separately, then re-assembling the skill

Chaining

Chaining involves the following steps.

1. Demonstration
2. Break the skill into its components
3. Perform simple drill in each component
4. Put all the components back together
5. Increase speed and add opponents
6. Integrate the skill into small game play

In summary, chaining is the process of breaking a complex skill into all of its components, then practising each part separately, before re-assembling the skill at the end.

Checkpoints

1 Give an example of chaining in a sport of your choice.

2 Give an example of shaping in a sport of your choice

3 Can you use either method for any complex skill? Explain your answer.

Current philosophy on practice

In the last ten years, phrases such as 'game sense', 'student-centred learning' and 'discovery learning' have become common among coaches and teachers. The Internet has taught us that knowledge alone is not enough: we need to understand the *process* of acquiring what we need if we are to display higher-order learning.

Coaches are favouring using these newer methods of encouraging students and athletes to find their own solutions to a sporting problem. Posing a problem and allowing students to find the answer by discovery produces results with long-term benefits. If students learn how to solve one problem by themselves, they can apply what they have learnt to other scenarios.

Game sense

Game sense refers to placing all new skills in a student-designed micro-version of the original game. The coach breaks the team up into groups and sets a task for each; for example, 'Work out a way to get the volleyball from the service reception to a spiker in an advantageous attacking position in a small game'.

Each group may solve this problem in a different way. Ownership of the solution will empower students to remember the concept rather than just learning it by rote. Student-centred learning and discovery learning are variations on this theme.

Checkpoints

Write a four-week training program in a sport of your choice for a group of 12-year-old children. They will train twice a week, and play on a Saturday. You must include:

- types of practice
- skills to be taught
- structure of each session.

Effectiveness of a training program

The overall goals of the coach, athlete, management and spectators will determine whether or not the training program is meeting the requirements of the sporting performance. If a club knows that it is in a re-building phase after the retirement of a large number of players, the goals may be to develop the physical fitness, skills and tactics of the young playing group.

Provided the goals are well known and accepted, a slow build of results may indicate that the training program is working. In other circumstances, inconsistent performances

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would not be tolerated. Many professional and amateur coaches have lost their jobs due to inconsistent results at a time when the majority felt that the playing group should be achieving success on the field.

In evaluating the effectiveness of a training program, there are several measures a coach could use.

- Competition results
- Physiological parameters of the playing group
- The number of chronic injuries
- Internal data collection
- An external audit; for example, West Coast Eagles 2008

Catchy fact
NBA basketballer Shaquille O'Neal wears size 22 shoes. He puts on a brand new pair before every game.

Checkpoints

Table 4.9 shows match statistics from a tennis match between Juan Martin Del Potro and Gilles Muller at the 2009 Australian Open. (Del Potro won the match in four sets: 6–7, 7–5, 6–3, 7–5.)

1 What information would this data tell a coach about their athlete's losing performance?

2 Is this data comprehensive enough to determine changes to a training program? If not, what other data would you need?

Table 4.9 Tennis match statistics

	Del Potro	Muller
First serve %	92 of 126 = 73%	114 of 179 = 64%
Aces	12	22
Double faults	3	9
Unforced errors	25	62
Winning % on 1st serve	76 of 92 = 83%	80 of 114 = 70%
Winning % on 2nd serve	21 of 34 = 62%	28 of 65 = 43%
Winners (Including service)	62	71
Receiving points won	71 of 179 = 40%	29 of 126 = 23%
Break point conversions	4 of 24 = 1 %	1 of 3 = 33%
Net approaches	20 of 25 = 80%	42 of 60 = 70%
Total points won	168	137
Fastest serve speed	206 km/h	209 km/h
Average 1st serve speed	180 km/h	190 km/h
Average 2nd serve speed	146 km/h	158 km/h

www.australianopen.com

Overtraining

Overtraining will be covered in detail in Chapter 14. As a general rule, overtraining occurs when the body has been given insufficient time to recover from training. Overtraining is usually indicated by a number of emotional, behavioural, psychological and physical symptoms.

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Why does overtraining happen?

Many things can contribute to an athlete experiencing overtraining. A poorly designed training program might cause overtraining. Poor design features might include an imbalance between training and rest. Overtraining could also be caused by excessive training (too much; too high an intensity); sudden changes in training load coupled with inadequate rest; inadequate and unreliable monitoring of training performance. Long-term fatigue is difficult to monitor, as it builds up gradually.

Figure 4.8 Long-term fatigue caused by overtraining builds up gradually

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TEST YOUR KNOWLEDGE

>> multiple-choice questions

1 Recording the power output of an athlete on a force platform is an example of:

A subjective analysis
B qualitative analysis
C quantitative analysis
D key performance indicators (KPI).

2 Qualitative analysis, according to Knudsen and Morrison, is based on four distinct stages. These are:

A observation, evaluation, interpretation, intervention
B preparation, observation, evaluation, intervention
C observation, intervention, evaluation, summation
D clarification, observation, intervention, evaluation.

3 Which method of analysis would best suit a marathon runner?

A Visual
B Journal
C Joint-analysis software
D Telemetry

4 If you were teaching a complex skill with many components to a group of ten-year-old children, which method would be most successful?

A Shaping
B Chaining
C Imitation or demonstration
D Imitation

>> short-answer questions

1 Explain the difference between qualitative and quantitative methods of analysis, giving specific examples in a sport of your choice. Briefly discuss why.

2 Shaping is suitable for complex skill actions with simultaneous elements; for example, hurdling. Beginners often see hurdling as a complex skill because of the event rules and because they are concerned about hitting the hurdles. A possible sequence to shape the hurdling skill over a number of training sessions is as follows.

- Athlete to run over five to ten cones, adjusted to allow them to take three rhythmic strides between each cone. This is to develop their running rhythm between the hurdles.
- Replace the cones with low obstacles that offer no resistance if hit; for example, hurdles 20 centimetres high
- Use hurdles set at the lowest height with no toppling weight
- Gradually adjust the hurdle height and spacing to competition requirements for the athlete's age group.

Adapted from Brianmac.co.uk

Explain the process of shaping a complex skill, using a skill in a sport of your choice.

3 Explain what other method is available to teach a complex skill, using a skill in a sport of your choice.

4 Why does a coach need to quickly decide whether or not an athlete is coping easily with an introduced skill?

>> essay questions

1 You have just been appointed coach of an elite sports team. Write a speech that you would use to address management, the playing group and the coaching staff. Special mention should be made of your overall plan (training), future short- and long-term goals, and how these will be measured.

2 Explain how you would use Knudsen and Morrison's model of qualitative analysis to create a profile of any individual in your class, in the sport you are currently studying. Include any methods of analysis that you would use.

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5 Leadership in sport

Leadership

When we speak of leadership, we generally think of a relationship between an individual leader and a follower or group of followers. There is an implied power base for a leader in a sporting organisation that has the potential to help or hinder the progress of the group.

Barrow (1977), cited in Weinberg & Gould (2007), defined leadership as 'the behavioural process of influencing individuals and groups towards set goals'. This definition is important, as it emphasises the vision of a leader to help others achieve shared goals, while also highlighting the interaction between the leader and group members, or audience. (www.athleticinsight.com).

> Tough is performing in adversity. Holding up to any situation. Doing what needs to be done no matter what.
>
> **Glenn McGrath, cricketer**

In this context, 'audience' refers to the players, spectators, management and officials. So we are focusing on the relationship between leadership styles and the audience with whom they are interacting. It is fair to say that the leadership of a sporting organisation can determine whether the organisation succeeds or fails. One of the most critical factors in how this success is measured depends on whether the majority share the leaders' vision.

Figure 5.1 Tom Moody played eight Test matches for Australia

Leadership towards a common goal

The English football league is a classic example of leading towards a common goal. Clubs are able to compete in several different competitions, all coexisting:

1 The English Premier League is a round-robin, home-and-away season, where the team on top of the table at the end of the season wins. There are no finals.
2 The Football Association Cup (or FA Cup) is a knockout competition covering all of the higher and lower leagues, and allows lower teams to pursue higher-level glory.
3 The League Cup is a knockout competition only for teams in the Football League. Unlike the FA Cup, where 731 teams entered in 2007–08, only 92 clubs can enter the League Cup: the 20 clubs of the FA Premier League, and the 72 clubs of the Football League, which organises the competition.
4 The Champions League is the top teams from the previous year from all over Europe, usually three or four from each country. It is played in a round-robin format, then as a knockout competition.

leadership
the impact individuals have on group dynamics related to a team objective

audience
a group of listeners, spectators, admirers or devotees

Teams in the English leagues target specific trophies in order to gain some success from a given season. However, most managers seek the English Premier League title, then the Champions League title. Many clubs feel that these prizes are out of their reach and put all of their resources into winning one of the lesser trophies.

Arsenal is one of the top teams in the English Premier League, and they have employed a policy of playing all of their young players in the League Cup. This situation sits well with most supporters as they recognise the need to bring on the young players in a less important forum. The club covets the Premier League title, as it is the greatest indicator of long-term success.

Catchy fact
Arsenal hold the record in the English Premier League with a 49-game undefeated winning streak in the 2003–04 season.

The same view is not tolerated at the smaller clubs, as their fans are simply chasing any success. This often sees lower-level clubs rise to the finals in both the League Cup and the FA Cup.

If the vision of the management and leadership does not suit the audience (whether players or spectators), the club faces a rocky future, as their goals are not aligned. See Chelladurai's leadership model later in this chapter.

We will consider leadership from these standpoints:

- Coaches as leaders.
- Athletes and other leadership positions within sporting organisations.

coach
an individual involved in the direction, instruction and training of a sports team or individual sportspeople

Wayne Bennett, the famous Brisbane Broncos Rugby League coach, said it best: 'Not everyone in sport can win. For some the only prize can be the character they have built within. It can also be the greatest prize of all'.

Checkpoints

1. What are the characteristics that make up an inspirational coach?
2. Why is it that a coach can have such a profound effect over us?
3. How can one coach extract brilliance from one player, while another can only achieve mediocrity with the same individual?

Coaches as leaders

> "The country is full of good coaches. What it takes to win is a bunch of interested players."
>
> **Don Coryell, San Diego Dodgers**

Figure 5.2 Coaches Wayne Bennett (rugby league) and Jane Searle (netball)

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There have been many great coaches who have achieved outstanding results. Coaches can have very successful careers without using mainstream methods. The variety of coaches in any elite sporting league is immense. Variety in management will reflect massive differences in the approaches to the players, to the task, and even in the day-to-day organisation of the club.

Leadership in sport

Good leadership means more than being inspirational and charismatic. Modern concepts of leadership value vision, innovation and the ability to focus on the task at hand while keeping an eye on future opportunities and concerns. Leadership is the power to influence others to set goals.

In coaching terms, this means the coach having a plan that gives direction to the team. The coach sets out goals that they want the team or individual athlete to achieve. This gives the athletes direction and creates a team 'culture'. Team culture is the atmosphere or environment that the coach creates within their club or organisation. Club culture is the heart and soul of the organisation; it creates an environment that seeks to give every athlete the maximum opportunity to achieve success: to bring out the best in a person. This may involve a coach appealing to the athlete's values. In achieving this direction, the vision must be translated into reality. In establishing a culture, the coach and athlete might identify rules or expectations that oversee everyday practices, such as:

- athletes being on time for all training sessions
- defining accepted behaviours
- looking after player welfare
- unifying all members of the organisation in pursuit of a common goal
- establishing dress codes
- making sure that everyone conducts themselves in a sporting manner.

Coaches are concerned with the athlete as a whole person, paying attention to the physical component of the sport as well as the psychological and social environments. Therefore, the culture must include parents, staff and all other parties involved in the group. This means that all processes within the organisation must be transparent and that it must make consistent decisions. This requires the leader to have exemplary communication skills so they can communicate this direction or vision to the squad. To achieve these goals requires commitment, encouragement, enthusiasm and emotion. Leaders determine the direction for the future. (Martens, 2004)

A coach must be able to recognise their own strengths and weaknesses, and assemble a support staff to perform the tasks they cannot do well. It also means being innovative and unpredictable. The coach is a strategist, an ideas person who comes up with unexpected solutions that transform the way the game is played. A coach with good leadership skills is able to delegate certain tasks while keeping control of the core business of planning and winning games.

From a coaching point of view, leadership also means setting clear and attainable short-term and long-term goals that players and coaching staff can aspire to. A good leader shares credit for success, but also accepts responsibility for their own failures.

Coaching styles

Different styles of player respond more positively to different styles of coach. Many great players have been forced to restart careers at rival clubs in order to avoid a coach with whom they have irreconcilable differences.

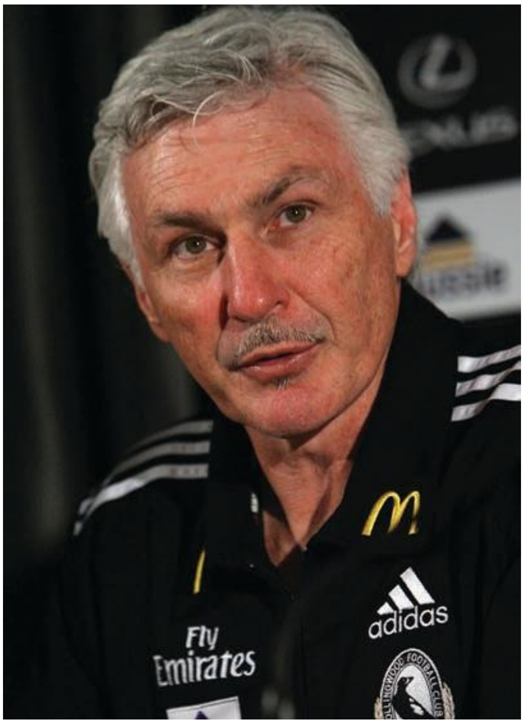

Figure 5.3 AFL coach Mick Malthouse

Figure 5.4 Sir Alex Ferguson, manager of Manchester United

Authoritarian coaches

An authoritarian coach takes on a dictatorial role and likes to dominate or control the players or athletes in their charge. An authoritarian coach has a controlling-type personality. This style of coach may be at odds with athletes who wish to have more input into the direction of the team and the club.

Mick Malthouse, coach of AFL team Collingwood, is a good Australian example of an authoritarian coach. As a player, Malthouse was very disciplined in his play; he was tough, accountable and a fierce competitor. These are all characteristics that he appears to value highly as a coach. He has clear expectations of his players and lets his players know when they have failed to carry out his plans.

An international example of an authoritarian approach is Sir Alex Ferguson, manager of Manchester United Football Club. Ferguson was a very successful club player with Glasgow Rangers, and often described as tough and uncompromising. These traits are reflected in his management style.

In one incident, Ferguson lost patience with David Beckham in the dressing room, and threw a soccer boot at him. Beckham required stitches above his eye to treat the injury. This was the beginning of the end for Beckham, who struggled to regularly play first team for Manchester United again. It was a strange situation, as Beckham was England Captain at the time, and was picked to play for England despite not regularly securing a place with Manchester United.

Summary of an authoritarian coach

An authoritarian coach is someone who:

- clearly defines team rules on and off the field, and is severe on players who break them
- puts prime importance on winning and on adhering to team strategies
- can be distorted by the media to appear overly passionate and fanatical
- can clash heatedly with players in close game situations
- has a level of confrontation that can push some players away from the club.

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Democratic coach

A democratic coach is more in tune with the needs and wants of the playing group, the coaching support staff and even the administrators. They include the playing group in major decisions and try to empower the group to have a personal stake in the team's direction.

John Buchanan, the former Australian Cricket Team coach, is a local example of a democratic coach. His coaching style was more of a managerial role, with much of the day-to-day direction of the team controlled by the senior playing group and specialist individual coaches.

This style proved very successful, as Buchanan's coaching record at international level is at around 75 per cent for Test Matches and 75 per cent for one-day international matches. This places him at the top of the list as the most successful cricket coach in history.

KEEP IT REAL!

Excerpt from an interview with 2009 West Coast Eagles coach, John Worsfold.

Figure 5.5 John Worsfold

How would you describe your style of coaching: democratic, authoritarian or casual?
Democratic for sure.

Is that because of your personality? Or just because of the way your coaching has evolved?
I think it is my personality. I think that I've got the ability to listen to people and give them the opportunity to feel like their opinion is welcome and listen to it, and also show that actions are taken from that feedback, whether it's positive action or it's just action that has forced us to reflect on what they've said but we don't actually change according to it. We would get a lot of good feedback from players who are comfortable to come and tell me if they think things could be done better.

Do you encourage the players to be very forthright?
Yes.

Do you think you've got that group of players now?
They are an extremely quiet group, but they have a focus that they want to be able to give feedback to each other and the coaches. Coaching is going to go the same way. It's a very strong focus within our group that we have strong communication and feedback with each other.

Would they ever do that during a game?
You'd expect they would, for sure.

How do you compare that to how you were playing under Mick Malthouse? Is there a difference in the way he dealt with people in the same situation?
Yes, I think the difference is that when I was playing with Mick it wasn't as full time an industry as it is now, so players would come and want to be told what to do, tell us how to do it and we'll go out and do it. Whereas now they've got plenty of time, they've got vision, they want to sit down and say, okay, if this happens, what happens here, so they go through all those exceptions to the rules, whereas with Mick we knew what were going to do and what our aim was, and we'd just turn up and do it.

Is that based a little bit on Mick Malthouse's personality?
Probably a little bit. Mick sort of knew what he wanted but he was still open for feedback. If you wanted to go and throw an idea in, he'd listen to you but you just found that you didn't really have the time or the opportunities to be able to do that, whereas we would make big windows open for players to be able to do that.

Does that happen very much?
Yes. Generally they will certainly do it more with the line coaches, because it might be a query they have about their role. But I expect them regularly to come and see me about how they are tracking overall.

KEEP IT REAL!

John Buchanan is the most successful cricket coach of all time. He coached the Australian Cricket Team from 1999 to 2007, with a winning record of nearly 75 per cent.

While I don't suggest for one moment that my way is the best way, or indeed my way is the only way, this is the way I live it and breathe it, and I'm happy to share a simple outline of it here and let you decide what its value is to you.

Figure 5.6 Cricket coach John Buchanan

There is a mix of principles which connect through everything I do, and while that encompasses such things as vision, planning, organisational culture, stretching beyond boundaries and so on, essentially, at the core of it all, is consideration of the individual.

It is about the *whole person*, not just the staff member, the cricketer, the volunteer, etc., or how best we can use a person's skills to benefit the bottom line, or achieve company results. It's about valuing the individual and their needs to develop intellectually, emotionally, technically, socially and spiritually.

It is about helping people. All of us need help in some way or other. I try to assist the people I meet every day of my life to feel a little bit better about themselves, to be a little bit better at sport or work or home, or to maybe have a clearer direction to what they want to be or what they can achieve.

Ultimately, in understanding yourself, accepting yourself, and then loving yourself for who you are, your personal style, your methods of communication become consistent. People understand you and what you stand for. This is the basis of strong and true relationships with your staff, family, peers and adversaries. It is from this point that managing, coaching, leading other people can begin.

www.buchanancoaching.com

Summary of a democratic coach

A democratic coach:

- delegates coaching tasks to either senior players or support coaching staff
- allows input from others in future directions of the team or organisation
- encourages good communication to ensure that all branches of the organisation are pulling in the same direction.

Casual coach

The casual coach is not concerned with dominating their players or letting the players dictate the future directions and goals. The casual coach is happy to respond to whatever situation or circumstance is facing them at the time. Sometimes they might use a more directed approach; on other occasions, they might use player-centred solutions. A casual coach is adaptable and able to flex with the demands of the situation.

A trait of this style of coaching was displayed by Mark 'Bomber' Thompson, coach of AFL team Geelong. In a Geelong vs Eagles match in 2008, Geelong, which was at the top of the ladder, was beating the opposition by almost 100 points. Thompson was seen eating a sandwich in the coach's box and paying little attention to the tactical aspects of the match. This is typical behaviour of a coach who is prepared to 'go with the flow'. However, this does not suggest that Thompson is casual all the time. In truth, at the elite level of sport, this casual coaching style would be the least common.

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Summary of a casual coach

A casual coach:

- places the onus on players to prepare themselves for the impending play
- lacks structured, rigid planning
- uses 'gut feeling' to help guide decision making and future direction.

Other coaching styles combine individual features of the categories outlined above.

Summary of coaching styles

- There are three main styles of coach: authoritarian, democratic and casual.
- All coaches must communicate successfully with their athletes if they are to be successful, regardless of their coaching style.
- Coaches must learn to adapt their methods to suit the needs of each athlete.
- Coaches need to adjust their style to suit individuals and the occasion.
- Elite coaches have many 'tricks' to maximise performance.

Checkpoints

1 **a** Use the Internet to research a coach, in a sport of your choice.

b Identify which coaching style best represents your chosen coach.

c Does your coach fit neatly into one category?

d Identify which athletes in your chosen sport would respond well to this style of coach, and which athletes would clash.

2 List and describe three coaching styles, and give an example of each.

3 Describe the characteristics of the coaching style that would be best suited to each of these athletes. Justify your answer.

- Ben Cousins
- Lleyton Hewitt
- Jelena Dokic
- Lauren Jackson

4 List the coaching styles that would best suit each individual in your class. What relevance does this have for your teacher or coach?

Excerpt from interview with Glenn Mitchell, Senior Sports Broadcaster, ABC Radio Perth

Who do you feel are the best sport coaches of all time?

The best coach I have had opportunity to spend time with, and to talk with and really analyse their strategies, was Rick Charlesworth, coach of the hockey gold-medal winning women's teams in Atlanta and Sydney. He is now the coach of the national men's hockey team, the Kookaburras.

Charlesworth is further ahead in his way of thinking than any other coach I've met. He is very lateral. He will take what he finds in one particular sport and then make it across to another sport. He will watch a sport like football from behind

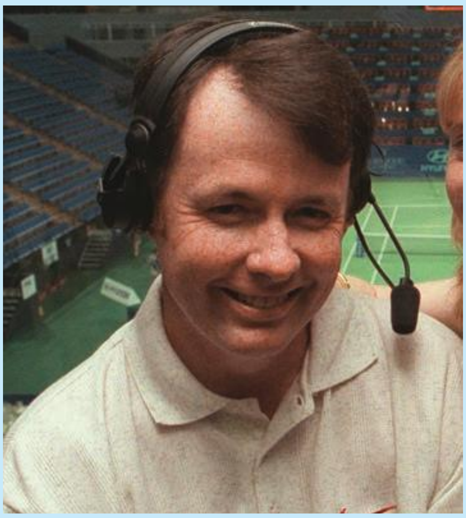

Figure 5.7 ABC broadcaster Glenn Mitchell

Glenn Mitchell interview (continued)

the goals. He looks at the way a team sets up on both offence and defence. He will look at sports like water polo and see how they transmit the ball from one end of the pool to the other, and he will try to utilise similar strategies in hockey. So for me, Rick Charlesworth is the most ‘catholic’ coach, going right across the board. He takes into account so many different aspects.

One coach I have always admired, although he is really a manager, is Angelo Dundee, the man who actually led Mohammed Ali throughout his career. Mohammed Ali was a very different personality, and Angelo Dundee never really looked after any aspect of Mohammed Ali beyond training. All he did was be a mentor for Mohammed Ali as far as boxing was concerned. He was all about positive reinforcement. He was able to make the connection very well with Ali’s personality, and give Ali what he needed to hear. And as a pair, an individual coach and an individual being coached, there’s none better than that combination.

The other two coaches I’d say that really fascinated me over time were Bill Jackson, who was the coach of the Michael Jordan-led team that won six NBA championships, three in a row, followed by three more in a row when Michael Jordan came back to the sport after his brief flirtation with baseball.

And the other is Sir Alex Ferguson, the manager of Manchester United. Both those men faced a very different set of criteria than a lot of other coaches have. They were working specifically with superstars. When you don’t have a salary cap, you bring together the very cream of the crop. And what happens is that each one of them has a massive ego. Everyone wants to be in the starting 11, everyone wants to be on the pitch. Everyone wants to be looked at favourably by the coach, and to win him over.

It’s difficult to make a team like that gel, and I think what Phil Jackson did with Michael Jordan, and what Sir Alex Ferguson has done with Manchester United, that underlines people management. And that’s one of the key things in sport, to be able to manage personalities, and to be able to know what you can say to one player that you can’t say to another. And what you would say to a group is different to how you would tackle it with one player or another. So there are a lot of different facets that come into play about who’s a good coach and who’s not.

Do you subscribe to a Ric Charlesworth-type theory, or do you feel that a coach does have a big influence after bounce-down?

I think a coach can have an influence to a point, but probably the most ironic thing is that where a coach doesn’t have any real impact is probably when a coach wishes to have the greatest impact, and that is at the end of a clutch game. When you are in time-on at the end of the last quarter of an Australian Rules football match, there is virtually nothing a coach can do in the last 90 seconds, apart from put out a message to say, ‘Hold it up, hold it up!’

But there’s a lot of mystique given to say ‘a great coaching move’. I don’t know how many great coaching moves are made during the period of a football match that actually end up influencing the outcome. Most coaches will tell you that 80 to 90 per cent of the work is done before the team crosses the white line on a Saturday afternoon. The planning is done during the week; they start looking at videotape, reviewing it, each player looks at individual DVDs of the opponent he will be playing on. They come together, they have whiteboard sessions, they do specific drills with cones and the like and various players playing certain roles in intra-club scratch matches at training; most of that analysis is done prior to the match and there might be one key move, that perhaps a team can throw you by playing a centre half-forward who is in good form at centre half-back, you might have to come up with some way of being able to move the chess pieces on the board.

But I think Ric Charlesworth is probably right, that largely, when you come up against an opponent and the game actually starts, most of the work has been done in the lead-in. If you are relying on the coach to win you the match on game day, then I think it’s probably a recipe for disaster if you haven’t done the planning in advance properly.

John Worsfold mentioned that his hardest coach to coach against was Paul Roos, partly because he said he knew what tactics were coming, but he still couldn’t do much about them. He knew they were going to be executed well. He said Mark Williams had just been able to turn them over even when they have been flying high. He said he’s either been lucky with his personnel or planned well. Who do you think in any sport (or in AFL) stands out as the most astute coach in terms of watching what’s going on and responding?

I think Paul Roos is a very astute coach. Rodney Eade is a very astute coach, too. He hasn’t necessarily had the best personnel in his coaching career, and has been able to make moves and changes. He introduced ‘flooding’ at the small Sydney Cricket Ground. He realised that his team, and the personnel he had, were tailor-made for

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Glenn Mitchell interview (continued)

flooding as many players behind the ball as they possibly could, and staging a war of attrition.

Leigh Matthews is a very clever coach; extremely clever. He was able to allow players, to a certain degree, to have personalities on the football field. He allowed them to run what they were doing themselves, using the great senior players that he had like Voss and Akermanis, Alistair Lynch, Mal Michael in defence, Justin Leppich down at full-back; those players were allowed to look after each particular line, to look after the defensive zone, the midfield, the attacking zone, the on-ballers, etc.

It's interesting that we talk so much about what they do on game day, but I think the bottom line is that it's very different for a coach nowadays in the elite-level sports. Coaching today is very different from what it used to be. It's now a case of people management. And in Australia we are following the philosophy of American sport, especially NFL football, where there is a head coach, and then you have all these minor coaches. You'll have a coach who is in charge of the forwards, the on-ballers, the midfielders; each of these coaches is giving specific feedback from the box to the head coach on game day.

The head coach has to decide which of these pieces of information he filters out and which he runs with. He's got the final say. You may have the defensive coach saying, 'We need to make this move'; the forward coach is saying something completely different; they might actually be at cross-purposes.

The coach is a 'sponge' on game day. He's getting information from his statisticians; he's getting information from the man who's running the whiteboard, so he knows that when his opponents make a move, the whiteboard is in front of him. It is always being updated, so he can see who they are moving to take care of one of his players. He's then getting his various zone coordinators, or assistant coaches, giving him feedback on where they are being hurt, and where they are gaining an advantage. It's similar to the captain on the bridge of a ship during a war; many things are happening at once: torpedos are being fired, there is a fire down in the engine room, they may have lost one engine … all this information is coming to him from all different points. He has to analyse and think, 'Okay, what is the criteria here? What is the priority? Do I need to put that fire out first of all? Do I need to worry about another torpedo coming towards the boat?'

It's the same in a coaching situation. The coach is sitting there thinking, 'Okay, I've been given these three pieces of information from completely different sources. Which is the one I need to prioritise, to get a message down to the runner, get him out on the ground, and get that area squared away? Once we've got that bedded down, then I'm going to worry about the next facet of the game.'

I think the best coaches are those who can multi-task. They can be sitting in a coach's box and absorbing information from all different angles. They are able to disseminate all that information, order it, and then think, 'Okay, thanks very much for the advice, I'm going to go ahead with A, ahead of B, C and D.' And he'll implement A, then go back and implement B. But it's a matter of being able to absorb all the information like a sponge, and then process it to come up with the best theory, because you employ all these support staff around you to provide you with information. You've got one pair of eyes; if you are following the ball, you can't be looking at what switch is being made off the ball, by an opposing coach in regard to tagging, or getting run with players to swap over. So you need that information coming to you all the time.

The best coaches can stay cool and calm in that situation and filter the information that's important, and then just get rid of what they feel. And the stuff they get rid of has to be done in a way that doesn't leave the coach who suggested it feeling, 'What the hell am I doing here?.'

There are some AFL clubs today where the team psychologist sits in the coach's box and monitors the conversations between the head coach and the assistant coaches. At the end of the game he'll sit down with the head coach and say, 'Do you realise that you were too short, too sharp? You didn't listen to that coach; you just shut off listening to him when he was talking to you. That is doing nothing for the motivation of that coach to keep trying to source ideas that are going to help you.' The psychologist doesn't even watch the game. His whole thing is watching the coaches' body language, watching how the 'boss' reacts to the 'underling', and then how the underling reacts to the boss if the boss refuses the underling's information.

A key area of coaching now is the actual by-play and the way that the coaching staff relate to each other under pressure on game days; getting a team to work not so much on the field, but getting them to work off the field in the coach's box.

Checkpoints

As a class, classify all of the current AFL coaches into one of the main categories of coaching style. Record your findings in a table with these headings:

Team	Coach	Style: Authoritarian, Democratic, Casual
Brisbane		
West Coast		
Geelong		
Melbourne		
North Melbourne		
Sydney Swans		
Adelaide		
Port Adelaide		
Fremantle		
Hawthorn		
Essendon		
Western Bulldogs		
St Kilda		
Carlton		
Collingwood		

Extension

1 As a class, debate the merits and relative successes of each coaching style.
2 Select three coaches you are familiar with.
3 Classify each coach, giving at least one example of one key trait they exhibit that aided your classification.

Catchy fact

Where did the word 'coach' come from? At first, a coach was a tutor; someone who guided students through various lessons or fields of study. The coach carried the student through the course, just as a coach (or wagon) might carry an 18th century English family to London.

Attributes of an effective coach

In order to be an effective leader, a coach requires certain skills. Among the attributes a coach should possess are:

- the ability to communicate with athletes, officials, management and media
- knowledge of the game
- knowledge of biomechanical principles
- knowledge of sport psychology
- knowledge of fitness-training methods
- knowledge of sports-injury prevention
- knowledge of sports nutrition
- respect for themselves and others
- assertiveness

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- the ability to motivate
- accreditation
- expert strategic sense
- the ability to be an effective teacher
- the ability to be a good organiser
- the ability to be a disciplinarian
- the ability to lead
- the ability to mentor
- the ability to be a facilitator.

Obviously, not all coaches have all of these characteristics. As in life, each person has different strengths and weaknesses. In professional sport, clubs have a team of coaches, which allows them to cover all of the above attributes within the team.

Checkpoints

1 Using the list above, choose three coaches you are familiar with and rate them on the criteria in this table using this scale:

High 3

Moderate 2

Low 1

Place the appropriate number under the correct rating for each criteria in your notebook or on screen.

Characteristic	Coach 1	Coach 2	Coach 3
Ability to communicate with athletes, officials, management and media			
Knowledge of the game			
Knowledge of biomechanical principles			
Knowledge of sport psychology			
Knowledge of fitness-training methods			
Knowledge of sports-injury prevention			
Knowledge of sports nutrition			
Respect for themselves and others			
Assertiveness			
Ability to motivate			
Accreditation			
Expert strategic sense			
Effective teacher			
Good organiser			
Disciplinarian			
Able to lead			
Able to mentor			

2 Add up the totals at the end of each column and then answer the following questions.
   a Which coach was numerically most successful on your rating system?
   b Does this number relate to the relative successes of the coaches that you have selected?
3 As a class, discuss the merits of your classification of the various coaches.
4 Rank yourself on the attributes of a coach. Who among your classmates would be a good person on your team as an assistant coach to cover your weaknesses?

KEEP IT REAL!

Coaches get credit for top WA crop

Craig O'Donoghue

WAFL coaches deserve enormous credit for the state dominating the top end of the AFL draft in recent years because they place the development of young players ahead of winning premierships, WAFC talent and coaching manager John Haines said yesterday.

WA players will again be prominent in the early stages of today's national draft with Nick Naitanui, Stephen Hill, Chris Yarran and Daniel Rich certain to be picked in the top 10. That means 14 of the 40 players selected in the last four years have come from Western Australia.

South Australia has only produced one top 10, Bryce Gibbs, in three drafts, and is expected to have only Hamish Hartlett picked this year. Vic Metro have had five top-10 picks during the same time period and could add up to four players today, while Vic Country lead the nation with 12 players but may only have two players in the elite bracket this morning.

Junior coaches understand the importance of having players drafted and give their youngsters the best chance to excel. All coaches follow a guide that bans tagging and flooding, asks for key position players to spend extra time on the field and for midfielders to play as forwards and defenders. One-on-one football is heavily encouraged, in a bid to force players to have both an attacking and defensive mindset, while coaches are also advised to rotate any players positioned as a loose man in defence.

'They're fairly simple guides, but when you implement those things in a match-by-match situation, they become powerful philosophies over the course of a season,' Haines said.

'There's been a significant shift in philosophy in the colts competition. At that level of football, we're trying to focus on individual development. Clubs see the benefit of that by getting players drafted, getting better players at league level and more money coming into the system.'

Players in the state under-18 squad were also educated about life as an elite footballer through four lectures after the national championships.

The appointment of former West Coast assistant Rob Wiley as high-performance coach had given Western Australia a big boost, and letting youngsters play league football before the draft further enhanced their AFL prospects.

And the bigger and drier WAFL grounds were proving also a major advantage, Haines said. 'The AFL wants the game played on open grounds with lots of movement, less stoppages and lots of run and carry. The WA style has always been that, and the AFL style has evolved to meet that.'

***The West Australian*, 29 November 2008**

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Checkpoints

1 What is the dilemma faced by coaches in the article on page 90?

2 Why has Western Australia been such a successful breeding ground for prospective AFL talent?

3 Why has the style of Western Australian football become so popular in the development of successful footballers?

4 Why do you think coach education is critical in ensuring the quality of up and coming footballers in Western Australia?

Coursework

Coaching in practice

Aim: Observation of coaching styles

Procedure:

Observe two training sessions with two different coaching styles. Record your observations. Your observations should include:

- the sport being played
- the participants' age group
- any knowledge required
- the number of athletes and the length of the session
- if the coach has accreditation
- the session plan
- the style of coaching used
- the types of communication observed – verbal, non-verbal
- feedback given – positive or negative?
- type of demonstrations.

Focus questions

1 What styles of coaching were observed? Explain the differences.

2 Were the coaching styles suitable to the group's age and skill level?

3 List the advantages and disadvantages of the coaching styles you observed.

4 Did the coach use effective communication?

5 Did the coach demonstrate an overall working knowledge of the requirements of the sport?

6 How was motivation used throughout the session? Was it suitable? Explain your answer.

7 What are the characteristics of an effective coach?

8 In what form was feedback given? Did it result in changes in performance?

9 Were suitable demonstrations given during the session? By whom?

> The key to teamwork [...] is to work less as individuals and more as a team. And the coach knows not to play his 13 best, but his best 13.
>
> **Wayne Bennett, former Brisbane Broncos coach**

Chances are that any student sitting this course has had a coach at some stage who has had a significant impact on their life. That coach may have shaped your future and made you the person you are today. The main reason you are doing this course may simply be a love of sport in general, or a desire to follow a career path that will allow you to remain physically active throughout your life.

Athletes as leaders

What determines the quality of a leader in sport? How does a coach or club choose a suitable leader to create the right feeling among the playing group, the fans and the media? Over the years, sports teams have struggled with the dilemma of who to choose as the 'face' of the club. The wrong decision can divide the playing group, alienate the fans and embarrass the management. The correct decision can unite all branches of the organisation and create a clear path forward.

Martens (2004, p. 38) lists six actions that distinguish an effective leader. An effective leader:

- provides direction; sets goals by having a vision
- builds a psychological and social environment conducive to achieving the team's goals
- instills values
- motivates members of the group to pursue the goals of the group
- confronts members of the organisation when problems arise, and resolves conflict
- communicates.

History of leadership theories

Leadership was originally looked at in terms of trait and behavioural approaches.

- The **trait approach** assumes that leaders are born and not made. The individual inherently has the genetic makeup to be either a good or a bad leader.
- The **behaviouralists** believed that effective leadership was related to the dominant behaviours of the individual. Imitation of known successful leaders would allow the individual to model the correct behaviours. This approach assumes that environment is more important than genetics.

Modern leadership theorists have elaborated on these one-dimensional models and provided more complex formulas.

Models of leadership

Chelladurai's multidimensional model of leadership

Chelladurai's multidimensional model of leadership is based on a Leadership Scale for Sports. Leadership Scale for Sports (or LSS) is a 40-item questionnaire developed by Chelladurai and Saleh (1978,1980), which has been generally supported by sports psychologists. The LSS looks at five dimensions of leadership: instructional behaviours, decision-making style (autocratic and democratic) and motivational tendencies (social support and positive feedback).

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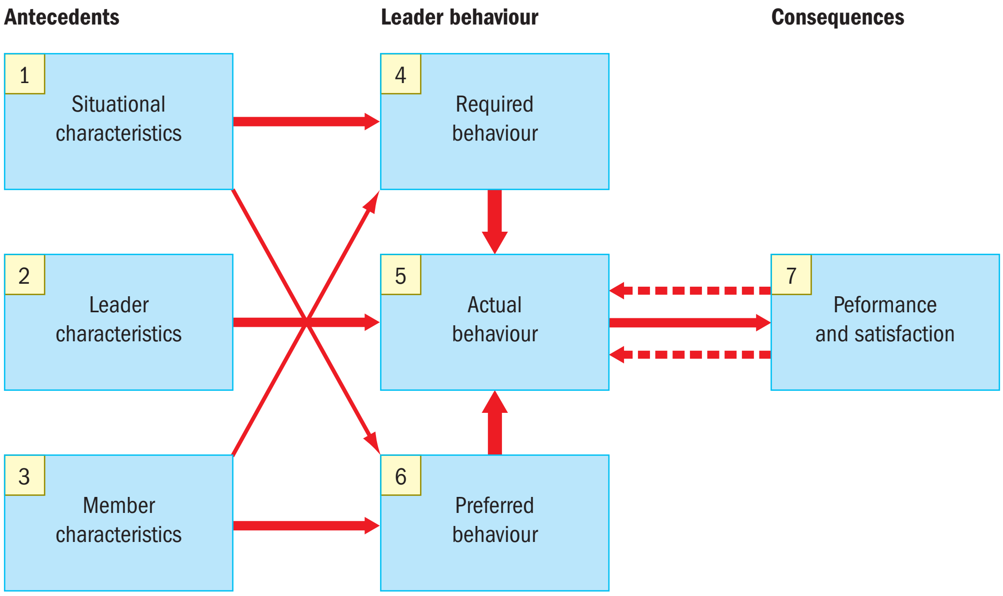

Figure 5.8 Chelladurai's multidimensional leadership model

Chelladurai's model is sport-specific, which places it ahead of most other measures that attempt to analyse leadership in a sporting context. The model suggests that positive outcomes (performance and satisfaction) will occur when there is congruence (or agreement) between the leader's actual behaviour (i.e. either organising practices or providing positive feedback), the group members' preferred leadership behaviour (i.e. preference for a highly organised supportive leader) and the behaviour that is required in relation to the situation.

Chelladurai proposed that the degree of success of a leadership group is directly related to the amount of satisfaction the followers receive from being led in the chosen direction. Chelladurai focuses on the importance of choosing a leader who is a correct fit for the direction of the organisation. If the organisation chooses wisely, then the satisfaction gained by the players, fans and management will be high. If the relationship is not harmonious, then the leader has several options:

- Maintain the approach, in the hope the group will realign
- Encourage others to be more accommodating
- Become more flexible or adaptable
- Remove obstacles (i.e. sack non-conformists)
- Resign from leadership

KEEP IT REAL!

Ben Cousins was a high-profile leader of the West Coast Eagles AFL Club for several seasons. He was the classic high-profile 'A-list' leader who took every football challenge head on. He was inspirational on the field, and remains one of the best West Coast Eagles players of all time.

Cousins faced several challenges as a leader, as his actions were not aligned with the overall direction of the club. Cousins initially tried to fit into the club's leadership expectations, but as incidents mounted up against him, he resigned the captaincy to take on other leadership roles at the club.

This was a clear case where Chelladurai's model helped explain the need for a leader's goals to align with the group's, or the amount of satisfaction received by all involved will be unacceptable.

Individuals may fail in leadership roles in one organisation, then find their goals align with another organisation. The list of both players and coaches who have been recycled and enjoyed success in another organisation is endless. Locally we have:

- Chris Connolly, former Fremantle Dockers coach, recycled into management at Melbourne Football Club
- Peter Bell was traded by the Fremantle Dockers, and then re-signed by them after winning premierships with North Melbourne. He was then named Captain!

Internationally we have:

- Terry Venables, who was sacked after coaching the English Soccer Team in 1996 Euro Championships, and later contracted by Australia to coach the Socceroos.

Theory to practice: choosing a leader

West Coast Eagles players vote for their leadership group by having each player rank the entire playing group on a number of key characteristics, including professionalism, preparation (rehydration), punctuality, reliability and adherence to team strategies. The leadership group is then selected based on the cumulative scores, giving ownership of the leaders to the playing group.

This supports Chelladurai's theory of leadership, that the expectations of the playing group and the leader must align. Each elite sports organisation places a different emphasis on what they regard as the most important leadership characteristics.

Checkpoints

1 List three sporting organisations that have selected leaders who have totally different key characteristics. Why do you think this is?

2 Give an example of an elite sportsperson who has had their leadership taken away due to misalignment of acceptable behaviour.

Leadership: findings of some research studies

Crust and Lawrence (2006) summarised their leadership studies as follows:

- Horn (2002) found that as athletes grow older and mature, they have a greater preference for an autocratic and supportive style of leadership. These preferences might reflect older athletes becoming more goal-oriented and serious about their performances.
- Weiss & Fredrichs (1986) found a relationship between poorer team performance and frequency of social support, which probably indicates that losing teams need more social support from leaders in order to sustain their motivation.
- Horn (2002) suggests that increased group performance and satisfaction results from congruence between required behaviour, actual leader behaviour and group preferences.
- Terry & Howe (1984) found that participants in highly interactive team sports, such as basketball, football or volleyball, prefer more autocratic leadership than participants in co-acting sports such as swimming or bowling.
- Chelladurai and Doherty (1998) found democratic styles are less effective for complex problems and are more time consuming.

Put simply, the implications of these studies are:

- athletes may change their leadership preferences as they mature
- losing teams require different support networks than winning teams

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- different sports prefer different leadership styles
- certain leadership styles are more effective at solving complex problems.

Adapted from www.athleticinsight.com

Checkpoints

1 What do these studies reveal about the considerations involved in selecting a leader?

2 Explain how leaders can be recycled and achieve success in different organisations.

3 Choose an elite sporting leader and list the characteristics they possess. Compare them to a failed leader, and explain the main differences.

Mental toughness

Mental toughness is a term we often consider to be a necessary trait of a leader. It is a quality that can be hard to define, but it is worthwhile looking at what some of the theorists believe.

mental toughness remaining focused and resilient even in challenging circumstances

Clough, Earle and Sewell (2002) developed the concept of the hardy personality by adding confidence as a further dimension, producing their own concept of mental toughness. Clough et al developed a valid and reliable measure of mental toughness known as the MT48 (Clough et al, 2002; Crust & Clough, 2005). Clough et al state that: 'Mentally tough individuals tend to be sociable and outgoing; as they are able to remain calm and relaxed, they are competitive in many situations and have lower anxiety levels than others. With a high sense of self-belief and an unshakeable faith that they control their own destiny, these individuals can remain relatively unaffected by competition or adversity.' (Chelladurai & Doherty, 1998 p. 38)

As a coach or a leader, it is necessary to take into account many factors when deciding on leadership strategies.

Murray and Mann stated that a proficient leader 'has a vision, an intense focus on outcome and results, a realistic strategy to carry out the vision and the ability to communicate the vision and rally support of others'. Leaders are there to coach, direct and nudge players in the direction of the goals. They have a strong ability to pass their intensity along to their others. They are always 'in the game' right along with the players.

A leader guides a team, not rules a team. A leader charts a course, gives direction and develops the social and psychological environment. The leader (either the coach or a player with leadership qualities) provides an atmosphere where others can learn and grow. A coach must give some responsibility to the group and have the courage to foster independence. Otherwise the members will feel that they are not trusted to take care of themselves and will be irresponsible. There must be a balance where the coach accepts their share of responsibility and gives some back to the team members.

Several characteristics are identified here that belong to outstanding leadership. Excellence in leadership is acquired by people who have a strong sense of vision, have passion and are able to get people to commit 100 per cent and take the necessary action to see that vision become a reality. Great leaders excel in communication and motivation, mutual respect, instilling confidence and enthusiasm, and showing credibility and integrity on a consistent basis.

Adapted from Sugarman, 2007

The following extract is describes the game play of a member of the Australian Women's Hockey Team:

> I knew Tracey was going to pass to me and so I instinctively got into position to receive the ball. When it came I had the opportunity to pass or shoot. Passing was the easier option but there was no question in my mind about what I was going to do. All through training we had practised this shooting position, so I had all the confidence and focus I needed to make the shot. There was never any doubt in my mind that I was going to score. This was the chance I had always wanted.
>
> From *Peak Performance,* Gilson et al, 2000

Checkpoints

1 What are the characteristics that this member of the Australian Women's Hockey Team possesses that identify her as a leader?

2 List the leadership qualities you would rate as important for these sports.

- **a** Australian Rules football
- **b** Women's tennis
- **c** Junior netball
- **d** Swimming

3 Were the traits you identified above common to all sports? Or are some qualities specific to the activity?

Other leadership roles within sporting clubs

Leadership roles are diverse. Here is Evan Crawford, Manager of Rugby Development with the New Zealand All Blacks Rugby Union Team, speaking about passion:

> Passion. Passion for the game. I think there's no-one in this organisation who doesn't have a genuine love and passion for what we do. Passion makes this place tick, along with good leadership and good governance. And the All Blacks are the pinnacle of that passion. They are the glue.
>
> From *Peak Performance* Gilson et al, 2000

Leadership extends beyond the coaches and players in any sporting organisation. The club's vision is often decided at board level, and the board engages the services of coaches and players. The direction of the club has been established by the board, which is responsible for developing the overall plan. The board selects a coach who embodies the club's vision, and trusts them to acquire players who suit the proposed direction of the organisation.

KEEP IT REAL!

Eddie McGuire and Collingwood Football Club

Collingwood Football Club evokes passion among its supporters and its detractors. It has one of the most dedicated supporter bases in world sport. Eddie McGuire has evolved from a journalist, TV reporter and host of *The Footy Show*, to chairman of Collingwood Football Club.

McGuire's media profile is huge, and he must continually tread a tightrope between the demands of a fanatical fan base, the running of the club and the performance of the players and coaching staff. He is one of the most powerful sports leaders in Australia, but he hasn't coached or played for any AFL team.

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Inspirational sporting leaders come in many shapes. There are many examples of inspirational leaders in various roles in sporting organisations. You may be familiar with:

- Kevin Sheedy (now with the AFL)
- Sepp Blata (former head of FIFA)
- Lawrie Lawrence (Former Australian Swim Coach, now spokesperson for children learning to swim)
- Frank Lowy (Football Australia).

Checkpoints

1 List some inspirational leaders within sporting organisations.

2 Outline, using a sport of your choice, an organisation that meets Chelludarai's model of compatibility of leaders and followers.

Figure 5.9 Leadership extends beyond the coaches and players in any sporting organisation

TEST YOUR KNOWLEDGE

>> multiple-choice questions

1 Chelladurai proposed that:

A leaders are born, not made
B leaders are a product of their environment
C leaders' behaviours must align with the group to maximise satisfaction
D leaders must set goals that are based on players having self control.

2 A coach who prefers athletes to help control the direction of training and group goals is a:

A democratic coach
B casual coach
C dictatorial coach
D authoritarian coach.

3 Martens (2004) identified six actions that distinguish an effective leader. Which one of these is **not** one of Martens' six actions?

A Leaders build a psychological and social environment conducive to achieving the team's goals.
B Leaders motivate members of their group to pursue the goals of the group.
C Leaders confront members of the organisation when problems arise, and they resolve conflict.
D Leaders confront members of the organisation and openly encourage conflict.

4 West Australian Football League (WAFL) coaches have developed more talented players per head of population than is statistically normal. This is due to:

A good local junior competitions
B better lifestyle and weather
C AFL being the main sport in Western Australia
D coaches agreeing to unwritten tactical modifications.

>> short-answer questions

1 What criteria could be used to determine the most effective leaders in your class? Rank all class members on these criteria.

2 Rank the 14 Curriculum Council sports on a continuum, rating leadership from most important to least important. Rate coaching leadership and player leadership separately:

Australian Rules football, basketball, badminton, tennis, swimming, soccer, softball, golf, squash, netball, volleyball, cricket, hockey, touch football

3 Why does the importance of leadership vary in different sports?

4 Analyse your school's leadership group, either administration or prefect body, and determine whether or not Chelladurai's model explains its success or failure. What changes would need to be made to address any issues?

>> essay questions

1 In a sport of your choice, briefly outline the significant leader in the organisation, and discuss whether or not they align with the spectators, management, players and the media.

2 You have been made coach of a junior sport team. Outline the process and criteria you would use to determine your leadership group.

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.6 Reflective learning and participation

Reflecting on performance

Coaches and athletes both have responsibilities regarding monitoring and reflecting on performance in order to guide improvement. A significant part of this process is aimed at ensuring that recovery from exercise is appropriate, to help establish that the training program is appropriate. In the case of overtraining, the resultant chronic injuries, mental fatigue and lowering of performance can only be avoided with good initial planning and a thorough program of reflection.

Sports science principles regarding physical and mental recovery are covered in great detail in Chapter 13. In this chapter, we focus on the methods of monitoring and reflecting on the mental and physical aspects of performance.

Methods used in monitoring or reflecting on performance include the following.

1 Athlete's training log or journal
2 Coaching staff training log or player summary
3 Coaching staff observation schedule
4 Athlete-centred: physical self-monitoring
5 Athlete-centred: mental self-monitoring (wellness score)

Catchy fact
In soccer, the average time for a penalty kick to cross the goal line is 600 milliseconds. The average time for a goalkeeper to move is 500–700 milliseconds. The critical cue in the goalkeeper's success at guessing the right way to move was dictated by impact. Goalkeepers actually need to move before the kick, but if they do, statistics show they guess the wrong way 59 per cent of the time. This is partly because the kicker can wait till impact to decide on the direction.

1 Athlete's training log or journal

A training journal or log can be used to reflect on the goals set for skill development and whether or not they are being attained. This involves the athlete writing a daily reflection after each training session. An athlete in team sports will record their progress in certain skills, strategies and tactics, and be encouraged to talk to coaching staff to establish external perceptions. The coach in many cases will be a line coach, who is the first point of contact.

Time must be allocated for this reflection process, and regular meetings with coaching staff are necessary to establish that suitable progress is being made. The use of a daily response in the form of a single sheet or a summary spreadsheet with a numerical scoring system is common.

training journal
document used to record physical and mental responses after an athletic performance

line coach
coach who looks after a distinct component of play (defensive or offensive)

Table 6.1 Reflective journal sample

Player's name:______________________________

Line coach:______________________________

Week commencing Jan 14	Session	Pre-game weight	Post-game weight	PRE/RPE for session 6–20 on Borg Scale	Injuries or soreness	Comments on skills or tactics
	Training Mon am					
	Training Tues pm					
	Training Wed am					
	Training Thurs pm					
	Training Fri am					
	Saturday game					
	Sunday recovery session					

Catchy fact

One easy method of monitoring recovery is to weigh players pre-game, then post-game, and use the weight loss as a guide to the quantity of fluid replacement required. For example, Sam had a pre-game weight of 75 kg and a post-game weight of 73 kg. He will need to consume two litres of suitable fluid over the next few hours.

2 Coach's training log or player summary

A training log is a good way for coaching staff to monitor progress. Having external observers do this is critical, as it adds another point of view to the data. Some athletes are not reliable in terms of self-reflection journals, so an external opinion provides the evidence about whether their training responses are valid.

A coach's training log would include a record of sports-specific and general physiological parameters, such as distance, intensity, resting heart rate, weight, levels of muscle soreness, fatigue and psychological state. Elite sports organisations will also have detailed skill observations that are monitored over a period of time. Weaknesses are identified and players are put on modified skill programs to correct technique imperfections.

Figure 6.1 Song Jung Sun of North Korea at the 2008 Beijing Olympic Games

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Table 6.2 Sample of a coach's summary of player progress

Player	Priority	Physical	Mental	Injury: Short-term (ST) Long-term (LT)	Physical conditioning	Strategy to work on	Monitoring and asssessment
John Jones	Kicking too often	Good overhead mark Good short pass Good set shot at goal Can't handball with non-preferred hand	Strong body language in one on one Self confident in most skills Poor communicator with coaches Too quiet at training	Hamstring strain in pre season: two weeks to full fitness assessment; ST Osteitis pubis candidate due to several groin strains; LT	VO_2max scores 68%; good Sprint speed needs work Bench press: 120 kg; acceptable	Looking at handball option in close contest rather than always kicking Running off player when own team wins a turnover	Meet with skill coach Fri and Mon for priority handball training Meet with psychologist once a week for ongoing mental strategies

Checkpoints

Player progress

1 Print out the player progress template from the DVD.

Table 6.3 Coach's summary of player progress

Player	Priority	Physical	Mental	Injury: ST/LT	Physical conditioning	Strategy to work on	Monitoring & assessment

2 Place each member of your class into the coach's planner.

3 Use the sport you are currently studying in your practical area as the basis for the observations.

4 Select two items to focus on for each aspect.

Player progress template

3 Coach's observation schedule

Valuable information can be gained if coaching staff regularly monitor skill learning, tactical understanding and interaction during practice. This information provides a long-term profile, containing skilled observations on the development of certain desired responses. Table 6.4 is a simple observation schedule a coach can use to monitor adaptations to training. It doesn't take skill learning into account. Coaches may ask line coaches to record suitable skill information that is more detailed than the coach's player summary.

Table 6.4 A coach's observation of an athlete's adaptation to training

Coaching observations	Signs and symptoms of non-adaptation
Direct communication	• Athlete tells me that: – they have heavy legs – they don't feel well – their legs are sore – they are tired

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Body language	• Facial expression and colour • Look in their eyes • Bending over to recover after an effort • Bad technique compared to normal
Physiological	• Increase in resting heart rate • Loss of body weight • Loss of appetite
Psychological	• Low motivation • Low concentration • Aggressiveness • No self-confidence
Others	• Poor eating habits • Poor sleeping patterns

Thibault, 1993

Catchy fact
The impact time of a golf club and ball is 0.0005 seconds. Tiger Woods won the 2002 US Masters Golf Championship with a 12-under total of 276, meaning that his clubs were in contact with the ball for 0.138 seconds over the entire four rounds.

Farrow and Kemp, 2003 p. 2

4 Athlete-centred: Physical self-monitoring

Elite sporting organisations require players to complete a daily response sheet for certain criteria. This is kept on file for each player; it is part of their contract that they will fill in the response sheet regularly and discuss the information with line coaches at regular scheduled meetings. Figure 6.2 shows a summary monitoring tool that provides athletes with a profile of their progress over a one-month period. Figure 6.3 is a daily response sheet, which can often make it harder to see a pattern.

5 Athlete-centered: mental self-monitoring

Encouraging an athlete to 'listen to their body' and monitor how they are feeling is an important tool. Athletes are encouraged to give themselves a wellness score.

wellness score
a rating an athlete gives themself, based on how they feel

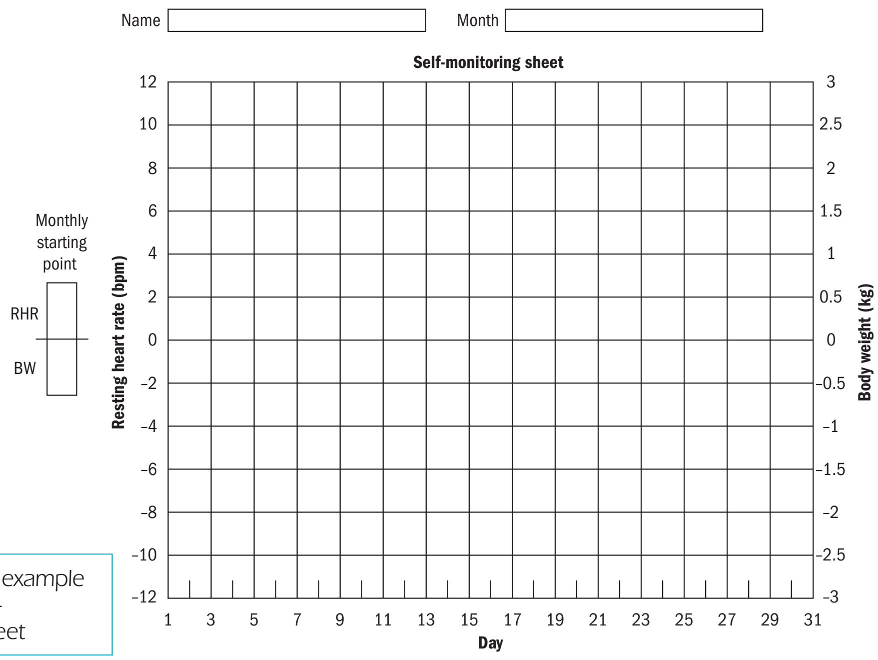

Figure 6.2 An example of athlete's self-monitoring sheet

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WEEK ______________________ DATE ______________________

WEEK'S GOAL ____

CIRCLE YOUR RESULTS FROM 1 TO 5 (1 = EXCELLENT 2 = GOOD 3 = OK 4 = POOR 5 = AWFUL) TRAINING NOTES/SCHEDULE	QUALITY OF SLEEP	ENERGY LEVELS	CONFIDENCE/ESTEEM	MUSCLE SORENESS	MOTIVATION	ATTITUDE TO WORK	ATTITUDE TO TEAM	COMMUNICATION	HEALTH			
DAY 1 ____ Heart rate ____ Weight ____ Sleep hours ____	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	
DAY 2 ____ Heart rate ____ Weight ____ Sleep hours ____	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	
DAY 3 ____ Heart rate ____ Weight ____ Sleep hours ____	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	
DAY 4 ____ Heart rate ____ Weight ____ Sleep hours ____	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	
DAY 5 ____ Heart rate ____ Weight ____ Sleep hours ____	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	
DAY 6 ____ Heart rate ____ Weight ____ Sleep hours ____	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	
DAY 7 ____ Heart rate ____ Weight ____ Sleep hours ____	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	Weekly total
Weekly sub-total												
Weekly average												

COMMENTS ON GOAL ACHIEVEMENT ____

SUMMARY NOTES ____

Figure 6.3 An athlete's daily response sheet

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Grant Thomas, then coach of the St Kilda Football Club, used wellness scores to cancel a 2004 training session when he recognised the players' wellness scores were indicating mental fatigue. These wellness scores are good indicators that the training is either too hard, too easy or at an appropriate level to allow adaptation. The body can only adapt when there is sufficient recovery time between successive physical and mental demands.

Figure 6.4 refers to a simple wellness rating that takes into account fatigue, sleep, stress, illness and muscle soreness. Table 6.2 is a daily analysis of the life demands on an athlete. This is a wellness rating that can be used to establish if the combined demands of training and competition are beginning to detract from athletic performance, hinting at overtraining.

Table 6.5 A competitive swimmer's daily training log

LOG SHEET	DATE ________
1 Sleep: How did I sleep last night?	1..........2..........3..........4..........5..........6..........7 Very very well — Average — Very very badly
2 General fatigue: How do I feel today?	1..........2..........3..........4..........5..........6..........7 Very very good — Average — Very very tired
3 Stress: What is my level now? Causes: (e.g. emotional upset, exams) ________	1..........2..........3..........4..........5..........6..........7 Very very low — Average — Very very high
4 Muscle soreness: How do my muscles feel right now?	1..........2..........3..........4..........5..........6..........7 Very very good — Tender but not sore — Very very sore
5 Training yesterday: Morning: • distance (km) ________ • gym work (mins) ________	• effort: 1..........2..........3..........4..........5..........6..........7 Very very easy — Neither hard nor easy — Very very hard
Afternoon: • distance (km) ________ • gym work (mins) ________	• effort: 1..........2..........3..........4..........5..........6..........7 Very very easy — Neither hard nor easy — Very very hard
6 Illness: Do you feel ill today? (Please list symptoms below) ________ ________	Yes No

Table 6.6 A daily analysis of life demands on an athlete

ANSWER SHEET

NAME ________ *DATE* ________

RESPOND BY CIRCLING the appropriate response alongside each item.
a = worse than normal b = normal c = better than normal

PART A					PART B (continued)				
1	a	b	c	Diet	**8**	a	b	c	Irritability
2	a	b	c	Home life	**9**	a	b	c	Weight
3	a	b	c	School/college/work	**10**	a	b	c	Throat
4	a	b	c	Friends	**11**	a	b	c	Internal
5	a	b	c	Sport training	**12**	a	b	c	Unexplained aches
6	a	b	c	Climate	**13**	a	b	c	Technique strength
7	a	b	c	Sleep	**14**	a	b	c	Enough sleep
8	a	b	c	Recreation	**15**	a	b	c	Between sessions recovery
9	a	b	c	Health	**16**	a	b	c	General weakness
Total 'a' responses ________					**17**	a	b	c	Interest
Total 'b' responses ________					**18**	a	b	c	Arguments
Total 'c' responses ________					**19**	a	b	c	Skin rashes
Record these values and the day's data on Data Log Part A					**20**	a	b	c	Congestion
					21	a	b	c	Training effort
PART B					**22**	a	b	c	Temper
1	a	b	c	Muscle pains	**23**	a	b	c	Swellings
2	a	b	c	Techniques	**24**	a	b	c	Likeability
3	a	b	c	Tiredness	**25**	a	b	c	Runny nose
4	a	b	c	Need for a rest	Total 'a' responses ________				
5	a	b	c	Supplementary work	Total 'b' responses ________				
6	a	b	c	Boredom	Total 'c' responses ________				
7	a	b	c	Recovery time	Record these values and the day's data on Data Log Part B				

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Overtraining can have serious consequences for an athlete. Coaches must be sure to identify the early warning signs of overtraining, and adjust training to avoid mental and physical exhaustion. When the body is put under stress, it has the option of either 'fight or flight'. If the program tries to achieve unrealistic gains, then the body's response will be 'flight', followed by a a decline in performance.

Figure 6.4 An example of a wellness training log

Fitsense

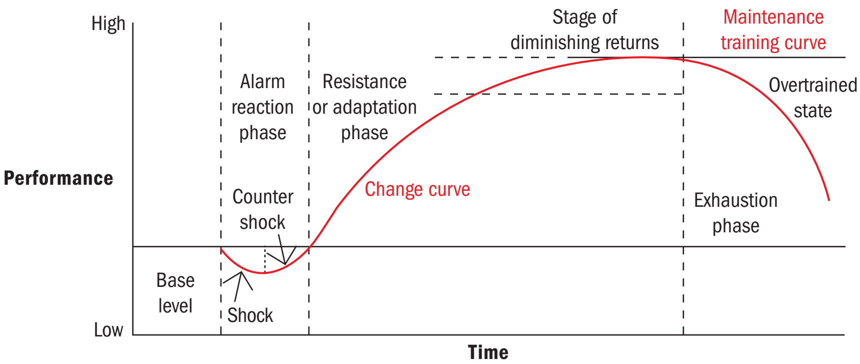

Figure 6.5 The relationship between the general adaptation syndrome and the concept of change, maintenance and overtraining

Methods of analysing skill development and learning

The flow-down effect from professional sport has impacted on the methods used by even junior sports organisations. The media attention on what athletes are doing at elite levels has had a dramatic effect on the professional approach to all sports. Coaches see AFL players, cricketers and tennis players receiving advanced analysis using state-of-the-art software and computer analysis. They see athletes recovering in the muddy waters of St Kilda beach, or walking laps in a swimming pool. They can go to websites and look at reports on player injury lists, and estimated progress to full fitness.

This media coverage, and access to sports science findings on improving performance, has meant that coaches at all levels are inspired to give their athletes the best possible methods for fast-track improvement.

This section focuses on the methods used to gauge skill development, and to ascertain whether or not permanent changes in performance have occurred. (A permanent change in behaviour is known as 'learning'.) Coaches are focused on trying to change skill behaviour to enhance long-term performance. It may sometimes be worthwhile making a short-term skill change to suit a certain strategy or tactic,

Catchy fact

Watch out for the trap of not stopping to relax. Otherwise you'll be like the woodcutter who never stops to sharpen his axe: he has to work harder to do what used to be easy. The same could be said for not including sufficient recovery in training.

KEEP IT REAL!

Hille stung into action

By Mic Cullen

To hear David Hille tell the story, there wasn't much to it. The 27-year-old was stung by a stingray on Sunday night, but was back training with the Bombers on Friday morning.

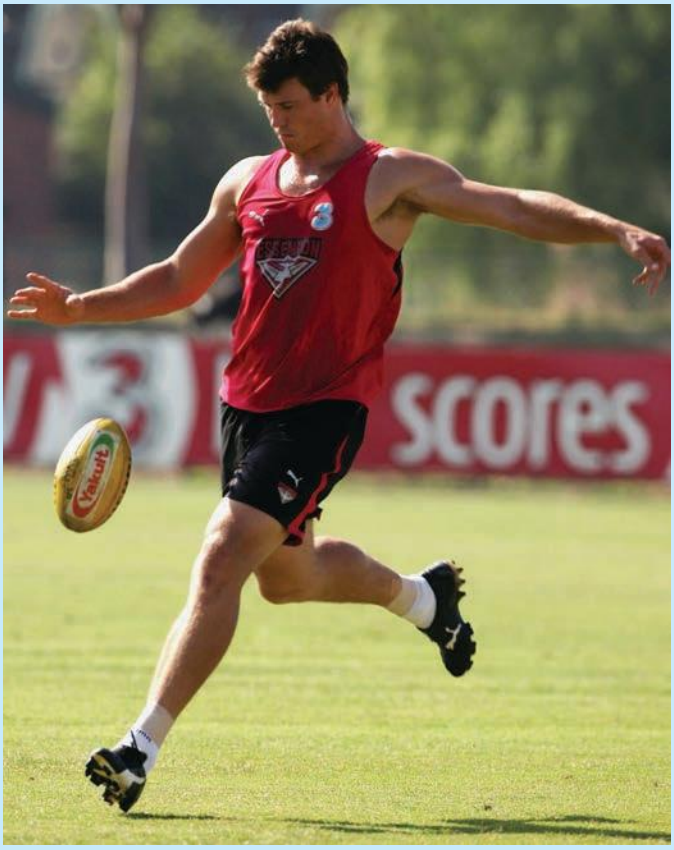

Figure 6.6 Essendon AFL player David Hille resumed training after a run-in with a stingray

Last year's Crichton medallist, as Essendon's best-and-fairest, was playing it down when he talked to the media about the incident.

'I was just walking on Sunday down at Albert Park beach, and managed to stand on a stingray,' he said at La Trobe University in Bundoora after an early morning training session.

'It was just a little bit murky, the water, so I couldn't really see where I was standing, and yeah, he got me. I felt like I stood on it, so I jumped up, but it still got me, so I just walked myself to the lifeguards and asked them what to do. They patched me up, and then I just drove myself to hospital.'

The third AFL player to be nailed by a rampant ray inside a year, Hille said he was pretty lucky, given the reactions of Eagle Daniel Kerr and Bulldog Jarrad Grant last year.

'Obviously we all know how serious these can be, and I'd like to think I'm on the rather lighter end of it. I didn't have the pain that Jarrad and perhaps Daniel had, so it seems to be quite a minor event.

'I got checked out by the toxicologist (at the hospital) and it was all fine. The ultrasound found the remainder of the barb, and that had to be removed, so I got that done on Monday, and that's that.

'I haven't had a really bad swelling response, like perhaps the others did, which is fortunate, because that's probably the majority of the issue.

'I was able to train today and it feels fine, and the majority of what I was doing today was easing myself back in from the hamstring.'

www.afl.com.au, 23 January 2009

but in general, long-term changes are sought. A tennis player facing a big-serving opponent may choose to chip and charge the return to take pace off the ball and force his opponent to come up with continual passing shots. This was a tactic employed by Wally Masur at Wimbledon against Boris Becker. The tactic was a short-term solution to negate the effects of an opponent. Masur successfully used the tactic, but rarely employed such a skill in his usual game plan. This required mastering a new skill for a short-term goal.

Checkpoints

1 Is walking in the surf a risk-management issue at AFL clubs? What alternatives would you suggest?

2 Can you think of any other recovery practices that might result in injury?

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Video analysis

Video analysis is a powerful tool for monitoring progress in skill development. Even at a simple level, video review provides valuable information to athletes and coaches. When video review is combined with motion-analysis software, it can be even more effective.

Products such as Swinger, Dartfish and Silicon Coach are all designed for relatively low-cost access by schools and junior sporting clubs. Golfers have been the obvious recent beneficiaries of this technology. Local golf clubs and golf shops have the facilities to record, view and analyse playing technique. Video capture allows slow-motion frame-by-frame review, as well as information on joint angles, acceleration and impact speed. A golfer's swing can even be overlaid on a professional golfer's swing. The feedback allows coaches to plan for error correction.

Video analysis using Dartfish software

The use of video-analysis methods was once the exclusive domain of elite coaches and athletes; however, constant improvements in hardware and software have made it possible for everyone to share in the opportunity. Dartfish video analysis allows teachers and students to enhance their knowledge in practical activity by using a video camera and Dartfish software to record performances. The image can then be viewed for instant visual feedback or loaded into the analyser for a more in-depth analysis. Dartfish provides a variety of techniques to analyse performance at the click of a button, including:

- splitting the screen to make visual comparison with an elite performer
- looking simultaneously at two or more angles of performance
- superimposing one image on another (e.g. an alternate angle or an elite performer)

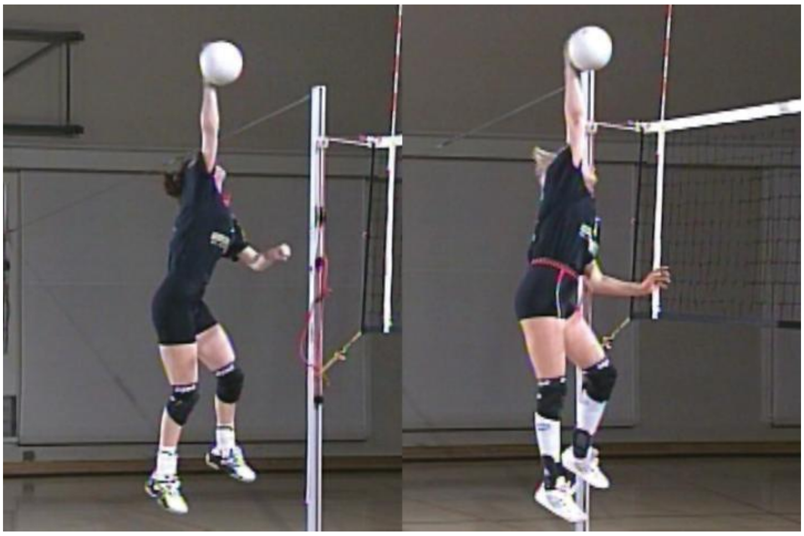

Figure 6.7 Performance comparison and movement breakdown using Dartfish

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- zooming in on key points
- illustrating their video with text tools and words (e.g. measuring angles, distances or time)
- getting a frame-by-frame snapshot of performance

This process of analysis allows students to gain a greater understanding of the key skill components, and facilitates a greater level of self-reflection. The analysis performed can then be collated into an electronic portfolio, known as a mediabook, for publication. Such publications can be useful for assessment, parent–teacher interviews and the development of student's digital portfolios.

Biomechanical analysis

The ability to illustrate video at key positions in a skill performance allows biomechanical measurements to be taken. Biomechanical principles are made more relevant and meaningful by using the student's measurements of angles, distance, speed and velocity extracted from the video.

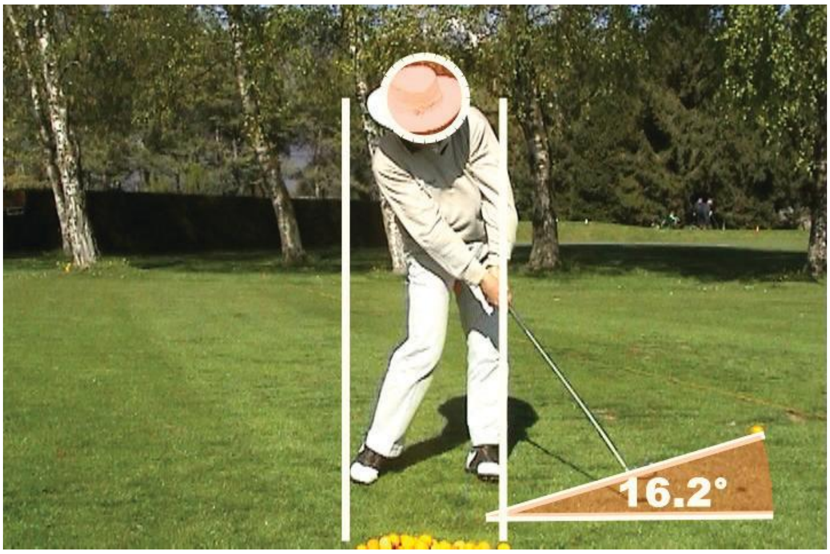

Figure 6.8 Golf swing with line and angle superimposed

Data collection

Data collection is made simple through the use of tagging. Statistical analysis of team and individual performances are available in real-time video clips of the event for each kick, header, throw in, etc., rather than appearing as numbers on a spreadsheet. It allows the ability to statistically break down a match or performance and watch individual events.

Figure 6.9 Analysing players' moves

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Tagging

The tagging process involves creating tagging panels with buttons for those events the coach feels are important to evaluate after the game. For instance, the coach of a girl's soccer team would create an event button for each player. Whenever a particular player is involved in the play, the button is clicked, allowing the coach to go back later and analyse that particular play with the player.

The time-lapse feature allows the coach to designate a pre-roll time so that when the player's button is pushed, the video actually captures several seconds earlier. The coach can also determine the length of the clip, so that the video capture ends when the player being evaluated is no longer involved in the play. In addition to creating event buttons for each individual player, coaches can also create event buttons for free kicks, corner kicks, throw ins, fouls, off-sides, goals, headers, crosses, shots and saves.

After the match, the team can go back and analyse specific phases of the game and evaluate what they feel might be important to work on leading into the next match. Another useful form of data collection and analysis can occur by reviewing data from an opponent. Coaches will often be able to access an opponent's games through film-exchange agreements. Dartfish tagging allows the coach to review and analyse those films to find out more about their opponent's offensive sets, player tendencies and defensive schemes. Tagging allows the coach to watch the game in near real-time without having to rewind, review, take notes or record counter numbers from the VCR.

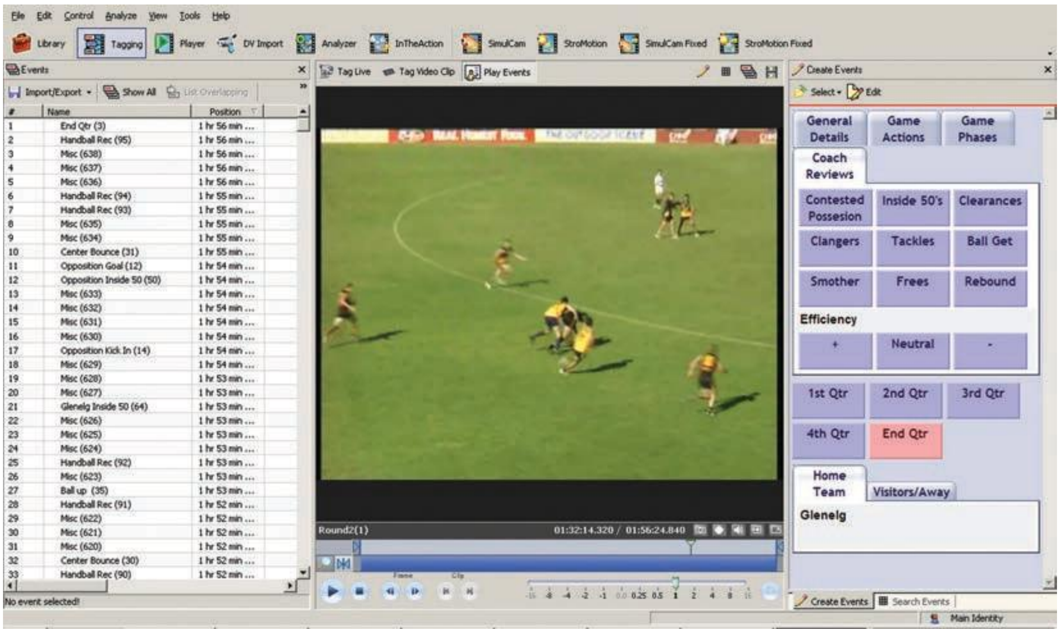

Figure 6.10 A Dartfish analysis screen

Coursework

Analysing your performance

Aim

You will be recording and reviewing your own performance. Use the Dartfish trial software on the DVD to complete the following steps for a sport of your choice.

Procedure

1 Video a performance, choosing which angle will be best for in-depth analysis. The best angle is usually side on, and from the same side that

Dartfish website

the action is occurring; for example, shoot from the right side for a right-foot kick. If time permits, you could shoot from two different angles.

2 Now open the video file in your Dartfish software-analyser tab.

3 Play the video two or three times, slowing it down and advancing it forwards and backwards one frame at a time. Review your performance.

   a What did you notice about your performance the first time you reviewed it?
   b How does slowing the video down help you?
   c What have you noticed that you were not aware of when you performed the skill?
   d Which style of learning are you currently using? What other styles of learning are there, and when did you use them in this task?

4 Now start thinking about your skill execution and what makes a well-performed skill. Use the Add Key Positions function from the Key Positions tab, and add the following information to your analysis

   a What is your goal for using video analysis as part of your feedback? What do you want to change about your performance outcome? Add this comment by typing in the information or adding it verbally at the start of the video as the first key position; for example, kick further, throw straighter, jump higher, etc.
   b In every skill there are important teaching or coaching points that help the performer to be successful and consistent. What are the most important coaching points in your video? Identify each point, adding it to your video as a Key Position by pausing the video at the appropriate time and adding 'teaching point' or 'skill phase' as the label in Key Position.
   c Analysise how your body looked at these key positions, then add written or oral commentary about how your technique affected the outcome.
   d Add technical changes that you could make to your technique and explain how these changes will affect the outcome.

Extension

5 Use Dartfish to create a movie comparing your technique before self-coaching and after, featuring both clips side by side.

   a What improvements were you able to make with your technique?
   b What advantages will these improvements give your future performance of this skill?
   c What biomechanical principles were you able to use to make the improvements or recognise deficiencies?
   d Explain how using Dartfish helped you improve your performance.

Activity above thanks to Dartfish

Reflective journals

Athletes use reflective journals to formally map their progress over a long time period. Memory is not a reliable method for gathering essential information regarding progress or lack of progress. Samples of reflective journals have already been been provided in the previous section on analysis and reflection,

Some useful headings in a reflective journal are:

- physical difficulty of session, using RPE (rate of perceived exertion) scale
- height and weight

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- sleep quality
- skill strengths
- skill weaknesses
- priorities for improvement
- injury status
- mental state (i.e. relaxed, stressed, exhausted, etc.)
- diet
- progress towards short-term goals
- progress towards long-term goals.

Peer analysis

Variety in the types of feedback an individual receives will maximise understanding of error corrections. Individuals all have preferred learning styles, so the more platforms used to provide feedback, the better. Peer analysis is the process by which a fellow athlete is asked to critically analyse skill performance.

From what you have learned in previous chapters, the process could be either qualitative or quantitative. In most cases it would be a qualitative analysis. This would require the peer to observe with a suitable checklist or rubric in order to subjectively evaluate performance. The observer must have the skill to accurately observe and record what they have witnessed.

Peer-assessment rubric

Following is a skill peer-checklist for touch football.

Table 6.7 Skill peer-checklist

Name________________________

Component	Satisfactory	High	Very high
Passing and receiving	Able to pass and receive a ball effectively in a practice situation	Able to pass and receive ball on the run in a game situation	Able to pass and receive ball, on the run and under pressure, in a game situation
Attack	Runs forwards when in possession of the ball	Runs into gaps when in possession of the ball	Runs into gaps, using dodging and speed, to avoid defence when in possession of the ball
Defence	Watches the ball and runs forwards to touch an attacking player	Watches the player closest to them, and runs to touch their attacking player when they are in possession of the ball	Can affectively use one-on-one and space defence. Runs forwards with speed to make a touch
Team play and tactics	Understands the basic principles of pass and move	Able to complete set plays (e.g. switches and wraps) in a game situation	Able to organise and execute complex and dynamic set plays, e.g. switches and wraps
Interpersonal skills	Shows communication and cooperation skills that contribute to decisions that are made in a game	Is beginning to demonstrate leadership skills in the team	Helps others to improve and encourages their peers throughout the game

Catchy fact

You've probably heard your coach or parents say, 'It's all fun and games until someone loses an eye'. That phrase comes from ancient Rome. The only rule during ancient Roman wrestling matches was 'No eye gouging.' Biting, kicking and scratching were allowed but the only way to be disqualified was to poke someone's eye out.

Checkpoints

1 In a sport of your choice, design a peer-assessment schedule incorporating major skills only. Include a rating system that will suit a peer assessor.

Coach or mentor analysis

Coach or mentor analysis is feedback from movement specialists, such as coaches. It is one of the key elements in the information-processing model. An appropriate critique by an expert can significantly reduce the time needed for skill development. Readymade templates of checklists and skill development are available from sources such as the following.

- Companies such as FME provide templates for all sports, which can be used to check progress through various checkpoints
- There are many checklists on the Internet. The validity of these checklists needs to be ascertained before the information can be deemed reliable. One good website is BrianMac. You can link directly to the website via the weblinks on the student DVD.
- Coaches and PE teachers with movement expertise
- Textbooks on individual sports
- State sports organisations, such as the Department of Sport and Recreation

Brianmac

KEEP IT REAL!

The following is an excerpt from an article by former AFL coach David Parkin.

Coaching philosophy

by David Parkin

As we formulate a philosophy for living our lives, over time coaches should be developing a 'system' for conducting their coaching. Your athletes should clearly understand the truths, principles, attitudes and values you bring to their environment as a coach.

1 Motivation vs inspiration

Inspiration comes as an externally imposed influence, which has minimal impact in terms of choices in behaviour, intensity of that behaviour and the sustainability of that behaviour. Inspiration is most often short lived. When a challenge requires sustained force and application over time, inspiration may help to kick start us, but motivation produces the perseverance required. Motivation, on the other hand is principally based on the intrinsic needs of people, i.e. how important is the outcome for the doer?

Coaches need highly motivated players to work with. This is where recruitment of the right people is so critical. The 'wanting' is always basic to success.

2 Continual improvement

Even if you're the so called 'best in the business', coaches need to be looking for better ways of doing all things. Improvement means 'change'. Change for many people creates stress or anxiety. But if you view change and stress as a stimulus and challenge and not a handicap, you can keep up with, and often be ahead of, the pack. The fact is, in the competitive world of Australian football, if you're reproducing exactly what

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Coaching philosophy (continued)

you did previously, then the best you can do is come a good second. Why? Because someone has already taken your benchmark and added something better and different to it.

3 Plan, prepare, perform 3:2:1

Planning must be the key ingredient for all aspects of football. If you plan well for everything, then there is a better chance of preparing adequately and performing optimally. I have always believed the emphasis should be 3:2:1, i.e. three hours of planning for two hours of preparation for one hour of performance – not the other way around. Planning must be equally stringent for the individual player as it is for the team.

4 Fitness, skill and game sense

My attitude to preparing footballers for the most challenging and demanding game in the world has changed as the game has changed. By the nature of the game's demands, it's the most difficult game to get right, when training the body, the techniques, the strategy and the mind. Whenever, wherever it's possible, the coach should attempt to reproduce 'game type' preparation, being careful to control aggression with competitive activities. We obviously need to train specific physical parameters. Technique and skill at times need concentrated work, but above all we need not to be doing 'mindless drills', and focus our attention on 'game-sense' activity. Footballers need to spend lots of time in situations that are pressured (in terms of time and space), to win possession, make good decisions, and execute effective disposal.

5 Leadership

Leadership is a critical component in terms of coach effectiveness. Most of us believe, due to personality and experience, that we need to use the same style of leadership with all people, in all places, at all times. My experience suggests differently. You need to adopt your style and approach according to the maturity or experience of the individual or group. Young, inexperienced athletes need some real direction and control. But as the player becomes more confident, educated, experienced and competent, they need to be far more involved in the coach–player relationship.

Successful teams, in the finish, always have a strong leadership group, who want to take ownership over the dynamics of the processes that are in place. The coach needs them to become far more democratic in their approach to the important issues of 'team'. Mature coaches give up some power to the group. They realise that group empowerment in most cases produces greater commitment through ownership.

6 Feedback systems

Very few individual coaches or athletes have the capacity to self-reflect accurately on their performance. We all have biases and blind spots when evaluating our roles. As a coach you need:

- an accurate, immediate feedback system for your footballers. If possible during the game (via the runner and quarter breaks), and obviously following the performance. If you want players to improve, they must start with a very accurate and realistic view of themselves. That usually has to come from an outside source. Little change will occur without feedback of quality.
- to set up your own system, i.e. mentor, or critical friend, or coach director, where you can receive consistent, relevant feedback about the effectiveness of your own performance as a coach. Obviously this can happen on a week-to-week basis, both in training and on game day. At the end of each season, all coaches and those support staff who service the needs of players should be subjected to a review by the athletes with anonymous questionnaires.

7 Honesty is the best policy

Honesty really does build trust between player and coach. Sometimes it's difficult to convey information that will be unpleasant for the athlete. But the one universal truth I have learnt is that while the truth may hurt, people of quality deal with it extremely well. Very few people can handle lies, innuendo and half-truths.

Remember, though, you aren't always right. Be careful to acknowledge privately and publicly when you are wrong.

8 Measuring success

It's not always possible, but to be able to confirm, or question or reject your methods, it's necessary to come up with performance indicators. These can only be validated on the basis of objective measures. Find systems and processes that can constantly deliver your key performance indicators. They give credence to your methods, and confirm your improvement or otherwise. Footballers will confidently give themselves over to a game plan when you can provide the evidence of its effectiveness.

9 Individual versus team

This is one of the ongoing dilemmas for coaches of Australian Rules football. It's easy to hide behind 'the team' in coaching, i.e. working in generalities – the one-shoe-fits-all concept. But the reality is that your success as a coach is more dependant on your ability to coach individuals within the team. All teams are made up of at least 22 individual players. It's your capacity to deal with them as individuals, as well as a cooperative, sacrificial and cohesive unit, which will make your coaching successful. In the finish, you will win or lose as a team. But the individual worth of each member should never be underestimated.

10 Team life = sacrifice

All things being equal, it's the team whose members are prepared to not only work with each other, but for each other that wins. This requires a high level of commitment to sacrificial acts, i.e. individual players are sincerely committed to making sacrifices so their mates can be more efficient and effective. Like all inputs critical for team success, these sacrificial acts need to be recorded, recognised and rewarded. Like all important football behaviour, it must be consistently reinforced or it drops away. The coach needs to, in conjunction with the team, work out a system or method to record, recognise and reward this kind of behaviour.

11 Goal setting

While it can be very time consuming, the coach should have a clear picture of what the team and the individual members want to achieve. Knowing people's motives can enhance the manner in which we communicate and direct people's behaviour. Goals can become lighthouses along the way, and specific markers to judge the degree of improvement and success we achieve. Take time with your footballers to understand why they are playing the game.

12 More is not better

We have reached the stage in our football education to understand that in preparing to play this demanding game, more is not necessarily better. In fact, rest and recovery are equally as important as strength and power training. How much is enough and how much is too much is the question a football coach must continually ask. Educate your footballers to understand and read their bodies. The doctor, fitness advisor and coach is often only as good as the honesty and accuracy of his player's understanding of themselves when they communicate. The first AFL club to educate their players to understand themselves in an honest and accurate way in relation to injury or illness, plus fitness levels and current form, will take an enormous advantage.

13 Lifestyle balance

My belief is that both player and coach need to plan and commit to the principle of lifestyle balance. Unless both can have a blockading technique, football can become a very all-consuming and often debilitating experience (especially when things aren't happening as you would wish). This means having a small, but sincere, commitment to establishing something beyond football. I would recommend this to all professional footballers and coaches. The research is starting to indicate that not only do you play (and coach) better, and have a longer career, but you give yourself a better chance of making a successful transition to normal life when it's all over. Coaches must be sincerely interested in their footballers, beyond their capacity to just produce good football. If you are committed to developing the whole person, the benefits and returns are significant.

14 Passion and fun

Passion for your sport is essential for coaching success. Footballers must sense your love for the game, and the role you play. It's a very demanding task. No-one denies

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the need for a very committed approach. But if this prevents us from having some real fun, i.e. laughing with and at each other, then we have a problem. Encourage joking relationships. Create an environment where people want to be.

15 Attitude

We know that talent (or how we choose our parents!) and preparation are really essential for athletic and football success. But I'm convinced that the attitude which a footballer brings to his competition is by far the most important ingredient for immediate and long-term success. It's amazing that if you want it enough, attitude will often overcome a lack of talent and preparation.

Conclusion

When times are tough and wins are few and far between, what you need is a strong system of coaching. It's not appropriate to significantly change your philosophy. Confidence in what you believe is negated rapidly, if the coach 'loses his way'. Having made up your mind as to the system for conducting your coaching, have the faith and belief to live by it.

***Coaching Update*, November 2002**

Checkpoints

You have just read an excerpt from a speech given by David Parkin, the former coach of Carlton and Hawthorn AFL clubs.

1 What philosophies do you feel are most important to a coach who is trying to look inwardly at what he does?

2 Which of these concepts could also be used by a player looking at improving their performance?

TEST YOUR KNOWLEDGE

>> multiple-choice questions

1 What is the main reason for using a reflective journal?

- **a** To guide skill development and correct errors.
- **b** To allow the athlete to record key information for constant review.
- **c** To allow monitoring of rehydration schedules.
- **d** To assess quantitative physiological parameters.

2 Video analysis is primarily used for:

- **a** physiological responses to exercise
- **b** determining the PRE during activity
- **c** assessing visual acuity in cue detection
- **d** biomechanical qualitative analysis.

3 Self-reflection after training helps athletes to:

- **a** gauge workloads using PRE
- **b** assess skill progression
- **c** set and measure goals
- **d** all of the above.

4 A junior sports coach is likely to use which method of analysis to help guide future direction?

- **a** Reflective journal.
- **b** Athlete-centred physical monitoring.
- **c** Coaching skills checklist.
- **d** Statistical analysis.

>> short-answer questions

1 Imagine you have just been appointed coach of the Australian Netball Team. Prioritise and justify the three most important forms of analysis that you would instigate.

2 Select the two most beneficial forms of analysis for the following activities. Explain why you have chosen those methods over other methods.

- **a** Road Cycling
- **b** Badminton
- **c** Hockey
- **d** Swimming

Review your answers. Why is specificity of feedback and analysis so varied between the activities?

3 Construct a table summarising key characteristics of coaches and players. How many are similar? How many are different? Why is this so?

4 If you were only to test physiological parameters in assessing performance, what information would you be neglecting? Would this process ever be beneficial?

>> essay questions

1 Explain how a coach would know if the training program is meeting the performance demands of the given activity. Refer to physiological, skill development, mental and social elements in your answer.

2 Identify and discuss the techniques for monitoring training and recovery.

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SECTION 3
FUNCTIONAL ANATOMY

Chapter 7 Muscle structure and function

3A.8 Explain the structure of skeletal muscle; i.e. epimysium, fascicle, perimysium, muscle fibre, myofibril

3A.9 Explain how skeletal muscles contract in relation to sliding filament theory; i.e. the role of myosin, actin and the sarcomere

3A.10 Understand the relationship between the velocity and duration of muscle contraction to the amount of force exerted by the contraction; i.e. force-velocity and force-length

3B.4 Understand the function of the nerve, impulse, spinal chord, motor unit (dendrite, axon, neurone)

3B.5 Describe the relationship between muscle contraction and nerve function

3B.6 Identify fast- and slow-twitch fibres and their relationship to physical performance types (sprint, endurance); i.e. characteristics of Type I, Type IIa and Type IIb fibres

7 Muscle structure and function

contraction
any movement resulting in tension being developed at a muscle

relaxation
absence of tension in a muscle

Everyday movements such as running, jumping, swimming or swinging a bat are made possible by muscles exerting forces on bones, via tendons. There are more than 660 skeletal muscles in the body and they produce a wide range of movements by working together. Each muscle is capable of two actions: contraction and relaxation.

Muscle types

There are three types of muscle tissue in our bodies: skeletal, smooth and cardiac.

Skeletal muscles

These external muscles are attached to the bones that make up our skeleton and are under our direct control. They are known as voluntary muscles and are made up of striped (or striated) cells.

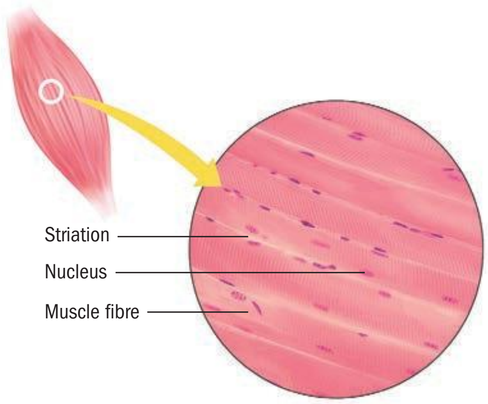

Figure 7.1 Skeletal muscle is striated (striped) or voluntary muscle

Smooth muscles

Smooth muscles are found internally in blood vessels and walls of the intestine and, unlike skeletal muscles, we have no control over them. For this reason, smooth muscles are also known as involuntary muscles. They are made up of spindle cells.

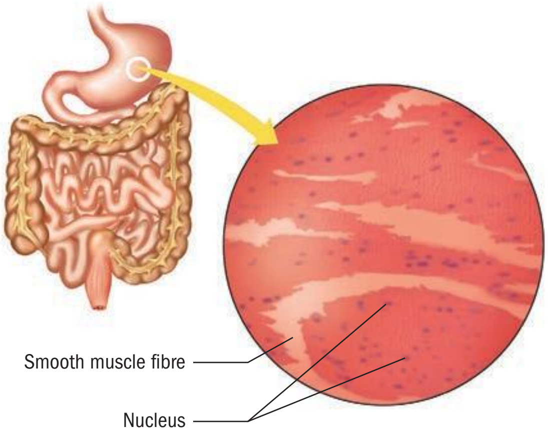

Figure 7.2 Smooth muscles are involuntary and made up of spindle cells

Cardiac muscles

As the name suggests, cardiac muscles are found in the heart, and make up its walls. They are also involuntary, and have a striped appearance.

All skeletal movements result from muscles pulling on bones. Muscles are attached to bones by tendons, which are generally situated at the end of the muscle belly. Tendons are made up of connective tissue and may cross joints to provide additional support to specific sites. Ligaments attach one bone to another bone and provide strength around a joint. To move a bone, a

muscle belly
main body of muscle

ligament
cord of thick, strong fibres that connects bone to bone

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muscle must cross over a joint. One end of the muscle is attached to a bone, whilst the other end is attached to another bone on the other side of the joint.

Nerves deliver messages telling muscles to contract, and forces are applied to bones by tendons. When the muscle contracts, it pulls the bones closer to each other and we are able to jump, run or swim. All of these structures form the neuromusculoskeletal system.

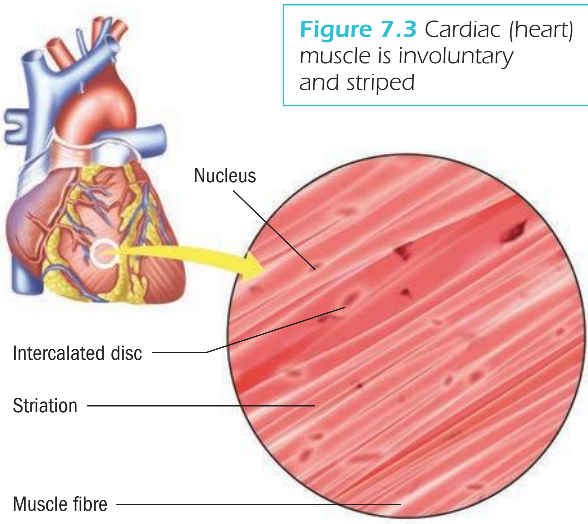

Figure 7.3 Cardiac (heart) muscle is involuntary and striped

neuromusculoskeletal
system of nerves, bones and muscles within the body

pennation
a muscle with fibres that attach obliquely to the tendon

unipennate
muscle fibres only branch out to one side of the tendon, e.g. the semimembranosis

bipennate
muscle fibres branch out to both sides of the central tendon, e.g. gastrocnemius

multipennate
muscle fibres branch out repeatedly from a number of tendons, e.g. deltoid

sarcomere
a segment of myofibril in a striated muscle fibre

fusiform
tapered at each end

The arrangement of muscle fibre and tendon varies within the body. Muscles can be further classified as fusiform or penniform. (See Figure 7.4.)

- Fusiform muscle fibres run longitudinally (in the same direction as the tendon); for example, the biceps muscle in the arm. There are few fusiform muscle fibres. They produce low force but can shorten over a large range.
- Penniform muscle fibres run at angles to the tendon. They make up 75 per cent of the skeletal muscles and produce great force. Muscles with greater pennation are slower than fusiform muscles and slower than those with less pennation but generate greater force and power because a greater number of sarcomeres contribute to muscle action. These can be further classified according to how they branch off the tendon.

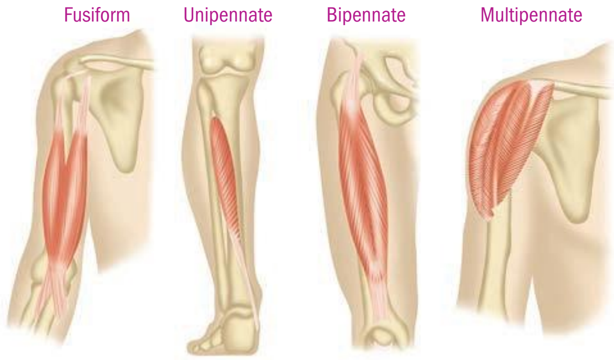

Figure 7.4 Muscle fibres in skeletal muscles, from left: fusiform (biceps); unipennate (calf); bipennate (quadriceps); multipennate (deltoid)

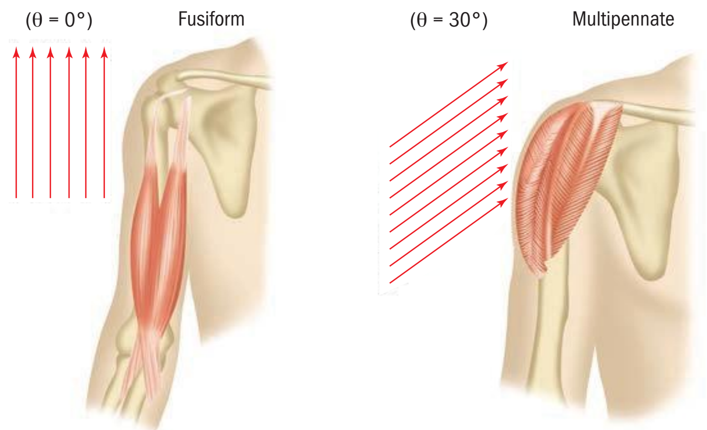

Figure 7.5 Effect of muscle-fibre packing and pennation on force development

Figure 7.5 reveals that with a 30° angle of pennation ($\theta = 30°$), there is a theoretical 13 per cent loss of each fibre's maximum force on the tendon. However, the trade-off is that pennation allows more fibres to be packed into a muscle, so the amount of force that can be generated increases proportionally.

It is worth investigating the effect muscle length and speed of contraction have on the ability of fusiform and pennate muscles to develop force. To do this, consider the opposing muscles of the upper and lower leg. The quadriceps and plantar flexors are able to develop high forces because of their low-fibre length (FL) to muscle length (ML) ratios (or FL:ML ratios) and relatively large physiologic cross-sectional area (or PCSA) and short fibre lengths.

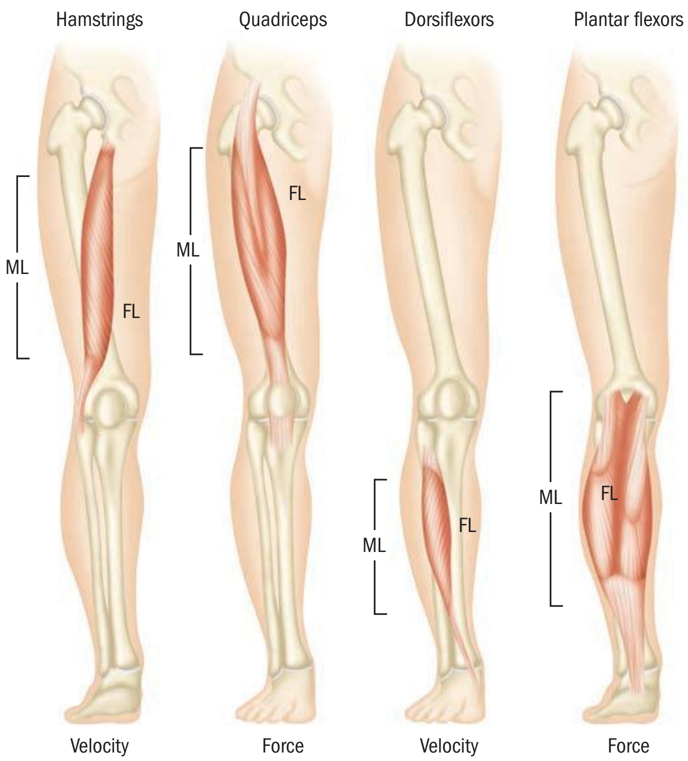

Figure 7.6 Hamstrings and dorsiflexors are designed for speed; quadriceps and plantarflexors are designed for force

The hamstrings and dorsiflexors are designed for speed, due to their high fibre length to muscle length (FL:ML) ratios and long fibre lengths.

Fusiform muscles, with their longer fibre lengths, are incapable of generating the same high forces of pennate muscles, because of their shorter lengths and greater cross-sectional area. However, fusiform muscles are able to generate greater contractile velocities, traded off for lower force outputs.

In summary, if we want muscles to contract forcefully and develop high amounts of strength, we call on pennate muscles. These muscles are able to generate great force over longer periods of time than fusiform muscles. If we want muscles to contract rapidly and develop greater power, we call on fusiform muscles.

The muscle belly consists of thousands of muscle fibres known as fasciculi, which run side by side along the length of the muscle. (See Figure 7.8.) Each of these fibres is encased in and surrounded by connective tissue known as perimysium, which helps keep the fasciculi together. The fasciculi are surrounded by

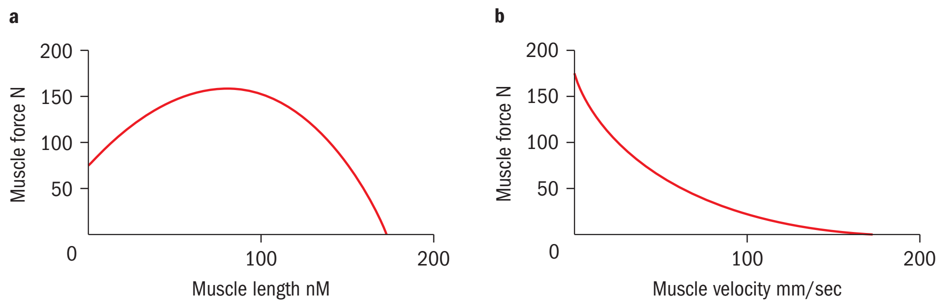

Figure 7.7 Muscle force resulting from different muscle length and contraction velocity

a) hamstrings
b) quadriceps

Catchy Fact
You use 17 muscles when you smile, but 43 muscles when you frown—so keep smiling!

Checkpoints

1 List four examples of fusiform muscles.

2 Why are pennate muscles able to generate greater force than fusiform muscles?

3 If muscles need to contract rapidly, should the muscle length to fibre length ratio be high or low? Briefly discuss.

4 We often hear of sportspeople stretching or injuring their ligaments.

- **a** How does this affect a sportsperson?
- **b** How is a ligament different to a tendon?
- **c** How do you think the colour of a ligament, tendon or muscle effects the time it will take to heal after injury?

endomysium, which collectively form the fasciculus. All of this is encased by a connective tissue called the epimysium. As this nears the end of the muscle, it thickens and eventually becomes the tendon.

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Muscle fibres are made up of myofibrils, which are similar to the many wires inside a telephone cable. These have many units, known as sarcomeres, which are arranged end to end for their entire length, with Z-lines delineating where these units start and finish. By further dividing the myofibrils, we end up with myofilaments: a thick filament (myosin) and a thin filament (actin) which attach to the Z-line. The overlap of these two myofilaments gives muscle its striped appearance.

Each muscle cell or fibre is surrounded by the cell membrane (sarcolemma), which encases a gelatin-like substance (sarcoplasm), which in turn surrounds the actin and myosin filaments. The sarcoplasm contains:

- mitochondria, where oxygen combines with other substances to produce energy
- myoglobin, responsible for the transport and storage of oxygen from the blood to the mitochondria

myofibrils
the part of the muscle fibre encasing the actin and myosin filaments

myosin
a thick protein filament found in a sarcomere, responsible for muscle contraction

actin
a thin protein filament found in a sarcomere, responsible for muscle contraction

mitochondria
cellular structures containing enzymes responsible for the production of energy under aerobic conditions

fascicle
dense cluster or bundle

myelin sheath
insulating layer that surrounds nerve fibres

axon
long nerve fibre that transmits electrical signals to other nerve cells

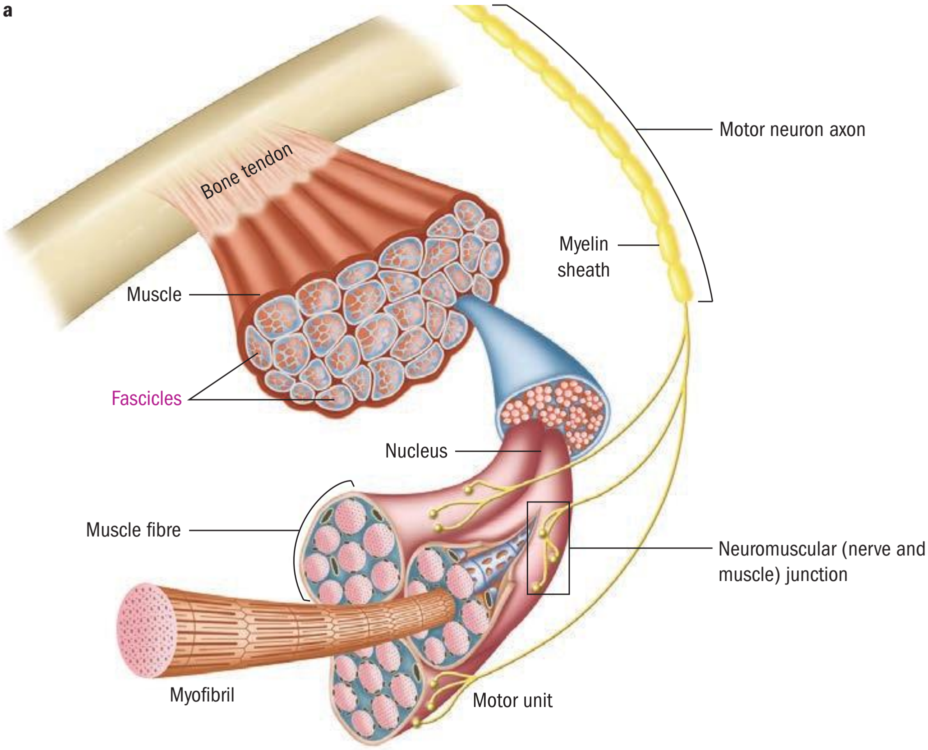
sarcolemma
thin cell membrane that surrounds a striated muscle fibre

sarcoplasm
the cytoplasm of a striated muscle fibre

sarcoplasmic reticulum
internal membranes in muscle cells or fibres

myoglobin
the protein that carries oxygen in muscle cells

a



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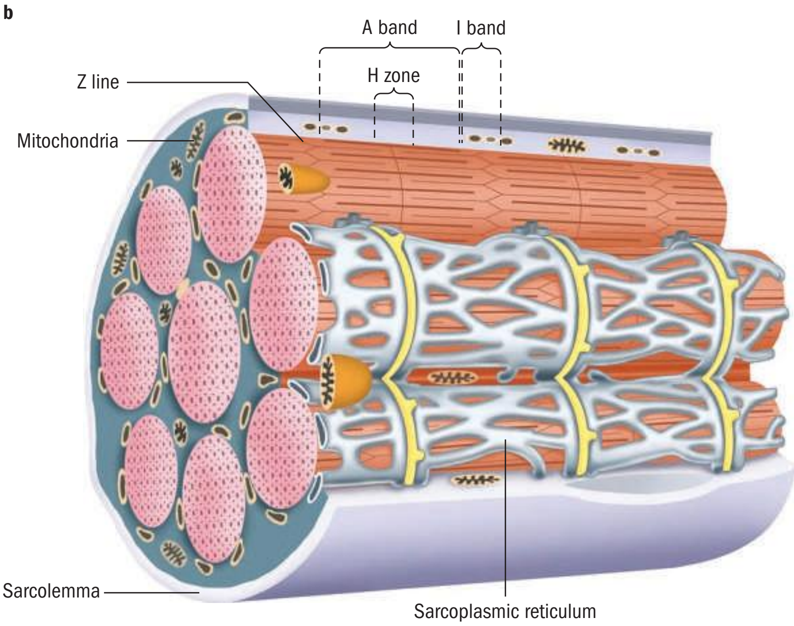

Figure 7.8 a) Inside a muscle fibre
b) Detailed view

enzymes
chemical substances that facilitate or speed up the rate of reactions occurring within the body

I-band
the area of myofibril containing actin

A-band
the area in the centre of the sarcomere, containing both actin and myosin filaments

H-zone
the centre of the A-band, which is free from the myosin crossbridges

- fat, glycogen, phosphocreatine (PC) and adenosine triphosphate (ATP) for energy production
- enzymes, for energy production and muscle growth
- actin and myosin filaments.

Actin and myosin filaments take up different parts of the length of a sarcomere. The light section that contains only the thin actin filaments is known as the I-band; the darker section occurs where the actin and myosin overlap and is known as the A-band. In the middle of the A-band is a very small section where only the thick myosin filaments occur. This is known as the H-zone. Thousands of these sarcomeres may exist along the length of a myofibril—all separated by Z-lines.

The nervous control of muscular contraction

Have you ever wondered how many complex processes are involved in hitting a hockey ball or shooting a goal in netball? Because these movements occur automatically and rapidly, you could be forgiven for thinking they are simple tasks. In fact, many complex processes must occur to bring about these movements.

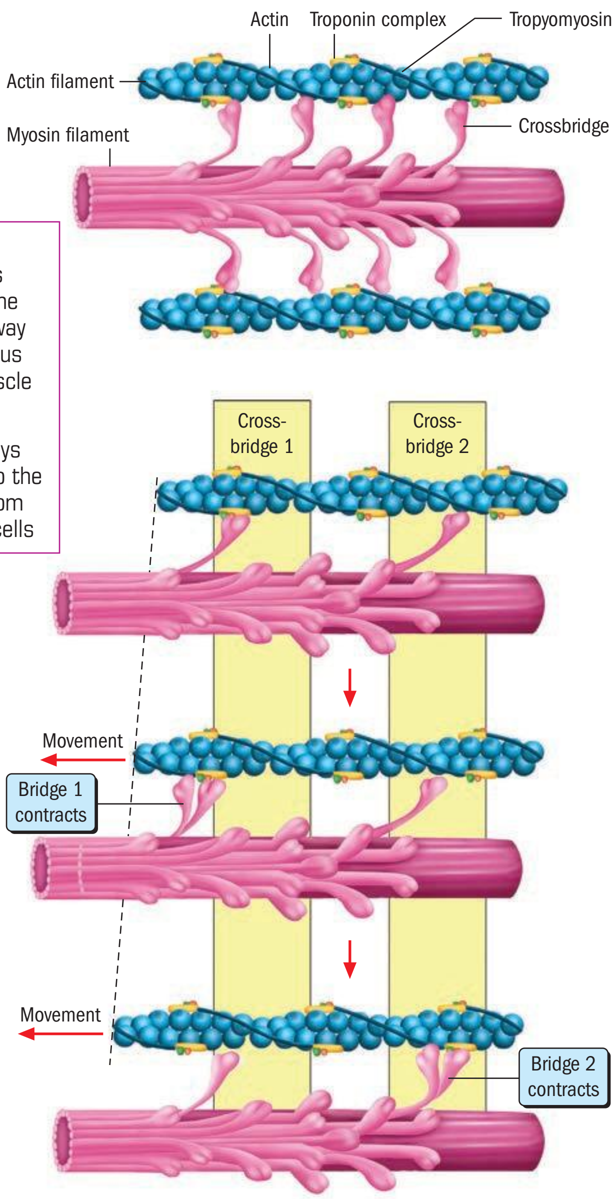

Figure 7.9 Structural arrangement of actin and myosin filaments in a sarcomere

The brain is responsible for initiating all actions, with the spinal cord carrying all of its messages. Messages are sent as electrical impulses via motor neurons; motor neurons, in turn, stimulate muscular contraction and hence movement. Instead of wires, we have a series of nerve cells or neurons that all contain:

- a cell body
- dendrites, which are receptors from other neurons or sense organs
- an axon, which conducts impulses away from the cell body.

Sensory neurons conduct impulses (or messages) from the sense receptors to

motor neuron
nerve cell that conveys nerve impulses from the spinal cord or brain away from the central nervous system towards a muscle

sensory neuron
a nerve cell that conveys nerve impulses back to the spinal cord or brain from muscles, organs and cells

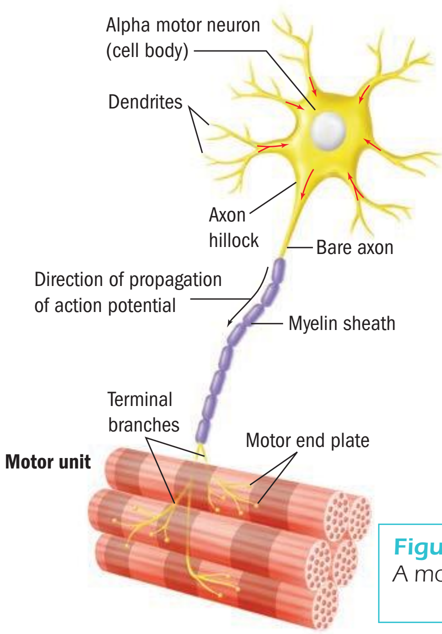

Figure 7.10 A motor unit

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the brain; motor neurons carry impulses from the brain and central nervous system to muscles and bring about movement. Many nerve cells extend the length of a myofibril in the same way that many sarcomeres do. They are placed 'end to end' from the brain to the many thousands of points throughout the body. The brain must monitor and receive messages from all these points in order to respond to a stimulus. Neurons that are 'linked' are known as neural chains.

It is important to understand that one motor neuron does not stimulate the whole muscle, but only a small portion of it. The motor neuron and the muscle fibres it stimulates are together known as the motor unit. One motor neuron may be responsible for stimulating one or two muscle fibres when precision is required; in other parts of the body it may stimulate thousands of muscle fibres where gross movements occur. The first might occur in the eye or fingers and the gross movement may be typified by, for example, the quadriceps in the kicking of a soccer ball.

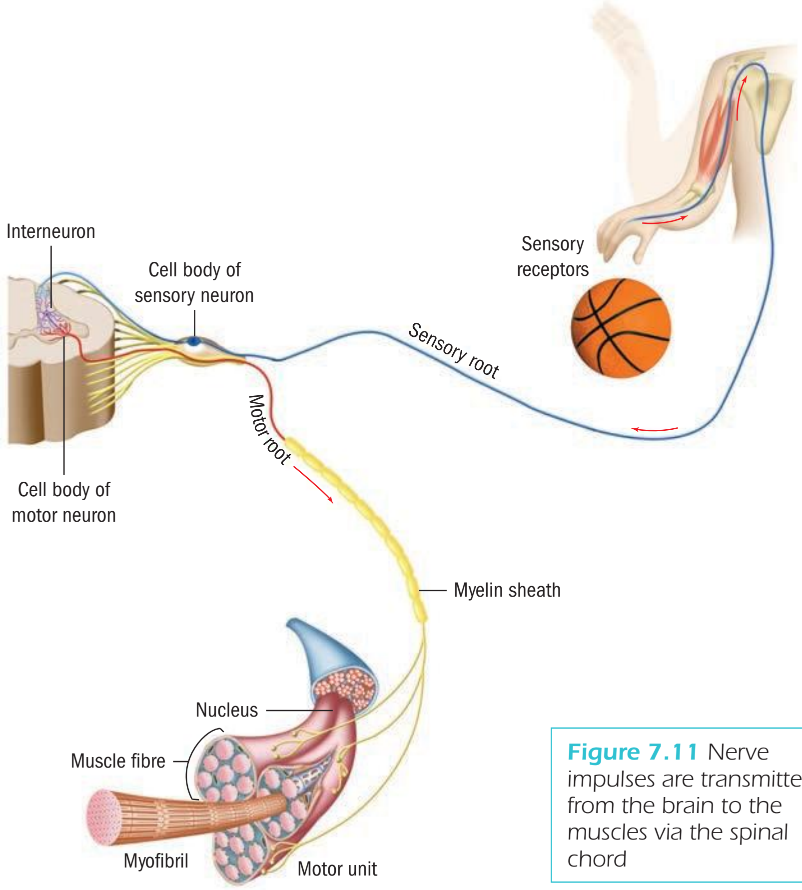

Figure 7.11 Nerve impulses are transmitted from the brain to the muscles via the spinal chord

Figure 7.12 Gross movements, such as kicking a ball, require more motor neurons than precision movements, such as playing chess

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synapses
region of communication; space between neurons and muscle fibres

acetylcholine
chemical substance responsible for the transfer of impulses from one neuron to another, or to muscles across the synaptic cleft or neuromuscular junction

exocytosis
the release to a cell surface of secretions through vesicles

acetylcholinesterase
an enzyme responsible for breaking down acetylcholine

cytosol
intracellular fluid; the liquid found inside cells

synaptic cleft
tiny space between two nerve cells or between the end plate and muscle fibre

motor end plate
motor neuron end responsible for transmitting nerve signals to a muscle fibre

ion channels
gaps in cell membrane that allow sodium and potassium ions to flow

end-plate potential
when the nerve signal crosses the synaptic cleft and changes the polarity of the muscle fibre

Nerves 'connect' to muscles at synapses on the individual myofibrils known as neuromuscular junctions similar to the way a cord plugs into an electrical kettle. However, there is no direct contact. The message must travel across the synapse via a chemical neurotransmitter called acetylcholine (Ach).

Upon the arrival of an action potential at the axon terminal, voltage-dependent calcium channels open and calcium (Ca^{2+}) ions flow from the extracellular fluid into the motor neuron's cytosol. This influx of Ca^{2+} triggers a biochemical cascade that causes neurotransmitter-containing vesicles to fuse to the motor neuron's cell membrane and release acetylcholine into the synaptic cleft, a process known as exocytosis.

Acetylcholine diffuses across the synaptic cleft and binds to the acetylcholine receptors that occur on the motor end plate. The receptors also double up as ion channels, and when bound by acetylcholine, they open, allowing sodium and potassium ions, in that order, to flow in and out of the muscle's cytosol. Because of electrochemical gradient differences across the plasma membrane, more sodium moves in than potassium moving out, producing a local depolarisation of the motor end plate, known as an end-plate potential (EPP).

This depolarisation spreads across the surface of the muscle fibre into transverse tubules, causing the release of calcium from the sarcoplasmic reticulum, resulting in muscle contraction and movement. Acetylcholine's action ends when the enzyme acetylcholinesterase breaks down the neurotransmitter and the used neurotransmitter diffuses away. The acetylcholine then becomes inactive very quickly, and the muscles relax.

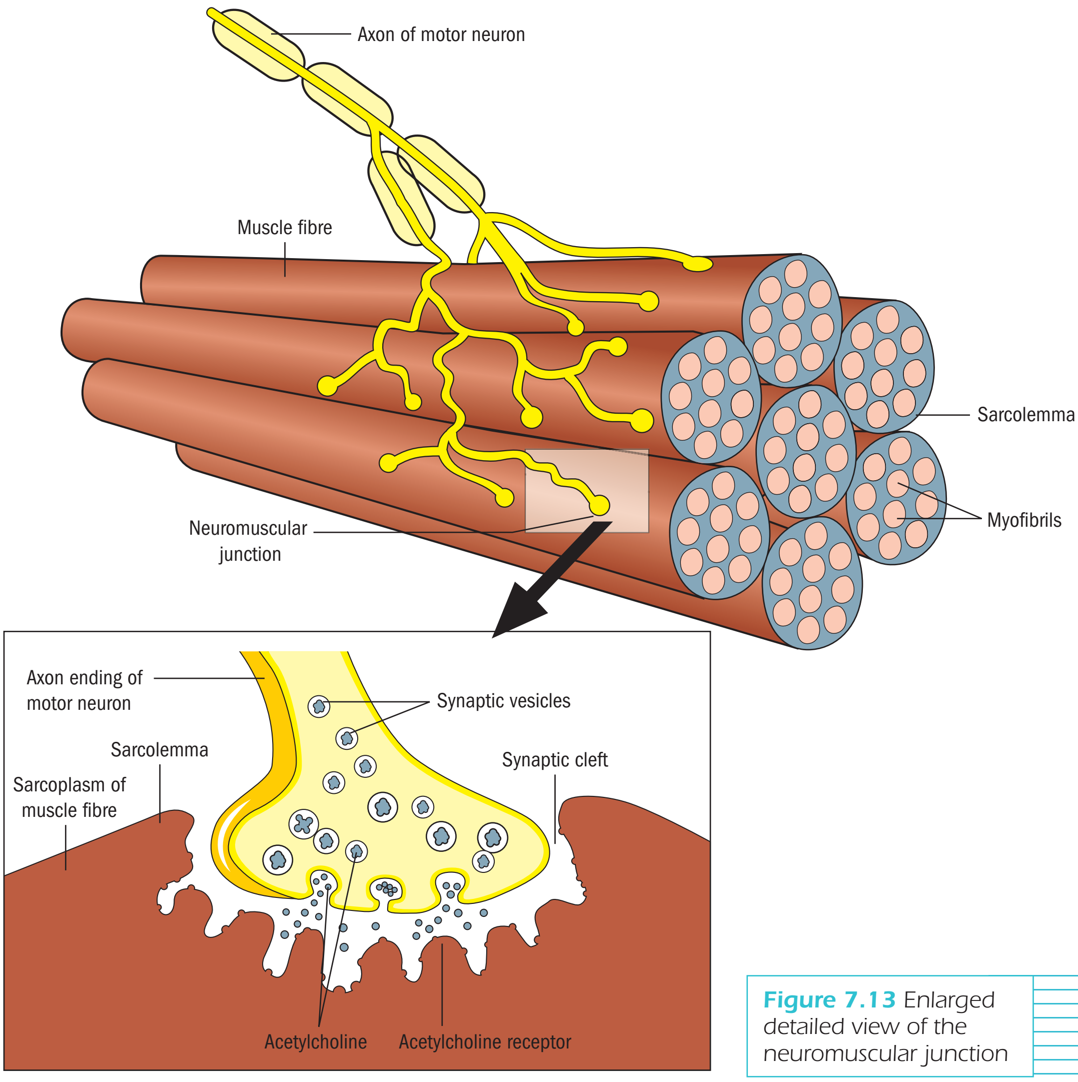

Figure 7.13 Enlarged detailed view of the neuromuscular junction

Catchy fact
Acetylcholine is a neurotransmitter synthesised in the human body from dietary choline and acetyl coenzyme A.

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The 'all-or-nothing' principle

Do all impulses from the brain result in movement or muscular contraction? Muscular movement is subject to the 'all-or-nothing' principle. When the electrical impulse reaches a certain threshold, all of the fibres of that motor unit will contract at the same time and as forcefully as possible. However, until this threshold is 'tripped', none of the fibres will contract at all. Once the impulse trips the threshold, the ATP stored in the muscle fibre is split, with the resultant energy release allowing muscular contraction to occur. The amount of adenosine triphosphate (ATP) stored at the muscle fibres is relatively small, so the body must supply the muscles with more ATP in order for it to continue to work and for the muscles to contract. The body is equipped with three energy systems to ensure the supply of ATP is maintained: ATP–PC, lactic acid and the aerobic energy system.

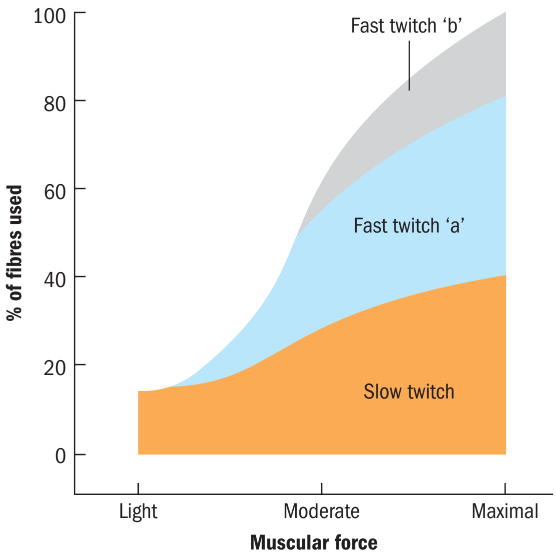
threshold the level that must be reached for a physiological effect to be triggered

preferential recruitment when the body recruits fibres according to the intensity of the activity about to be undertaken

ATP–PC creatine–phosphate energy system

So how do we vary the intensity of muscular contractions? Not all muscle fibres contract every time there is a signal telling them to contract. The number of fibres recruited to contract is governed by the strength of the nerve impulses from the brain. When the nerve impulses are stronger, more motor units are activated and more muscle fibres will contract. For a task requiring minimal application of strength, such as lifting a glass, only a few muscle fibres will be activated. The most forceful contraction (for greater application of strength) will occur when the maximum number of muscle fibres are activated in a muscle; for example, when lifting a heavy weight. The greater the frequency of arrival of impulses, the greater the force developed at that muscle.

The body recruits fibres according to the activity demand, which is called preferential recruitment. The intensity of the task determines which type of muscle fibre is preferentially recruited for the task. If an immediate and rapid response is required, then fast-twitch fibres (which are quickest to respond) will be recruited first. Slow-twitch fibres are preferentially recruited if the event is of lower intensity.



Howell & Howell 1991, p. 114

Figure 7.14 The recruitment of fibres increases as muscular force increases

How muscle contractions occur

The 'sliding filament' theory

When a muscle contracts, the myofilaments slide across each other: the actin slides over the myosin. The brain sends a message to muscles for contraction to occur. This is an electrical impulse that travels along axons to muscles at synapses of individual myofibrils at the neuromuscular junction (see Figure 7.13). The acetylcholine activates the release of calcium (Ca^{2+}) ions stored within the sarcoplasmic reticulum—over the actin and myosin filaments.

This stimulates the crossbridges on the myosin to reach out and attach to the actin filaments. The crossbridges shorten and pull the actin filaments towards the centre, and the muscle contracts. This happens thousands of times along the whole length of the muscle fibre, and results in a shortening of the muscle's overall length.

crossbridges oar-like projections from the myosin filaments, which assist muscle cells to attach to others

Unless stimulated again, the crossbridges relax as the calcium ions are drawn back into the sarcoplasmic reticulum and the muscle returns to its original length. It is important to note that the length of the filaments does not change—the filaments simply slide over each other. In Figure 7.15 the I-band is the small band where only the thin actin filaments are found. The darker area where the actin and myosin filaments overlap is known as the A-band (see also Figure 7.8b on page 121). In the middle of the A-band there is an area where only myosin filaments are found, and this is known as the H-zone. Because the actin filaments slide over the myosin filaments, the I-band and the H-zone will eventually disappear during a muscular contraction. The A-band does not change because the myosin does not move. A muscle may shorten to up to 50 to 60 per cent of its resting length.

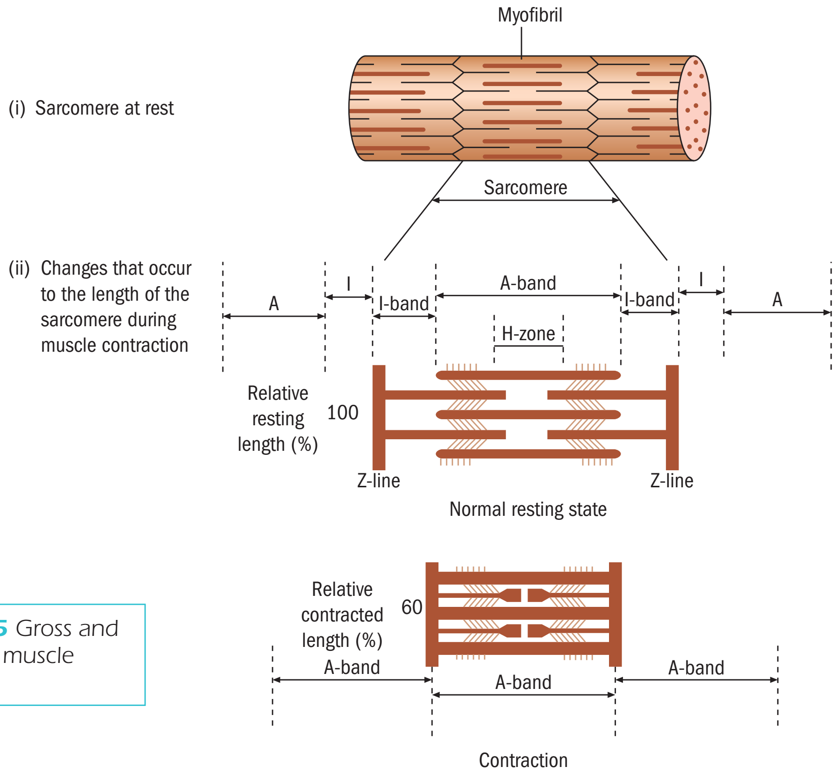


Figure 7.15 Gross and microscopic muscle structure

As mentioned, athletes exert different forces during performances, and different numbers of motor units are recruited within a muscle. A cricket player hitting a six would be using most of the motor units in their arms. Remember, the greater the frequency of electrical stimulation at the myofibrils, the greater the force generated by muscles.

Muscle contraction and relaxation summary

In a resting muscle:

- very few electrical impulses reach the muscle. (Although some myosin crossbridges do remain in contact with actin; the muscle is never truly relaxed but remains toned. This allows contractions to occur more rapidly and allows correct posture to be maintained.)
- calcium (Ca^{2+}) ions are stored in the sarcoplasmic reticulum
- adenosine triphosphate (ATP) is stored, or not broken down.

During a muscle contraction:

- nerve impulses travel along axons to axon end plates
- acetylcholine (Ach) travels across the synaptic cleft to myofibril
- sarcoplasmic reticulum releases calcium (Ca^{2+}) ions
- myosin crossbridges attach to actin
- adenosine triphosphate (ATP) is broken down and energy released, causing crossbridges to shorten
- actin is either pulled (or slides) over myosin, and the muscle shortens or contracts.

During relaxation:

- nerve impulses stop
- calcium (Ca^{2+}) ions are taken up by sarcoplasmic reticulum
- myosin crossbridges are broken down and actin returns to its resting state
- the muscle relaxes.

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Checkpoints

1 True or false?

a Tendons attach one bone to another.

b Multipennate muscle fibres produce greater forces than unipennate muscle fibres.

c Nerve cells come into direct contact with muscle fibres.

d Ach (acetylcholine) activates the release of calcium ions, which stimulate crossbridges on myosin to reach out and attach to actin filaments.

2 Draw a sarcomere (all that is contained between Z-lines) and clearly label the following

- Z-lines
- I-band
- actin filaments
- A-band
- myosin filaments
- H-zone

3 Describe how the 'sliding filament theory' of muscle movement occurs. In your answer, briefly explain how a message sent from the brain very quickly becomes a muscular movement.

4 How are athletes able to control the amount of force that a particular muscle group exerts? For example, a performer may use their arm muscles to pick up a drink bottle and later use the same muscles for hurling a discus 60 metres.

5 What does the 'all or nothing' principle refer to?

Types of muscle contraction

There are three types of muscular contraction, classified by the movements they cause. These are listed below in order of occurrence in everyday activity, from most to least common:

- Isotonic contraction
- Isometric contraction
- Isokinetic contraction

Isotonic contraction

An isotonic contraction is the most common type of muscular contraction. It occurs whenever the muscle length changes through a range of motion or action. When a constant load (or weight) is being moved, differences exist in the amount of force applied at various joint angles. For example, at the beginning of a bicep curl, the movement is relatively difficult and slow as the elbow begins to flex. As the joint angle decreases, the muscle shortens further, the movement becomes easier and the speed of contraction increases.

If the muscle shortens during an effort, a concentric isotonic contraction has occurred; for example, the upward phase in a bicep curl during elbow flexion. This is the most common type of contraction undertaken by most muscles. However, if the muscle lengthens while tension is developed, an eccentric muscular contraction has occurred. This would occur in all gravity-resisting movements such as lowering the barbell from the bent arm position during a bicep curl. The big disadvantage with isotonic contractions is that there tends to be only one point in the range of movement when the muscles are working maximally, so the entire range is not being worked fully.

Isometric contraction

An isometric contraction occurs when tension is developed but there is no change in the length of the muscle. Isometric contractions involve little change in muscle length while tension is developed; for example, Pat Rafter's grip on his tennis racquet, with forearm flexors contracted isometrically. Many 'fad' exercise programs focus on isometrics and promised strength gains by 'working out for only five minutes a day'. We know that this is impossible, but the main disadvantage with isometrics is that they produce elevated systolic blood pressure when muscles contract around blood vessels and restrict blood flow. This can place undue stress on the circulatory system, as the heart needs to pump harder to force blood through those restricted areas.

Isokinetic contraction

The tension developed during an isokinetic contraction is maximal throughout the entire range of motion. Isokinetic contractions are common when using Cybex, Nautilus and Hydra-gym hydraulic fitness equipment. On this equipment, the amount of force applied by the machine always equals the amount of force applied by the muscle. The harder you push or pull, the greater the resistance offered by the machine. Because these machines work the muscle maximally throughout the entire range of motion, they tend to be favoured by many athletes. They develop the greatest improvements in both strength and endurance. There are none of the 'weak spots' common to isotonic workouts with free weights.

Different muscle types

Muscles are made up of two different types of fibres:

- Red, type I slow-twitch fibres (ST): these are best suited to aerobic endurance work; for example, triathlons.
- White, type II fast-twitch fibres (FT): these are best suited to short-duration high-intensity anaerobic work; for example, the bursts of power and speed required to sprint.

biopsy
removal of a tissue sample for laboratory examination

It is possible to discover your muscle fibre 'make-up' by undertaking a muscle biopsy. Biopsies are commonly undertaken in talent-identification programs, where fibre type is critical in determining the types of contractions favoured by an athlete. It is also worth noting that unless an athlete has the 'right' fibre composition, all the training in the world will not make a huge difference.

KEEP IT REAL!

Which fibre is that?

Muscle biopsies are used to examine small samples of muscle tissue. The sample can be obtained by either an open or a needle method, and is usually performed under a local anaesthetic.

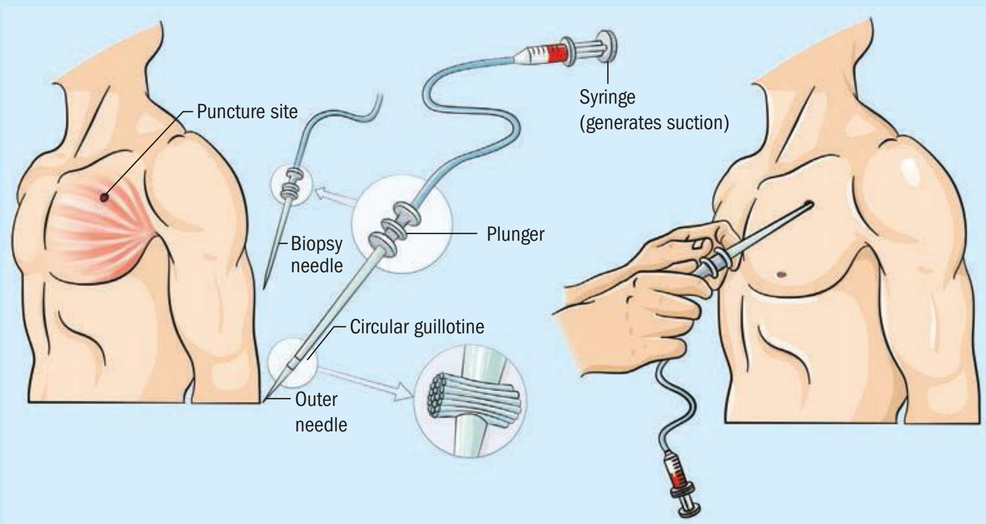

Figure 7.16 A small plug of tissue is removed during a biopsy

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Open biopsies involve a small incision through the skin into the muscle, so that a sample of tissue can be removed and sent off for analysis.

Needle biopsies are less invasive than open biopsies. A small 'plug' of tissue remains in the needle when it is removed from the muscle and this is sent to a pathologist for examination.

Muscle biopsies are used to:

- distinguish between nerve and muscle disorders
- identify specific muscular disorders; for example, muscular dystrophy
- identify metabolic functions occurring in muscles
- diagnose infections that affect the muscles
- determine the structure of muscle cells (fibre composition).

Histology tests (or tissue tests) use chemical stains to see the muscle's appearance and the structure of the muscle cells. These tests are used to determine the fibre 'make-up' an athlete possesses, as well as how muscle fibres are responding to different training conditions.

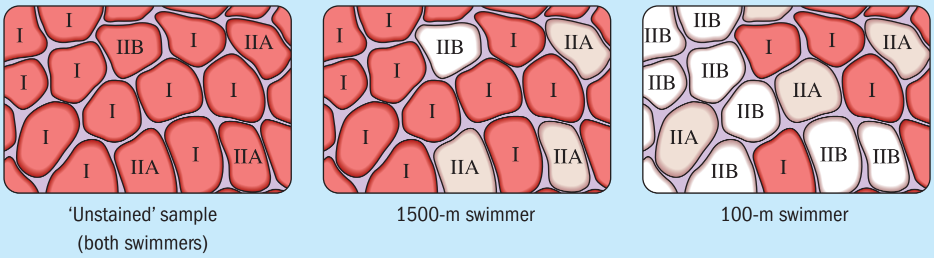

Figure 7.17 Muscle biopsies reveal different fibre compositions in 100-metre and 1500-metre swimmers

Slow-twitch (ST) fibres contract slowly and are able to perform over extended periods of time, producing low forces. Fast-twitch (FT) fibres produce larger forces than ST fibres, but tire more rapidly.

The muscles of our body are made up of a proportion of slow-twitch and fast-twitch fibres, which vary from muscle to muscle. The proportion of red as opposed to white muscle fibres varies from individual to individual, although most people have roughly equal proportions of each. Athletes with a predominance of one fibre type over another will tend to succeed in events requiring that particular muscle fibre type. For example, an athlete with a predominance of fast-twitch fibres will perform best in sprint events, while an athlete with a majority of slow-twitch fibres will perform best in endurance events. Can you think of other examples?

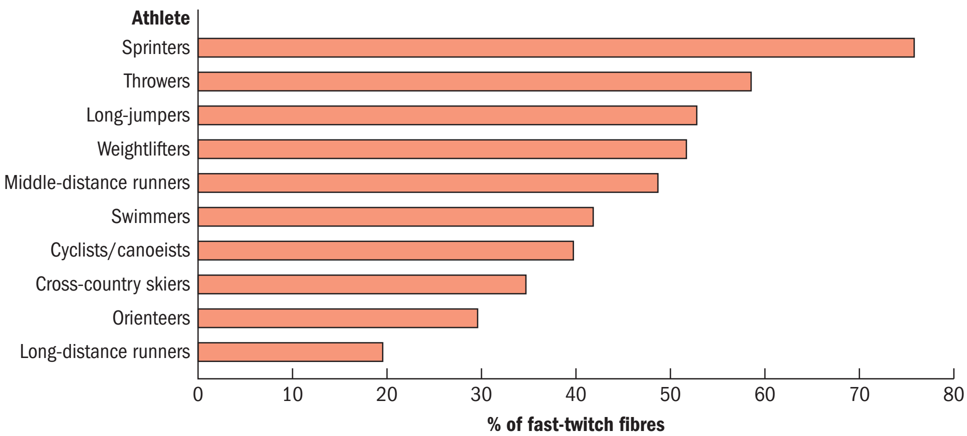

Figure 7.18 The percentage of fast-twitch fibres found in various types of athletes

While the proportion of fast-twitch and slow-twitch fibres is generally about equal in muscle groups, variations can occur between muscles, or muscle groups. The proportion of each fibre that an individual has in their body tends to be genetically determined. Recent research indicates that genetic endowment is much more important for sprint-type events than for endurance activities.

The soleus muscle in the lower leg contains about 30 per cent more slow-twitch fibres than other leg muscles, which predisposes it to endurance performance. The triceps in the upper arm contains 25 per cent more fast-twitch fibres than other arm muscles, making it very powerful and fast. An athlete could conceivably have a high proportion of slow-twitch fibres in their thigh muscles and a high proportion of fast-twitch fibres in their arms.

Fast-twitch fibres are better suited to anaerobic conditions that require performers to call upon speed, power and explosive efforts. Once these fibres are recruited, they begin to produce metabolic by-products that cause fatigue, so they can only be used for a very short time. Slow-twitch fibres, as the name suggests, contract slowly and repeatedly and are best suited to aerobic conditions. They are slow to fatigue and are recruited for endurance activities, or where submaximal efforts occur repeatedly over a long period of time.

submaximal
less than maximal effort; usually below 75 per cent maximum heart rate

Researchers have recently found that slow-twitch fibres cannot become fast-twitch fibres, and fast-twitch fibres cannot become slow-twitch fibres. However, some fast-twitch fibres can take on slow-twitch fibre characteristics with aerobic or endurance training. Someone like former 1500-metre swimming champion Grant Hackett would find it difficult to compete against a sprint swimmer such as Michael Phelps, but Phelps could be trained to swim a competitive 1500-metre race. For this reason, fast-twitch fibres are further classified as:

- fast-twitch B, which are purely anaerobic
- fast-twitch A, which are partially aerobic.

Table 7.1 Characteristics of fast-twitch and slow-twitch fibres

Characteristic	Fast-twitch	Fast-twitch	Slow-twitch
	Type IIB	Type IIA	Type I
Performance conditions	purely anaerobic	partially aerobic	aerobic
Colour	white	white/red	red
Oxidative enzymes	low	medium	high
Myoglobin content	low	medium	high
Glycolytic capacity	high	high	low
Mitochondria density	low	medium	high
Capillary density	low	medium	high
Calcium capacity	high	medium/low	low
Myosin ATPase	high	high	low
Phosphocreatine stores	high	medium/low	low
Triglyceride stores	low	medium/low	high
Fibre diameter	large	intermediate	small
Contraction speed	high	moderate	slow
Force capacity	high	intermediate	low
Fatigue resistance	low	medium/low	high

Examining Table 7.1 will make it easier to understand the fibre make-up of various performers. Basically, they have the fibres that are best suited to the activities they perform. Let's look at athletes who have a high proportion of slow-twitch fibres: triathletes, marathon runners, long-distance cyclists and rowers. These athletes repeat the same muscle activity again and again over long periods of time.

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The characteristics of slow-twitch fibres that benefit these performers are:

- high capillary density: this means large supplies of blood, and large transfer of oxygen to working muscles
- high mitochondrial density and oxidative enzymes: this leads to large release of energy under aerobic conditions
- high triglyceride stores: triglyceride is the preferred fuel under submaximal aerobic conditions.

Fast-twitch fibres are found in athletes who require speed and explosive power. The characteristics of fast-twitch fibres that benefit these performers are:

- high phosphocreatine stores: the quickest source of energy and adenosine triphosphate (ATP) under anaerobic conditions
- high glycogen stores: the preferred fuel during near maximal efforts calling upon the lactic acid system
- high glycolytic enzymes: these speed up glycogen breakdown during high-intensity efforts lasting beyond ten seconds.

triglyceride
the preferred state of fatty acids in order to enable storage

Fibre-recruitment theory

Slow-twitch fibres are recruited before the fast-twitch motor units in most activities, and as muscular forces increase, so does the pattern of recruitment of fibres. For example, a swim in the slow lane at the local pool will use slow-twitch fibres, while an all-out 100-metre swim will recruit the fast-twitch A fibres. Depending on how hard the swim is done, i.e. how much force is exerted, the fast-twitch B fibres may also contribute to performance.

Checkpoints

1 Clearly indicate what happens to each band or zone in Table 7.2 during eccentric and concentric muscular contractions by using the words **increase**, **decrease** or **no change**. Use Figures 7.8 (page 121) and 7.15 (page 126) to help.

Table 7.2

	I-band (increase, decrease, no change)	A-band (increase, decrease, no change)	H-zone (increase, decrease, no change)
Type of contraction			
Eccentric			
Concentric			

2 Briefly explain why isokinetic contractions are responsible for the greatest gains in muscular strength and power, compared to isometric and isotonic contractions.

3 What is the main difference between fast-twitch A and fast-twitch B fibres?

4 Copy and complete the following fibre characteristic table by inserting the words **high** or **low**.

Table 7.3 Fibre characteristics

Characteristic	Slow-twitch	Fast-twitch
Oxidative enzymes		
Myoglobin content		
Force produced		
Fatigability		

Mitochondria density		
Glycogen stores and glycolytic enzymes		
Phosphocreatine stores		
Motor-neuron size		
Triglyceride stores		

Factors affecting muscle strength

You have already discovered that various factors affect the amount of muscular strength performers are able to generate. Following is a summary of those factors.

- Fibre arrangement: multipennate muscles are stronger than bipennate and unipennate muscles, with fusiform muscles being capable of developing the least strength when all types are compared.
- Muscle-fibre recruitment: when maximal force is required, the fibres in all motor units must be recruited; only a couple of the fibres are required when an easy task is required; for example, throwing a dart.
- Muscle-fibre type: fast-twitch fibres are able to generate greater strength than slow-twitch fibres due to their characteristics. Fast-twitch B fibres are 'stronger' than fast-twitch A fibres, although fast-twitch A fibres have some aerobic qualities that can be developed through aerobic training.
- Speed of contraction: multipennate muscles tend to have the smallest range of movement and contraction speed, but are able to develop the greatest strength. As the speed of contraction increases, the amount of force a muscle can generate proportionately decreases.

There are a few other factors that affect muscle strength, including gender and age.

- Gender differences: female and male muscles are equally strong if they have the same cross-sectional area. However, because females have smaller cross-sectional areas than males, female muscles tend to be about 60 per cent the strength of male muscles.
- Age differences: muscles tend to be at their strongest between the ages of 20–30 and then progressively deteriorate by about one per cent per year after this. This occurs because the body synthesises less protein, which is required for building muscles, after the mid-20s. This natural deterioration can be arrested by performing regular weight-bearing or resistance exercises.

Coursework

Muscle cross-sectional area vs strength

Aim

The aim of this laboratory activity is to see if any relationship exists between the cross-sectional area of muscle and the force it is able to generate.

Procedure

1 Because we cannot 'slice' through the biceps to obtain its true cross-sectional area, we are going to measure its circumference with a flexible tape measure. Each subject will perform the same activity.

2 Measure and record the circumference of the fully flexed biceps for each subject.

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3 Ask each subject to perform a bicep curl with a dumbbell until they use a weight they cannot complete a bicep curl with.

4 Record their most successful maximal effort. Note: Try to choose a weight the subject believes to be close to their maximum, as subjects are being tested for strength not endurance. Subjects should only use their biceps, and avoid swinging or swaying the back to initiate the bicep curl. The subject should stand against a door frame to prevent swinging or swaying. Record your results on a table similar to the following.

Name of subject	Bicep circumference	Maximal weight curled
Paul Bram	26 cm	42 kg
Peter Trippa	24 cm	35 kg
Susan West	16 cm	20 kg
Mary Wilson	16 cm	25 kg

5 Plot your results on a graph to show the relationship between bicep circumference and weight curled (strength).

Questions

1 Does a relationship exist between cross-sectional area and strength generated by muscles? If so, what is it?

2 Are there any 'exceptions to the rule', i.e. are any results different from the general trend?
   a How do you account for these differences?
   b Comment on the result obtained by females compared to those obtained by male class members (if applicable).
   c If you could not obtain results from both males and females, which gender do you believe would obtain the greatest results given the same bicep circumferences? Why?

3 Comment on the speed of contraction required to obtain the greatest force or maximal contraction.

TEST YOUR KNOWLEDGE

>> multiple-choice questions

1 Fast twitch II B muscles:
- **a** can be converted into fast twitch II A fibres after 12 months of aerobic training
- **b** are best suited to high-intensity activities or actions
- **c** are found in high proportions in endurance athletes
- **d** none of the above.

2 During isometric contractions the H-zone:
- **a** increases slightly
- **b** decreases
- **c** remains unchanged
- **d** doubles in size.

>> short-answer questions

1 What characteristics of slow-twitch fibres enhance their ability to take up and utilise oxygen? Briefly discuss the role of each of these characteristics.

2 Provide a brief summary of the nervous control of muscular contraction

>> essay questions

1
- **a** Discuss the different nervous control and muscles involved in a golf putt over 10 metres compared to drive off the tee with a 1 wood that travels 200 metres. Your response should consider the number of motor units recruited, as well as the fibre types recruited and the signals sent by the brain to the muscles.
- **b** Discuss the difference between motor and sensory neurons in the above example, and how sensory neurons can be used to provide feedback to the golfer.

2 You have just been appointed the coach of the women's weightlifting team training for the Commonwealth Games.
- **a** Why you would include eccentric activities in the resistance program?
- **b** Why would it be relevant to include isometric contractions in some of the sessions?
- **c** Which fibre characteristics would you be attempting to develop in fast-twitch fibres to bring about improvements? Clearly outline how these improvements would boost weightlifting performances.
- **d** You are sometime confronted by situations where muscles 'spasm' and seem to be constantly contracting. Outline the neuromuscular conditions under which this happens.

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SECTION 4
BIOMECHANICS

Chapter 8 Advanced biomechanical principles

3A.11 Define and relate momentum to a selected sport, including conservation of momentum (Newton's 2nd law), the impulse-momentum relationship and the coefficient of restitution.

3A.12 Define and relate moment of inertia, angular momentum, levers, and the three classes of levers to a selected sport.

3B.7 Define and apply fluid mechanics in physical activity, including spin (the Magnus effect, top spin, back spin, side spin, no spin), Bernoulli's principle and the sporting application of drag reduction, e.g. swimsuit skins, cycling helmets.

Chapter 9 Analysing basic movements patterns

3A.13 Identify the relationship between torque and the use of levers in sport: torque = force x perpendicular distance of lever arm

3A.14 Apply biomechanical principles to analyse physical skills, including balance, coordination continuum, force-motion, force-time, inertia, optimal projection, range of motion, segmental interaction and spin.

.8

Advanced biomechanical principles

Momentum

momentum
the amount of motion possessed by a moving body

transfer of momentum
process where momentum is transferred from one part of a body to another

Momentum is the amount of motion possessed by a moving body. The units of measurement we use for momentum are kilograms (kg) and metres per second (m/s). The momentum of an object is directly related to its mass and its velocity. For example, if two objects:

- with different mass are moving at the same velocity, it will be harder to stop the object with the greater mass.
- with identical mass are moving at different velocities, it will be harder to stop the object with the greater velocity.

$$\textbf{Momentum} = \textbf{mass} \times \textbf{velocity}$$

$$P\,(\textbf{momentum}) = m\,(\textbf{kg}) \times v\,(\textbf{ms}^{-1})$$

We can experience transfer of momentum from one body part to another. In long jump, for example, the 'locking' or rapid slowing of the free leg when the thigh is parallel to the ground transfers momentum as additional force to the take-off leg.

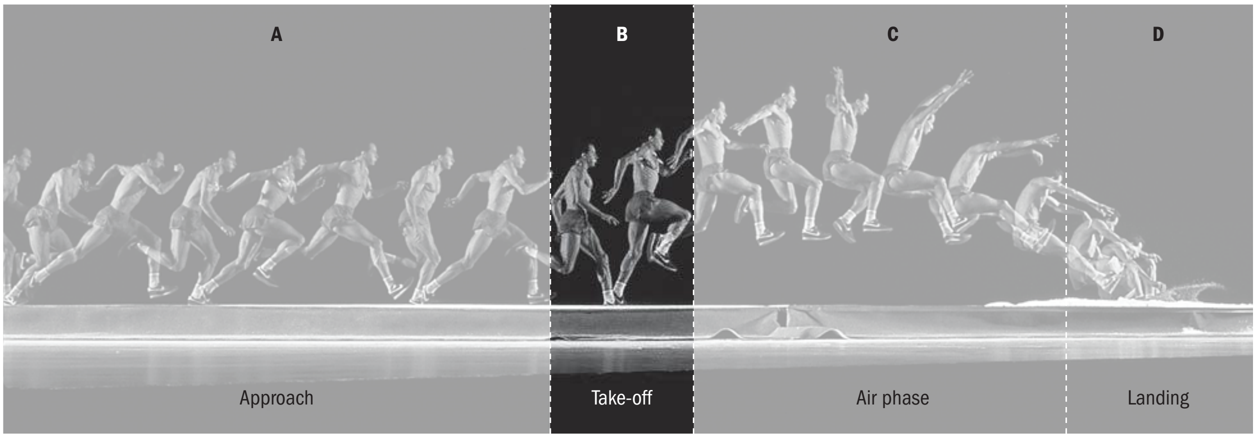

Figure 8.1 Momentum is transferred from the lead leg to the take-off leg during the last step in long jump

Angular momentum

angular momentum
a measure of the amount of angular motion possessed by a rotating body

Angular momentum (or rotational momentum) is a measure of the amount of angular motion possessed by a rotating body. Put simply, it is how hard it is to stop a rotating object. The greater the moment of inertia and velocity, the harder it is to stop an object's angular

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motion. Because angular momentum is the quantity of rotational motion a body has, it is calculated by multiplying the moment of inertia and rotational velocity. A rotating body's moment of inertia is proportional to its size.

Angular momentum = moment of inertia × rotational velocity

moment of inertia
a measure of how difficult it is to change an object's rotary motion; the tendency of an object to maintain its current state of angular motion

rotational velocity
the speed of rotation measured in radians per second and rate of angular change of an object about the axis of rotation

Moment of inertia

The greater the moment of inertia, the more difficult it is to change the rotation of an object. The moment of inertia of an object is proportional to its mass and the distance from the axis of rotation that the mass is located.

Rotational Inertia = mass × radius of rotation²

$$I = m \times r^2$$

This principle can be shown by the use of long and short boards in surfing. As their names suggest, short boards are short and light, and long boards are long and heavy. Even though long boards are much faster through the water, their weight and length make them difficult to turn because they have a high moment of inertia. The same principle can be demonstrated by picking up a short, light tennis racquet and rotating it from side to side. This is relatively easy; the racquet turns and is manoeuvred without much effort. However, turning a longer and heavier tennis racquet in the same way becomes much harder because the moment of inertia and mass have both increased which, in turn, slows down the turning motion.

Experimenting with inertia

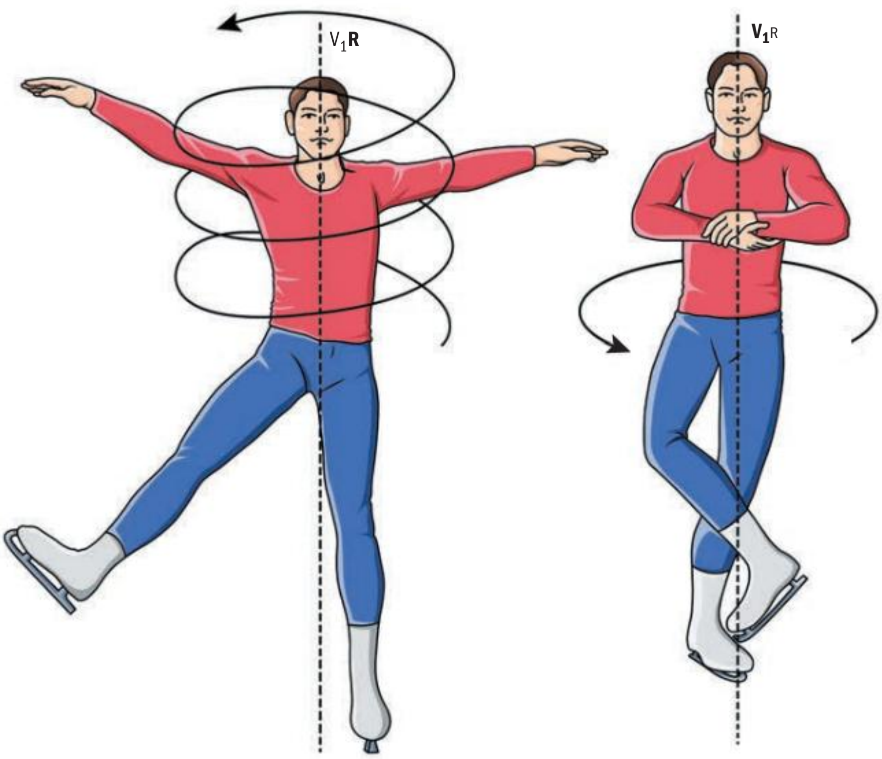
axis of rotation
an imaginary line that something revolves around

The moment of inertia principle has many implications for sport, particularly in the use of equipment. In junior sport, equipment for children has been modified to reduce the moment of inertia. For example, the bats used are often lighter (reducing the mass) and the racquets are shorter (reducing the distance from the axis of rotation).

Equipment has also been redesigned to take into consideration the principles of angular motion and moment of inertia. Oversized tennis racquets have their weight distributed away from the central axis, increasing the moment of inertia and helping to reduce off-centre impacts. Cricket bats now have an area scooped out of the back of the bat to allow the weight to be distributed to the sides of the bat. This increases the moment of inertia, meaning that off-centre impacts won't destabilise the bat and cause unwanted rotation.

The human body can also alter its position and distribution of mass about an axis of rotation, altering the moment of inertia. This can be seen when an ice skater starts in a pirouette with their arms extended, then brings their arms in towards their body. As the arms come closer to the axis of rotation, the moment of inertia decreases, allowing the body to speed up and rotate more quickly.

Figure 8.2 Bringing arms closer to the body decreases the moment of inertia and increases the speed of rotation



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Coursework

Using biomechanical principles

1 Sit on a swivel chair. Hold two dumbbells close to your body and have someone set you spinning. Extend your arms for a couple of rotations, then pull them in close to your body.

a When was your moment of inertia highest and lowest?

b How does moment of inertia affect the speed of the spin?

c Give three examples of how moment of inertia is important in sporting situations.

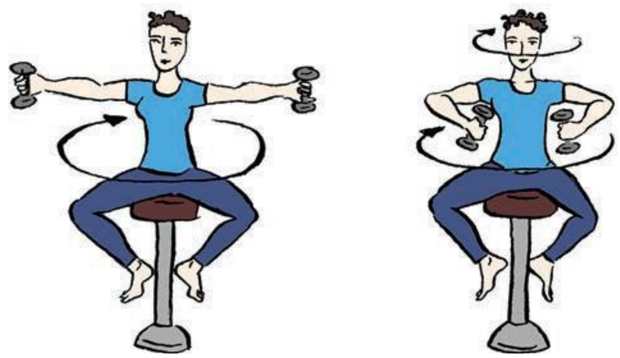

Figure 8.3 Experimenting with inertia

Conservation of angular momentum

The conservation of angular momentum describes how the total momentum of a body stays constant during a movement. Angular momentum will remain constant until an unbalanced torque acts on the object (which is Newton's first law of angular motion).

conservation of angular momentum a rotating body will continue to turn about its axis of rotation with constant angular momentum unless an external or eccentric force is applied to it

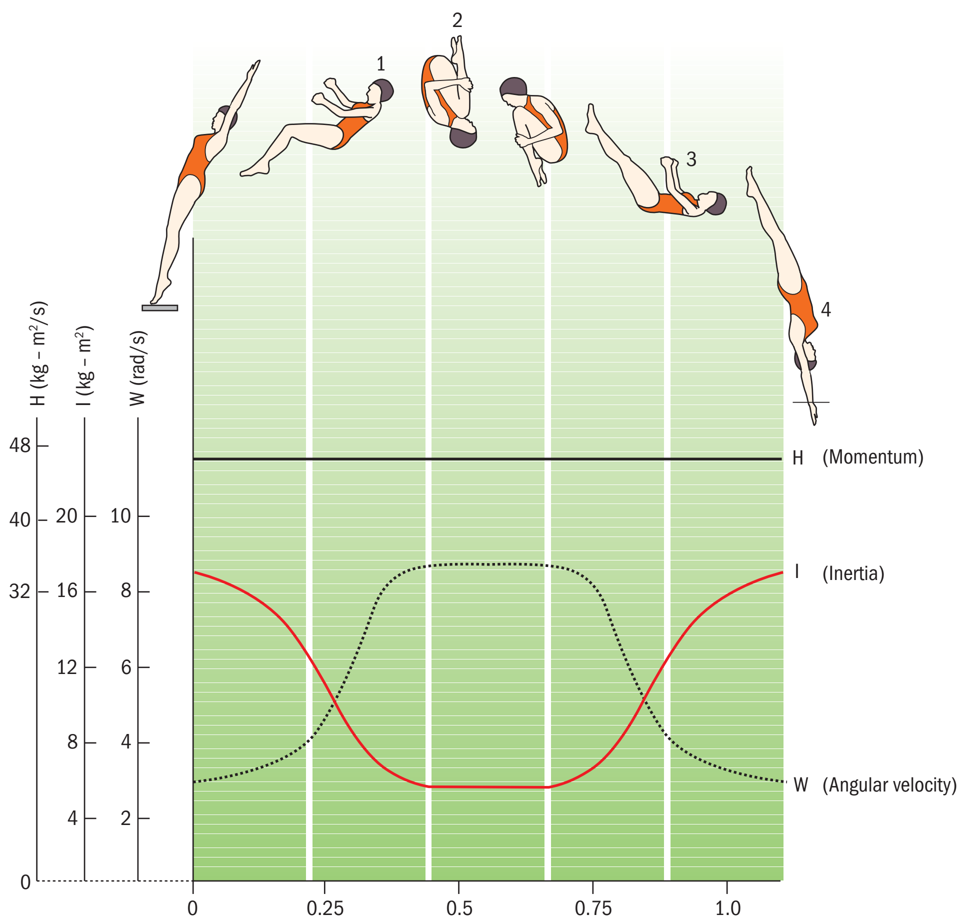

Figure 8.4 A diver showing conservation of angular momentum

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In sporting situations, athletes are able to alter their body shape to assist in conserving angular momentum. For example, divers are able to move from an open position into a tuck position, which decreases their moment of inertia and increases their angular velocity, therefore allowing angular momentum to be conserved. Once the diver takes off from the diving platform, their angular momentum cannot change, but they can change their inertia by coming out of the tuck position into a pike position, which will result in reduced rotation and angular velocity.

Coursework

Equipment: ropes or roman rings, beat board

Procedure: Perform the following activities on the rings or ropes and observe the relationships between the angular momentum, moment of inertia and angular velocity.

Trial 1: Perform a basic swing, then tuck your legs up to your chest and go into an inverted position. Redo, and attempt to go into the inverted position with straight legs.

Trial 2: Perform a backward roll dismount off the rings. Endeavour to release your hands earlier with each attempt.

Trial 3: Attempt a split-leg backward dismount.

Trial 4: Perform a star jump from the beat board. Vary the speed of your run-up.

Trial 5: Perform a tuck jump from the beat board. Vary the speed of your run-up.

Trial 6: On the floor, perform a number of forward rolls: squat, standing, dive and straddle.

1 In Trial 1, which position was easiest? Why?

2 In Trial 2, how did you generate enough rotation to perform the skill?

3 In Trial 3, why is this skill more difficult than Trial 2?

4 In Trial 4, what effect did varying the speed of your run-up have on performing the jump?

5 In Trial 5, what effect did varying the speed of your run-up have on performing the jump?

6 In Trial 6, how does the moment of inertia affect your ability to do forward rolls? Explain your answer using the different types of forward rolls you performed.

Checkpoints

1 Define the term ‘angular velocity’.

2 List three sports skills where increased angular velocity is beneficial to performance.

3 What is meant by ‘moment of inertia’?

4 Look at Figure 8.4.

a Explain what is happening to the diver’s angular velocity and moment of inertia in positions 1–4.

b What happens to the diver’s angular momentum after taking off from the springboard?

c In which position would a diver find it easiest to complete somersaults: tuck, layout or piked? Why?

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In sprinting events, if the arms are bent, their moment of inertia is less than if they were straight. A rotating body has a fixed momentum and any reduction in the moment of inertia will cause acceleration and increased rotational velocity. In sprinting, this principle affects arm action and leg recovery. The more the arms are bent at the elbow joint and legs bent at the knee joint, the quicker these limbs will be able to rotate at these joints and the greater their contribution to forward movement and momentum.

Any increase in the moment of inertia has the opposite effect of reducing rotational velocity. Increasing the moment of inertia to slow rotation is used in the different flight techniques of the long jump and in many gymnastic routines to slow forward rotation and prevent performers from over-rotating.

Figure 8.5 An ice skater extending arms and legs during landing to slow rotation and prevent over-rotating

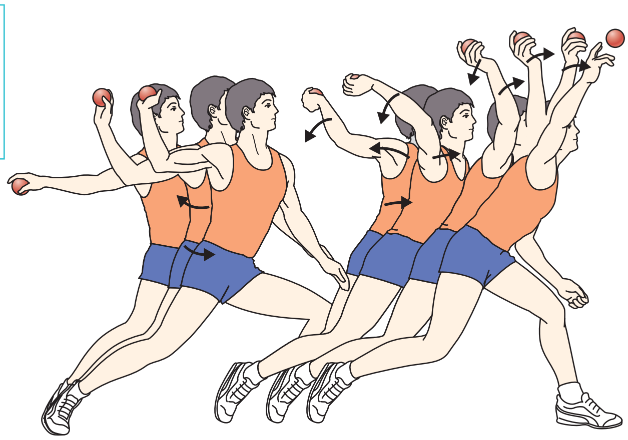

Figure 8.6 Transfer of momentum from the left to the right as hips rotate prior to release of the ball

There can also be a transfer of angular momentum from one body part to another. This is applied in the throws when, for a right-handed thrower, 'locking' and slowing the left side of the body immediately before delivery transfers angular momentum to accelerate the right side (the throwing side).

We know that angular motion is created by applying an unbalanced force that does not pass directly through the axis of rotation of the object. Because the force applied is off-centre, it produces a torque (or turning effect) that changes the rotation of the object. This is how tennis players are able to place spin on the ball, and how soccer players 'bend' a ball into goal around the goalkeeper. As with linear motion, Newton's laws apply equally to angular motion; however, you will notice the term *force* is replaced with *torque*, as we are primarily discussing the rotation of objects.

torque
any action that causes an object to change its rotary motion

Newton's laws of angular motion

First law: A rotating body will continue to turn about its axis of rotation with constant angular momentum unless an external couple or eccentric force is exerted on it.
Second law: The angular acceleration of a body is proportional to the torque causing it and takes place in the direction in which the torque acts.
Third law: For every torque that is exerted by one body or another, there is an equal and opposite torque exerted by the second body on the first.

Torque

Torque is the turning effect created as a result of force being applied to an object outside its axis of rotation. For example, in the Paralympics, a wheelchair sprinter gets the chair in motion by applying torque to the wheel with their hands, causing the wheels to spin around

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the axle. As Newton's second law of motion states, acceleration is proportional to the torque that causes it. Therefore, the larger the torque, the greater the change in rotation of the wheels, and the greater the acceleration.

Torque = Force × *Distance

* (shortest distance measuring line of action from rotational axis)
* (perpendicular distance of lever arm)

$$T = F \times d$$

The size of a torque depends not only on the size of the force being applied, but also on the distance from the axis of rotation to the line of the force. In the wheelchair example, the further the force (produced by the hands on the wheel) from the axis of rotation (the axle), the easier it will be to move the chair.

KEEP IT REAL!

Because basketball and tennis wheelchair athletes need to be able to move around the court quickly, they only have a large outer rim on the wheel of their chair. Although they won't reach really high speeds with this set-up, it means they require less torque to get the chair moving, allowing them to make sudden changes in direction.

On the other hand, wheelchair sprinters like Louise Sauvage have a small push rim located much closer to the axle of the wheel. Although it is harder to get the chair moving off the start line, Sauvage is able to achieve high speed throughout the race. The initial inertia that she must overcome to get her chair mobile requires large amounts of force, hence her muscular upper body.

Coursework

Simple examples of torque

1 Try pushing a door closed via its handle.

2 Try again, this time pushing the door as close to the hinged side as you can. Which action required the greater torque? Explain your answer.

Angular motion responds to torque in exactly the same way that linear motion responds to force. Newton's third law of angular motion explains that for every torque exerted by one body, there is an equal and opposite torque exerted by a second body. One of the most common examples of this is an athlete applying a torque to one part of their body by contracting a muscle or a group of muscles that cause the part to rotate. For example, when a gymnast on the beam starts to overbalance, she uses her arms and upper body to correct the overbalance.

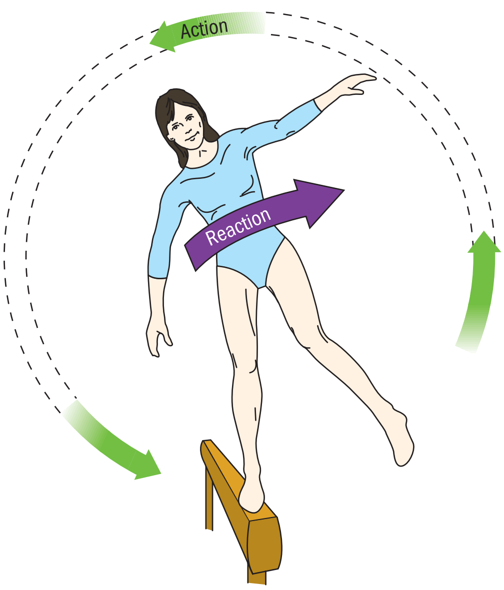

Figure 8.7 A gymnast creates an angular reaction to restore her balance

Eccentric forces

A force that does not act in a line that passes through the centre of mass of an object will cause that object to rotate *and* move in a straight line. This type of force causes a torque to act on the object, and is known as an eccentric force. For example, a diver bouncing on the end of a three-metre board before take-off jumps straight up and down because force is applied through the centre of gravity. This is called translation. However, if the diver moves their body slightly forwards at take-off, the centre of gravity moves outside the line of force and causes the diver to rotate forwards.

eccentric force
a force that acts outside an object's centre of gravity, causing it to rotate as well as move in a straight line

translation
when every particle within a body has the same motion

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The same principle can be tested by pushing a gym mat along a wooden floor. If you push the mat through its centre, it slides (or translates) along the floor, but if you push it nearer to one end it translates and also rotates.

We see eccentric force used a lot in sports where spin is applied on a ball; for example, performing a tennis slice, kick serve or volleyball topspin serve.

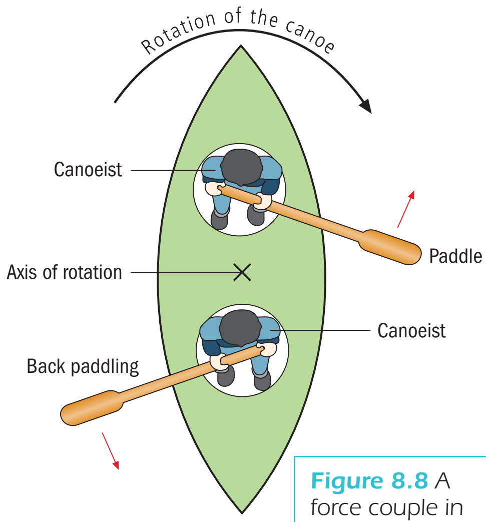

Figure 8.8 A force couple in canoeing

Force couples

force couple
two or more forces act on a body to cancel any linear motion

When two or more forces act on an object eccentrically, the object's linear motion is effectively cancelled and only changes in spin take place. This is known as a force couple. For example, in order to rotate a canoe fully, each canoeist must apply an eccentric force by paddling; one canoeist must be paddling forwards and one paddling backwards, applying the same amount of force. They do not move in a straight line but spin the canoe around its axis.

Checkpoints

1 Motion is generally classified as being linear, angular or general. Classify the type of motion in the following activities.

- **a** A child sliding down a water slide
- **b** An athlete sprinting 100 metres
- **c** An Olympic diver during a one-and-half forward somersault
- **d** A road cyclist during a 40-kilometre individual time trial over a straight course
- **e** The legs of the cyclist mentioned in (d)
- **f** The hands of the cyclist mentioned in (d)
- **g** An ice skater gliding in a straight line
- **h** A swimmer during a 100-metre butterfly event
- **i** A car travelling along a street at 60 km/h

2 What is the 'axis of rotation'? Provide two examples of an internal and external axis of rotation in a sporting situation or physical activity.

3 Define the terms 'angular velocity' and 'torque'.

4 What is an eccentric force? How is it different from a force couple?

5 What are Newton's three laws of angular motion? Give a sporting example of each law.

Levers

lever
a machine that transmits energy from one place to another through a rigid structure rotating around a fixed point

To understand how torque applies to sporting situations, you need to consider levers. A lever is a simple machine that transmits and changes mechanical energy from one place to another. There are many different kinds of levers used in everyday life; for example, pliers, hammers and crowbars. However, biomechanics primarily deals with levers within the human body, and with extended levers that we use in sport, such as bats, clubs, sticks or racquets.

In the human body, our muscles, bones and joints work together as levers (see Figure 8.9). Bones act as levers, providing a rigid structure that moves around a joint. Being a fixed point, the joint provides an axis for movement. The muscles complete the leverage

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system by providing the force necessary to move the resistance attached to the lever. The weight of a person's limbs (and anything else they are trying to move, such as a ball) produces the resistance to be moved.

All levers consist of three parts:

- The axis or pivot point (sometimes known as the fulcrum)
- The resistance or load that is to be moved
- The force or action that causes the load to move

The position of each of these parts enables us to classify levers into three distinct classes: first class, second class and third class.

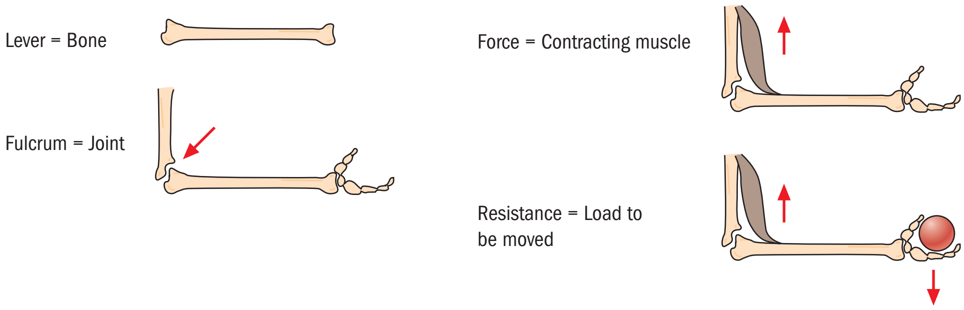


Figure 8.9 Our muscles, bones and joints work together as levers

Classes of levers

There are three classes of levers:

- First-class lever: the axis is between the resistance to be moved and the force used to move it; for example, a seesaw.
- Second-class lever: the axis is at the end of the lever and the resistance is between it and the force; for example, a wheelbarrow.
- Third-class lever: the axis is at the end of the lever and the force is applied between it and the resistance; for example, carrying a load on a shovel.

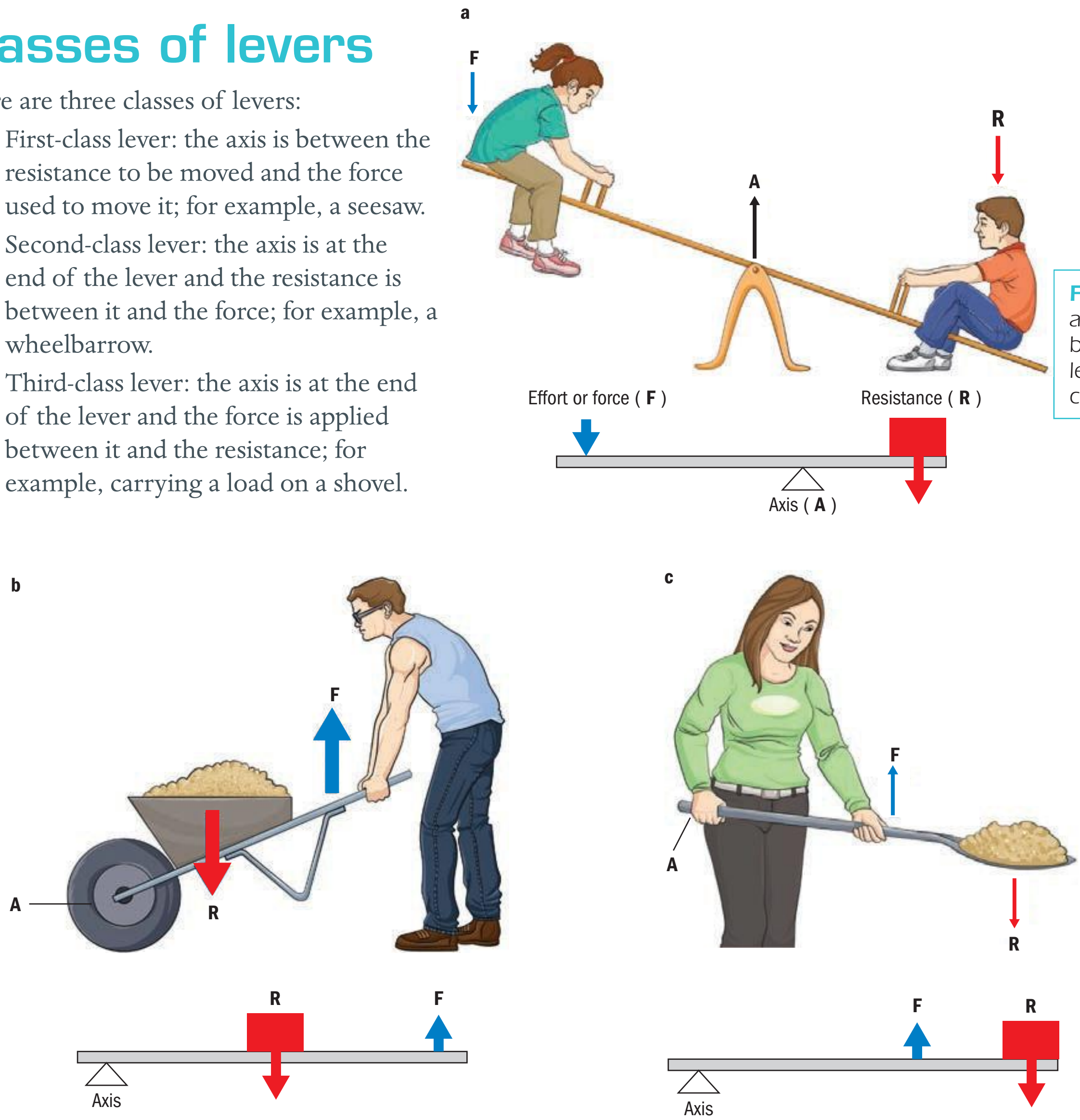


Figure 8.10 a) a first-class lever b) a second-class lever c) a third-class lever

Use of levers

force arm (FA) the distance from the force to the axis of a lever

resistance arm (RA) the distance from the load to the axis of a lever

Levers are used extensively in sport, sometimes through muscles pulling on bones when, for example, you perform a bicep curl, and sometimes through the use of external levers, such as oars when rowing. When describing the use of levers, it is important to know the following definitions:

- The force arm (FA) of a lever is the distance from the force to the axis. In the human body, this is the distance from the muscle attachment to the joint.
- The resistance arm (RA) is the distance from the load to the axis.

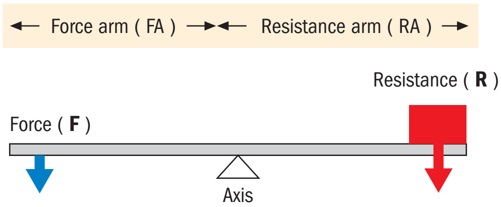


Figure 8.11 The force arm and the resistance arm on a lever

A longer force arm means it requires less effort to move a resistance, and a longer resistance arm maximises the speed and range of motion of a lever. This helps to explain why most levers of the human body are third-class levers.

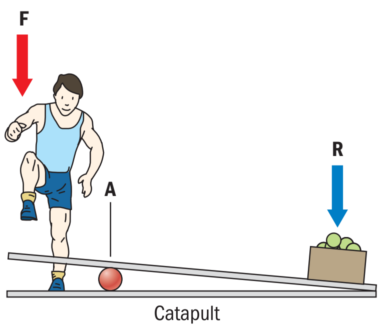
The length of the force arm and resistance arm also have implications for the external levers we use in sport. Implements such as tennis racquets, squash racquets, golf clubs and softball bats act as extended levers. A softball bat has a longer resistance arm than force arm and therefore requires a greater effort to swing it. Although it requires a greater effort, the increased length of the resistance arm means that the far end of the bat moves through a greater range, which increases its velocity. This is important for maximising the distance the ball will travel after being struck.

Velocity is greater at the end of a long lever than at the end of a short lever. This means that a tall tennis player who fully extends during the service action is able to produce greater velocity than a shorter player who can't reach as high. The greater the velocity at point of impact, the greater the momentum imparted to the tennis ball.

Checkpoints

Complete the following to test your understanding of the classes of levers.

1 Label the six illustrations a–f in Figure 8.12 as either first-, second- or third-class levers.



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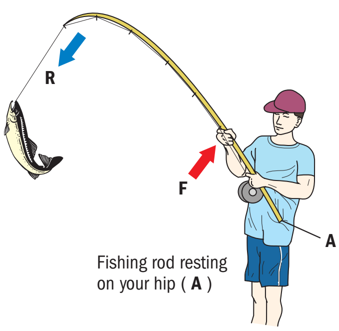

b

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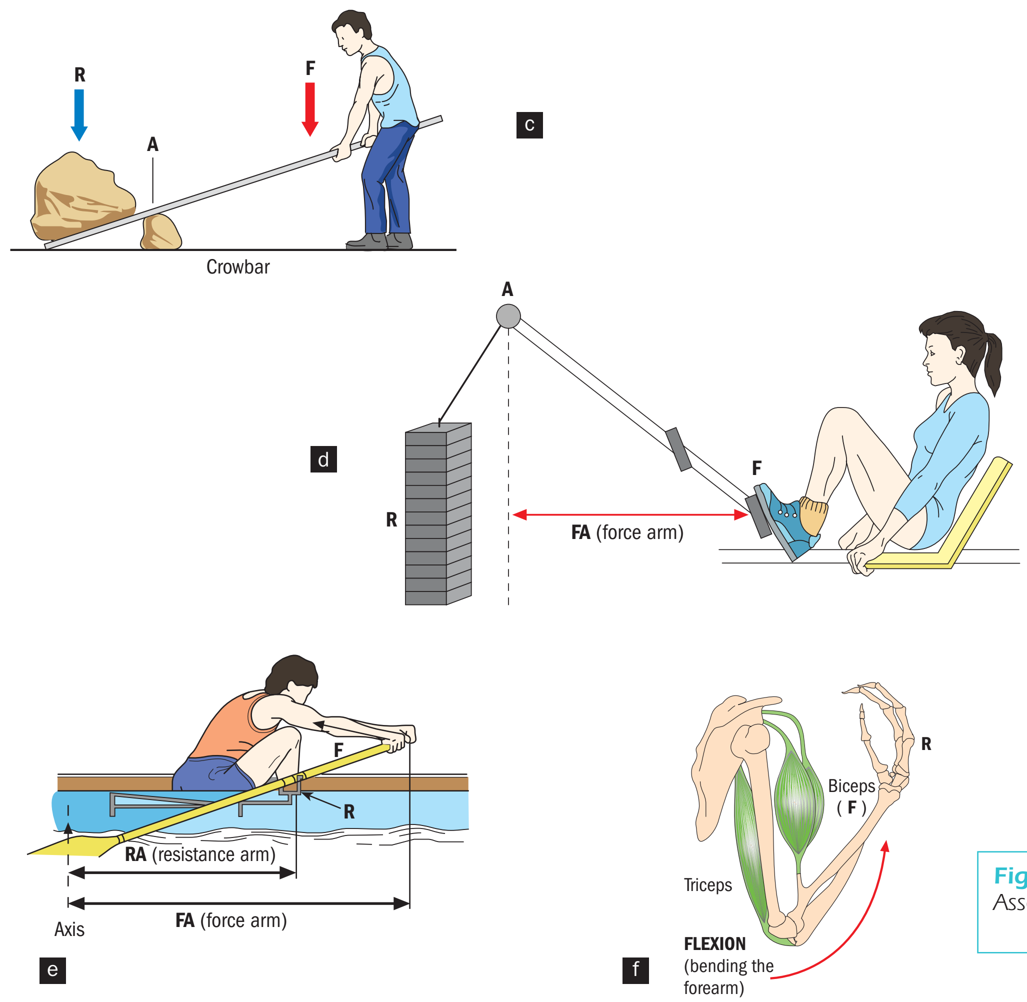

Figure 8.12
Assorted levers

2 Based on your knowledge of the use of levers, why do you think most levers in the human body are third-class?

3 Describe three sporting situations where having a long resistance arm is beneficial in optimising performance.

Factors that affect the use of external levers

There are three factors that affect the use of external levers:

- The length of the lever
- The inertia of the lever
- The amount of force that can be applied

The length of the lever

The maximum linear speed of any part of a moving lever occurs at the point furthest from the axis. For example, golfers have found that increasing the length of their driver by just a few centimetres results in longer drives because the ball is hit by the club head with greater speed.

The inertia of the lever

The ease with which a lever can be rotated; for example, how easy it is to swing a bat depends on the mass of the lever and its length. Heavier levers and longer levers are more difficult to rotate.

Modified sports often reduce the length and mass of sporting implements to make it easier for children to use the equipment. Placing the hands at various positions on the lever can also alter its inertia. Athletes with disabilities must take external lever length into consideration as an extension of their own bodies.

The amount of force

Muscles surrounding joints apply force to levers (bones) within the body. The amount of force that can be applied by a muscle varies, depending on the strength of the muscle and the angle of the joint. Although using a longer, heavier external lever allows an athlete to project an object further, it requires greater muscular strength to handle the implement effectively. This is a trade-off that needs to be carefully considered.

The amount of force an athlete is able to generate via their muscles determines the implement (or lever) length they are able to use. As you can imagine, it would be pointless handing a full-size tennis racquet to a ten-year-old beginner, which is why junior sporting equipment is often modified to reduce the lever length.

KEEP IT REAL!

Australian Don Elgin is a Paralympian who was born without the lower part of his left leg. He competes in the pentathlon, and is currently ranked second in the world. The pentathlon is made up of five events, which are varied for disabled athletes depending on the disability. Elgin competes at 100 metres and 400 metres, and in long jump, discus and shotput.

Elgin has four different prosthetic legs that he uses in the five events. For the 100-metre sprint and the long jump he uses a compressed carbon fibre leg and foot which has the sole of his running shoe attached to the bottom. The leg for the 400 metres is similar, but is made of a softer, springier carbon fibre that stores more energy and is more suitable for the longer distance.

His discus leg is more solid and slightly longer than his normal walking leg. It compresses and works well with the spinning motion of the discus throw. The shot-put leg is solid and slightly shorter than normal to assist with the forward motion needed to put a shot.

Elgin has his legs specially made for him and he is always trying new designs. He tried a discus leg with a swivel joint, but it spun so well that he couldn't stop the spin to throw the discus.

Figure 8.13 Don Elgin has many different prosthetic legs

Coursework

A biomechanical investigation of levers

Perform these activities. Comment on your results and how they relate to the principles of leverage.

1 Use a rounders bat to hit a tennis ball as far as you can. Repeat three times. Repeat again, using a cricket bat. Average the distances hit and explain why one implement makes the ball go further than the other.

2 **a** Hit a softball off a batting tee. First try with a grip at the end of the handle, then with a grip further along the bat. Explain the differences you note with each grip.

b Given your knowledge of biomechanics, what grip would you recommend for a beginner softball player? Why?

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3 List four different sports where having longer limbs (or levers) would be an advantage. In your answer indicate how the longer limb or lever length gives the performer an advantage.

4 People who possess certain body builds are often targeted by talent-identification programs and then extensively coached to improve specific skills. Some people believe that unless you have the right body build, it is difficult to succeed in certain sports. Discuss, with reference to the biomechanical advantage short or long levers might provide.

Impulse

The amount of change in the momentum of an object is related to the size of the unbalanced force and the amount of time it acts for. Another name for this change in momentum is impulse. The larger the impulse applied, the greater the change in momentum. The two things that affect impulse are:

- the magnitude of the unbalanced force. If the length of time is constant, then impulse can only be increased by increasing the size (or greatness) of the force applied. For example, in rowing the oar can only physically be in the water for a certain length of time each stroke, so the rower needs to use greater force with their legs and upper body to increase impulse.
- the length of time the force is applied. If the force applied is constant, the impulse can only be intensified by increasing the length of time the force is applied. For example, a discus throw using the spinning action of the body prior to release increases the time over which the force is applied, thus imparting greater impulse to the discus. This provides a greater change in momentum and greater speed of release.

impulse
application of force over a period of time, which changes the velocity of a body or object

$$\textbf{Impulse} = \textbf{Force} \times \textbf{time}$$

$$I = \textbf{Newtons} \times \textbf{seconds}$$

Conservation of momentum

The conservation of momentum principle applies to any collision between two objects; for example, a foot contacting the ground while running, a stick hitting a ball or two balls colliding. When a collision occurs, the total momentum of two bodies before impact is equal to the total momentum after impact. This is best explained by Newton's third law of motion: *For every action there is an equal and opposite reaction.*

For example, when swinging at a ball in baseball, the baseball bat hits the ball and continues through after impact, as part of the follow through. The momentum of the bat is passed on to the baseball. Newton's third law explains this: when the bat applies a force to the baseball during the impact, the baseball applies the same amount of force in an opposite direction to the bat ('an equal and opposite reaction').

Conservation of momentum is important in impact sports. In contact sports such as Australian Rules football, it is not uncommon to see a lighter player seriously affect a heavier player in a contact. This is because lighter players such as rovers are often faster and therefore able to gather more momentum, giving them an advantage at points of contact or impact.

The conservation of momentum principle also has implications for equipment choice. For example, using a heavier

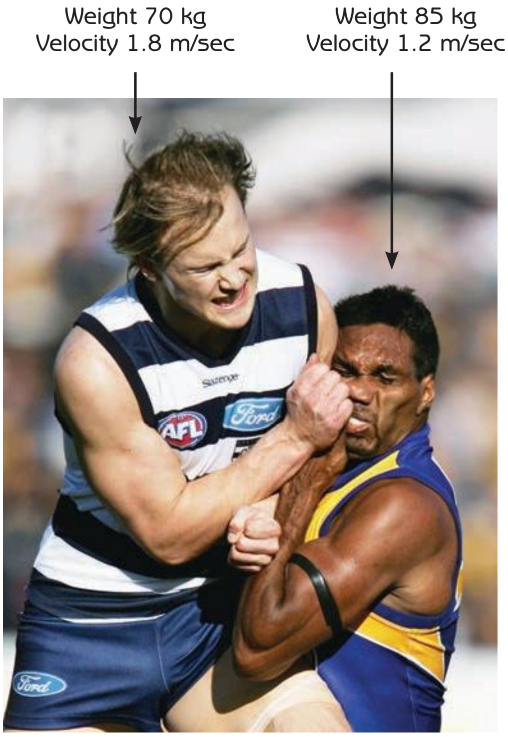

Figure 8.14 The player with the most momentum (left) is the least affected in a collision

ball in ten-pin bowling gives the bowler a better chance of success because it has more momentum at impact, although if it is too heavy it becomes more difficult to control and bowl accurately. This is particularly important in bowling, because energy is being transferred and lost through all ten pins for a strike to take place, therefore momentum at impact must be very high.

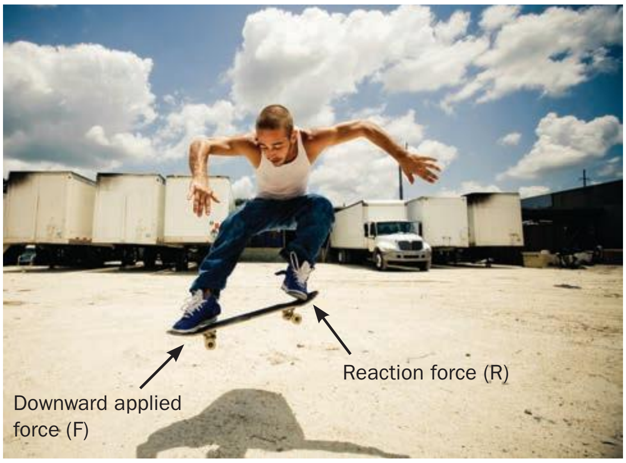

Figure 8.15 Ground reaction forces give the skateboard lift

Newton's third law of motion is not quite as obvious in some sports as it is in ten-pin bowling. For example, in skateboarding the skater accelerates upwards into a jump by exerting more force on the tail of the board than the front. This causes the board to pivot around the rear wheel, forcing the tail to hit the ground. When the tail of the board hits, the ground exerts an equal force back onto the tail, resulting in the board rising up into the air.

Elasticity: the coefficient of restitution

elasticity the ability of surfaces to 'give', then return to their original shape

coefficient of restitution measure of how much movement energy remains after a collision between two objects

The size of the forces acting during an impact depends on the speed of each object before collision and the elasticity of the objects involved in the collision. Surfaces that rebound to their original position quickly result in less energy being lost in the collision. For perfectly elastic collisions, the coefficient of restitution equals one, and for totally inelastic collisions, this equals zero. Strangely enough, the coefficient of restitution that measures elasticity doesn't have specified units of measurement.

For example, a tennis ball will bounce higher from a Rebound Ace surface than it will from an en tout cas tennis court because the Rebound Ace surface is more elastic. A new tennis ball has greater elasticity than an older one, and will therefore bounce higher and return to its original shape more quickly. This situation is advantageous for a tennis player, because they are able to generate more velocity when the racquet collides with a new ball. This is why players call for 'new balls' at regular intervals during tennis matches.

The strings of tennis, squash and badminton racquets play an important role in changing the velocity of the ball during impact in each game. The elasticity and tension of the strings affect how quickly the ball will rebound off them. Elasticity in this case refers to the ability of the strings to 'give' and return to their original shape, while string tension is

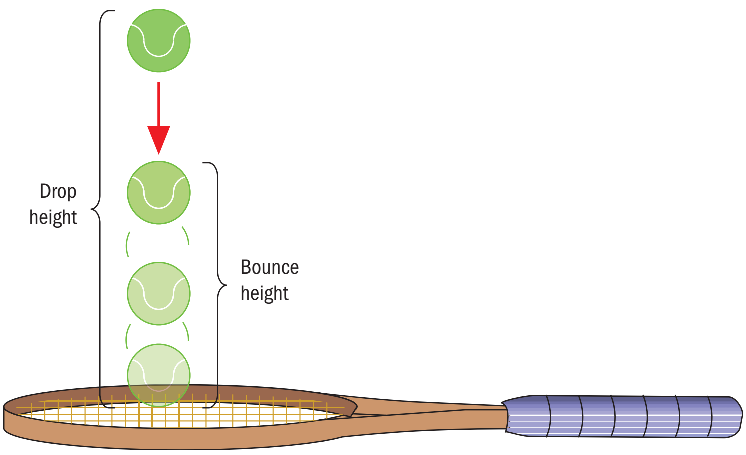

Figure 8.16 The coefficient of restitution can be computed from the drop height:rebound height ratio

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how tightly the racquet has been strung. There is a specific string tension for each racquet that produces the best elasticity, and this varies for each player. Some players like to have tightly strung racquets for more control and better spin, while others have their racquets strung at lower tension, allowing them to hit the ball with greater power. This is because of the effect elasticity has on impulse.

Coursework

Investigating ball elasticity

Equipment: superball, squash ball, tennis ball, golf ball, medicine ball (refrigerate some of the balls for a few hours), bucket of hot water, some balls not fully pumped up, tape measure

Procedure

1. Attach the tape measure to the wall.
2. Drop each ball from a height of one metre.
3. Record the height each ball rebounds.
4. Vary the temperature of the balls (e.g. heated or refrigerated) and the surfaces you drop them onto. You could try a basketball court, tennis court, football oval, etc.

Questions

1. Discuss the different elastic qualities of the balls you tested. What does 'elasticity' mean?
2. How does elasticity of the ball and the surface it contacts affect its rebound?
3. Discuss why the elasticity of the ball and the surface it is used on may be important to sport. Give practical sporting examples.
4. Explain two ways in which a tennis player can generate more velocity through using principles of elasticity. Discuss elasticity and absorption of force when a tennis player executes a drop volley.

Checkpoints

1. Explain Newton's second and third laws of motion in your own words. Give an example of how they can be applied, using a sport of your choice.
2. If the force applied to two objects is the same, which will have the greater acceleration: the larger mass or the smaller mass?
3. Explain how the principle of conservation of momentum can be applied to sprint running.
4. What does 'elasticity' mean? Explain two ways that a tennis player can generate more velocity through elasticity.

Fluid mechanics: the effects of water and air

Air resistance and spin

Increased air resistance, such as throwing or kicking into the wind, decreases the time in the air and the distance a ball will travel once it has been kicked or thrown. Similarly, decreasing air resistance by throwing or kicking with a tailwind increases the distance a

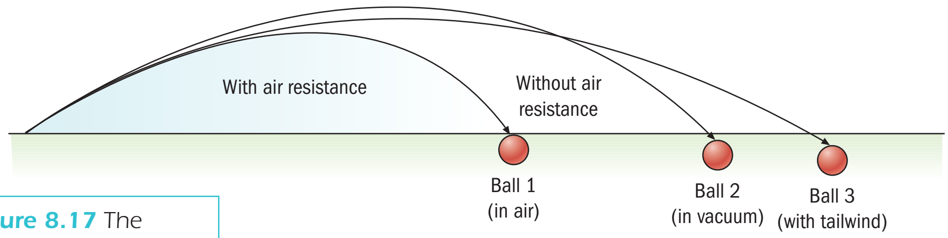

Figure 8.17 The influence of air resistance on ball flight

ball will travel. You will often hear commentators stating that a particular end of a football ground has a certain goal advantage due to wind strength and direction. The greater the surface area of the object being projected and the more speed it has, the greater the effect of air resistance.

The Magnus effect is a lift force that affects the flight path of a ball that has been thrown, hit or kicked. This is often used by tennis players, table-tennis players, golfers and soccer players. A spinning ball passing through the air causes a disturbance to the air flowing around the ball. It is more difficult for air to pass by the side of a ball that is spinning in the same direction as the ball is travelling. This causes high pressure on one side of the ball. The high pressure exerts a force on the ball, causing a deviation in the flight path in that direction.

Many sportspeople use the Magnus effect to curve the flight path of a ball to their advantage, to either give them greater control over the ball involved or to confound their opponents who are expecting a regular flight path. When the ball has backspin, sidespin or topspin, the Magnus effect changes the flight path of the ball from what it would have been without spin (see Figures 8.19 – 8.21).

There are three types of spin that affect the trajectory of the flight path:

- Top spin
- Backspin
- Side spin

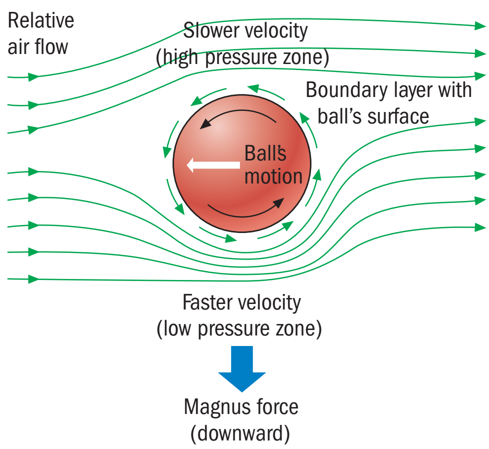

Figure 8.18 The influence of the Magnus effect on a spinning ball. The high-pressure zone will push the ball down and make it drop at a faster rate

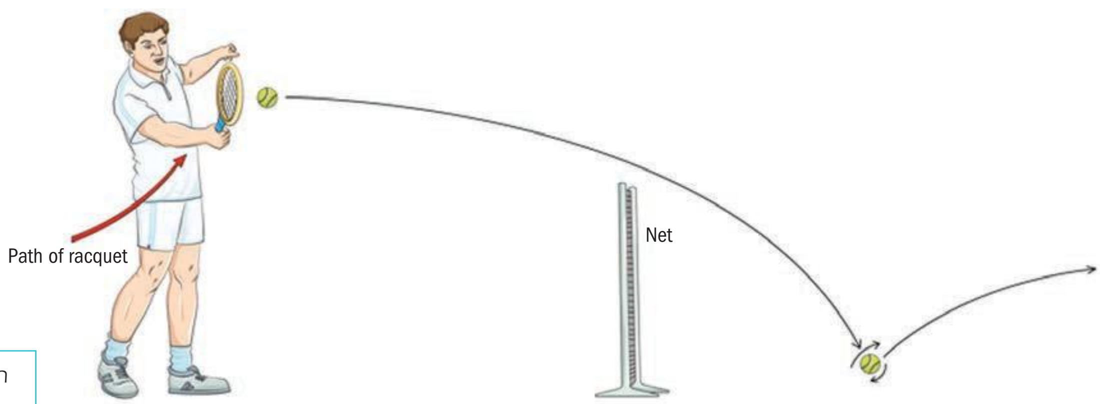

Figure 8.19 Top spin causes the ball to dip sharply in flight

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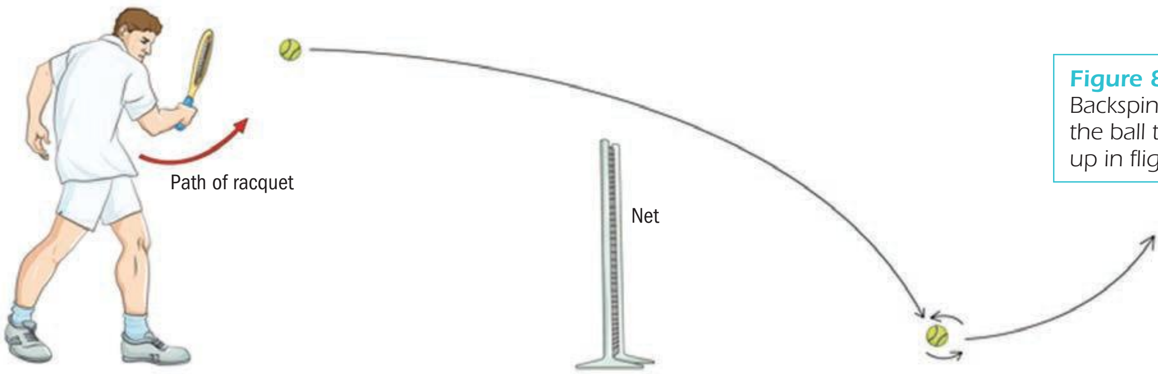

Figure 8.20
Backspin causes the ball to hold up in flight

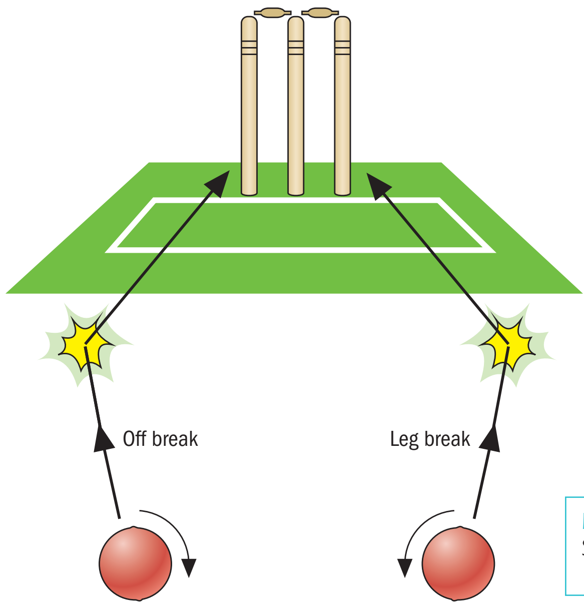

Figure 8.21
Side spin

The Magnus effect in baseball and cricket

KEEP IT REAL!

Baseball

Baseball pitchers like to vary the speed and spin of the ball in an effort to keep the batter guessing. A fastball travels through the air with backspin. This creates a high-pressure zone in the air ahead of the baseball. Also, the raised seams on the baseball help it churn the air and create high-pressure zones.

A curveball has opposite spin, which moves in the opposite direction to a fastball; it has topspin causing it to 'break', or drop down as it approaches home plate. When throwing a curve, the pitcher creates downspin by rolling their palm and fingers over the top of the ball while releasing it. A curveball, thrown with topspin, creates a high-pressure zone on top of the ball, deflecting the ball downward in flight. Combined with gravity, this gives the ball an exaggerated drop in flight that is difficult for the hitter to track.

Cricket

Swing bowling in cricket occurs when the ball moves in flight as a result of three different physical factors, including:

- the speed of release
- the 'roughness' of the ball's surface created by constant surface rubbing by players, the application of sweat or saliva by the bowler, and the effects of play as the ball gets used more
- the bowler's use of the seam.

When the ball leaves the bowler's hand, the surface of the ball is exposed to two different types of airflow:

- The regular even fl w moving over the smoother, polished part of the ball surface
- The turbulent fl w moving over the roughened side of the ball

These different air flows cause a net increase of forces favouring the turbulent side of the ball, which causes it to move in the air in that direction.

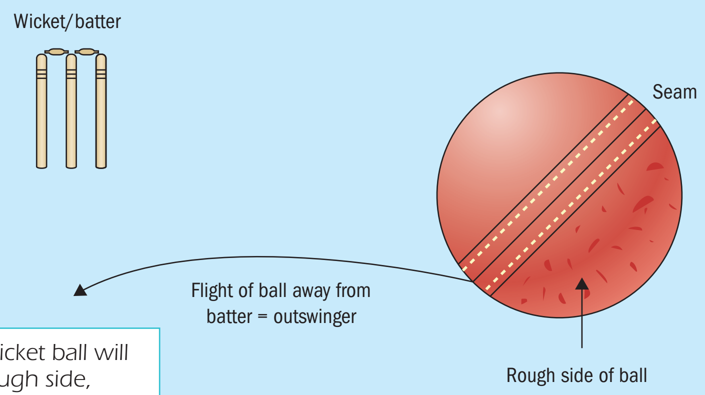

Figure 8.22 The cricket ball will move towards its rough side, which has increased air pressure and decreased velocity

Summary of air resistance and spin

- Aim the rough side towards the batter's off-side to produce swing away from the batsmen (an outswinger)
- Position seam away from the batter
- Side-on action with the arm coming across the body when following through
- Ball will swing in the direction of the wind

Buoyancy

Around 250 BCE, Archimedes discovered that 'any object, wholly or partly immersed in a fluid, is buoyed up by a force equal to the weight of the fluid displaced by the object'. Hence the concept of buoyancy was born.

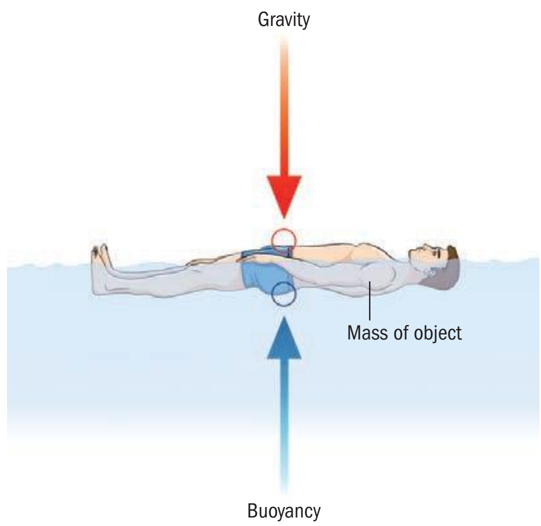

Figure 8.23 Flotation occurs when the centre of gravity remains above the centre of buoyancy

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As shown in Figure 8.23, the density of the object acts downwards under the effect of gravity, and the buoyant force provided by the displaced fluid acts upward. If these two forces equal each other, the object will float. If the density of the object is greater than that of the displaced fluid, the object will sink.

The centre of gravity is the point in the body through which the gravitational force acts; the centre of buoyancy is the centre of gravity of the volume of water displaced by the body.

When the centre of gravity appears above the centre of buoyancy, the body remains stable and afloat in water. However, when the body parts move and the centre of gravity falls outside the centre of buoyancy, the body will rotate in the water to try to bring them both into alignment: the 'righting moment'. This principle is used by synchronised swimmers as they move body parts to enable their bodies to rotate and twist in and under water.

Swimmers who float higher in the water are subject to less resistance to forward movement than swimmers who are less buoyant. Females tend to be more buoyant than males because of their greater relative percentage body fat. Swimmers use the 'S-shaped pull' through water to lift them in the water; it also leads to improved swimming performances.

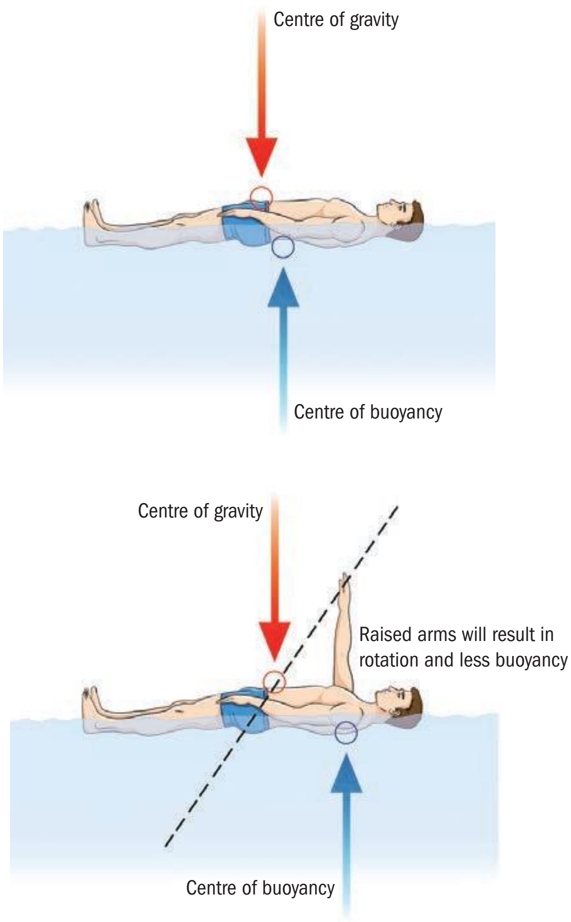

Figure 8.24 When the centre of gravity moves outside the centre of buoyancy, the body will rotate

Lift and drag

Bernoulli's principle is based on pressure differences. It was specifically created for fluids, but is also holds true for objects and movements in air. Objects can be designed to create low pressure above them and high pressure beneath them because of their shape, creating lift. This occurs with objects such as Frisbees and with the wings of aeroplanes. Lift occurs because objects are forced to move from areas of high pressure towards areas of low pressure; hang gliders obtain their lift on take off from the air pressures created near cliff faces.

Formula I teams work to create 'negative lift' by placing inverted wings at the front of their racing cars. These wings act to push the car downwards and give greater stability at high speeds, especially during cornering.

Bernoulli's principle is used in many water-based activities, particularly swimming. The 'S-shaped stroke' in freestyle was developed by James Counsilman, a brilliant swimming coach. Counsilman discovered, via the use of underwater cameras, that the S-shaped stroke, where the swimmer moved their hand *across* the axis of rotation rather than simply straight up and back, produced a lift similar to the wing of an aeroplane.

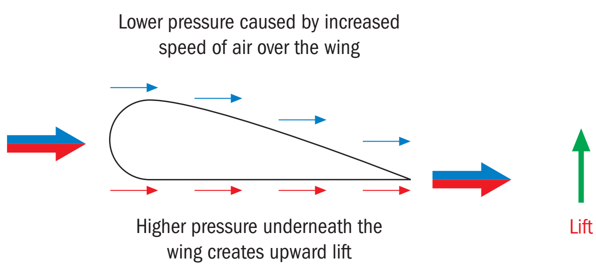

Figure 8.25 When high-pressure air moves towards low-pressure air, lift is created

This technique has been studied and fine-tuned over the years. Swimmers now

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deliberately shape their hands to create an airfoil (or wing-like shape); as they pull through the water, the water travels at a greater velocity over the top of the hand than it does underneath, and lift is created. Ideally, swimmers want to move forwards as fast as they possibly can. If a swimmer's hands are tilted and pulled alongside the body, there is both vertical and horizontal force created. This also supports Newton's law of action and equal reaction. The curved hand path is encouraged in all strokes by nearly all Olympic-level coaches.

Checkpoints

1 Use your understanding of the Magnus effect to explain why a dimpled golf ball can be struck further than a smoother golfball that has no dimples. Draw a diagram to aid your explanation.

2 Discuss why cricketers shine only one side of the ball, and not the other. What are they hoping to achieve when they bowl the ball?

3 Some of the new one-piece swimsuits have come under scrutiny because it is claimed that they provide swimmers with increased buoyancy, as well as reducing surface drag. Clearly outline how increased buoyancy would contribute to faster swim times.

Drag and friction

friction
force that opposes the efforts of one body to move over another

Friction is the term used for the force that opposes a motion. It is caused by the interaction between two surfaces moving against each other. Friction causes a ball to slow down and eventually stop after it has rolled along the ground.

In some sporting situations, it is advantageous to increase frictional forces between two surfaces to give the athlete a stable base to apply force against. This can be done by increasing the force that pushes the two surfaces together. For example, a mountain-bike rider will move their weight over the back wheel when riding up slippery terrain. This places more force on the tyre, allowing it to grip better.

The other way to increase friction is to increase the surface area of the two contact points: the ground and the soles of the performer's shoes. We see this in an athlete's choice of footwear. In cricket, tennis, football, soccer and hockey, players try to improve their frictional contact with the ground by wearing appropriate footwear. Many footballers

Figure 8.26 Different soles ensure maximum friction in different conditions and on different surfaces

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have moulded soles for dry conditions, and boots with longer screw-in stops or blades for wet days. This ensures adequate friction or resistance to motion at the contact of the two surfaces.

Drag forces can either be surface drag, form drag or wave drag; in most instances a combination of all three drag forces opposes forward movement.

drag
a force pulling an object backwards due to a low-pressure air pocket

Surface drag

Surface drag is also known as skin friction, and it has less impact on swimmers than the other two forms of drag. The resistance to forward movement can be affected by:

- the body's surface area
- the smoothness of the body and the water
- the velocity of the water flow compared to the body.

surface drag
resistance to forward movement in water; skin friction

Fluid friction refers to forces such as air and water, which work in the opposite direction to a moving object. Some sports aim to *decrease* friction; for example, snow-ski bases are waxed to make them slide more easily over the snow. Millions of dollars are spent in sporting arenas trying to work out ways of minimising frictional forces. In swimming, for example, we have seen the introduction of high-tech swimsuits that decrease surface resistance, allowing a faster speed of water to flow over the surface of the suit. Some swimmers 'shave down' to minimise friction and drag in the water; the use of full-length body suits has taken this quest for 'smoothness' even further.

form drag
when an area of high pressure and an area of low pressure meet after a body has passed through

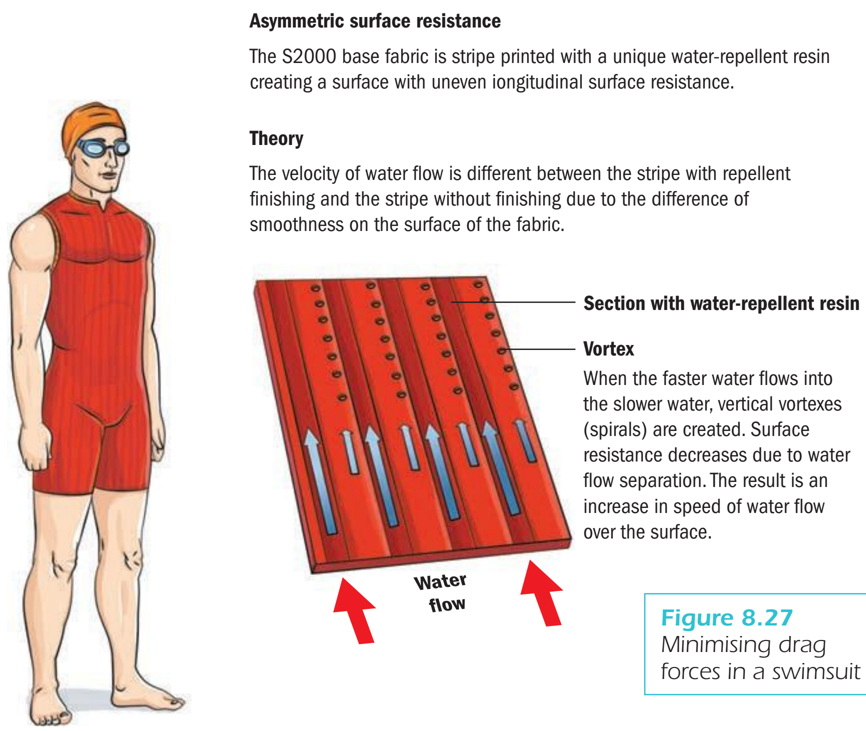

Figure 8.27 Minimising drag forces in a swimsuit

Catchy fact
The design of the Speedo Fastskin II swimsuit was modelled on shark skin. Sharks have very small tooth-like, triangular-shaped scales that help to channel water over their skin, thus minimising drag.

Form drag

Form drag is explained by Bernoulli's principle. Form drag is the separation of a flow of water (or air) caused by a body moving through it. As a result, one side of the body will have an area of high pressure and the other side an area of low pressure. When these two meet after the body has moved on, a turbulent pocket of water (or air) is created, resulting in a suction-like effect that slows the body down.

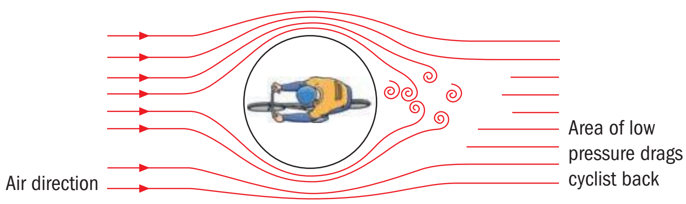

Figure 8.28 Air travelling around a cyclist causes drag and trailing turbulence

slipstreaming
riding in the slipstream, an area of reduced air pressure and forward suction that is directly behind a rapidly moving object

Cycling has undergone many equipment changes in an effort to reduce wind resistance. Bicycles are aerodynamically designed in shape and size; disc wheels have replaced spokes; handlebars now have aerodynamic extensions and helmets have taken on a teardrop shape (see Figure 8.29). Cyclists aim to reduce form drag by cycling close together in a pack, using slipstreaming, or drafting. This also sees them cycling in reduced air pressures, with less resistance to forward movement. Cyclists can also reduce form drag by crouching over their handlebars and remaining as streamlined as possible.

Figure 8.29 Teardrop-shaped helmets and disc wheels help to reduce drag forces.

Wave drag

Swimmers create waves as they move through water because they are partly submerged: part of their body is situated above the water but most of it is under the water. The quicker a person swims, the greater the effect and forces of wave drag. Trying to remain as streamlined as possible via swimsuits and improved body position and technique will minimise the effects of wave drag.

Picture two freestyle swimmers. One swimmer keeps her head in the water and breathes from side to side, with her body essentially remaining horizontal to the water surface. The other swims with her head out of the water and, as a result, drops her legs and swims with her body at ten degree tilt to the water surface. The second swimmer would create more wave drag and be considerably slower in the water.

Air resistance has implications for most sporting situations, even running, but it has a particular effect on objects that are travelling quickly. As objects always move from an area of high pressure to an area of low pressure, the object is effectively pulled back (or dragged). By streamlining equipment and body position, turbulence is reduced and drag can be minimised.

Catchy fact
If we lived in a vacuum (where air resistance is taken away) and hit a baseball into the air at 266 km/h on a 55° angle, the ball would travel almost 244 metres!

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TEST YOUR KNOWLEDGE

>> multiple-choice questions

1 Which of the following is true?

A Holding a baseball bat with one hand at the bottom and one hand halfway up the bat will increase the resistance arm and make it easier to bunt.

B Holding a baseball bat with both hands at the bottom will increase the resistance arm and make it harder to swing, but it will generate greater speed at the end of the bat and potentially enable longer hits.

C Holding a baseball bat with both hands at the bottom will increase the force arm and make it easier to swing, generating greater force at the end of the bat and potentially enable longer hits.

D Using a shorter baseball bat will allow it to be swung quicker because it is lighter, generating greater swinging speeds at the end of the bat.

2 You take a video of a promising 100-metre sprinter. Upon replaying it, you notice a flaw in her technique that, if changed, would result in faster running times. Select the most likely flaw.

A Front foot placement tends to occur beneath the centre of gravity and results in too much upward lift.

B The moment of inertia during the start is decreased by having the line of gravity close to the base of support, and this needs to increase to get off to a faster start.

C Incomplete extension in the ankle joint, resulting in lower than maximal ground reaction force and forward and upward lift.

D She should aim for increased stride frequency by decreasing her stride length by flattening the arc of the return leg.

>> short-answer questions

1 The following techniques are used for shotput. Most students use the side-on technique; most elite shot-putters introduce a spin similar to that of a discus thrower.

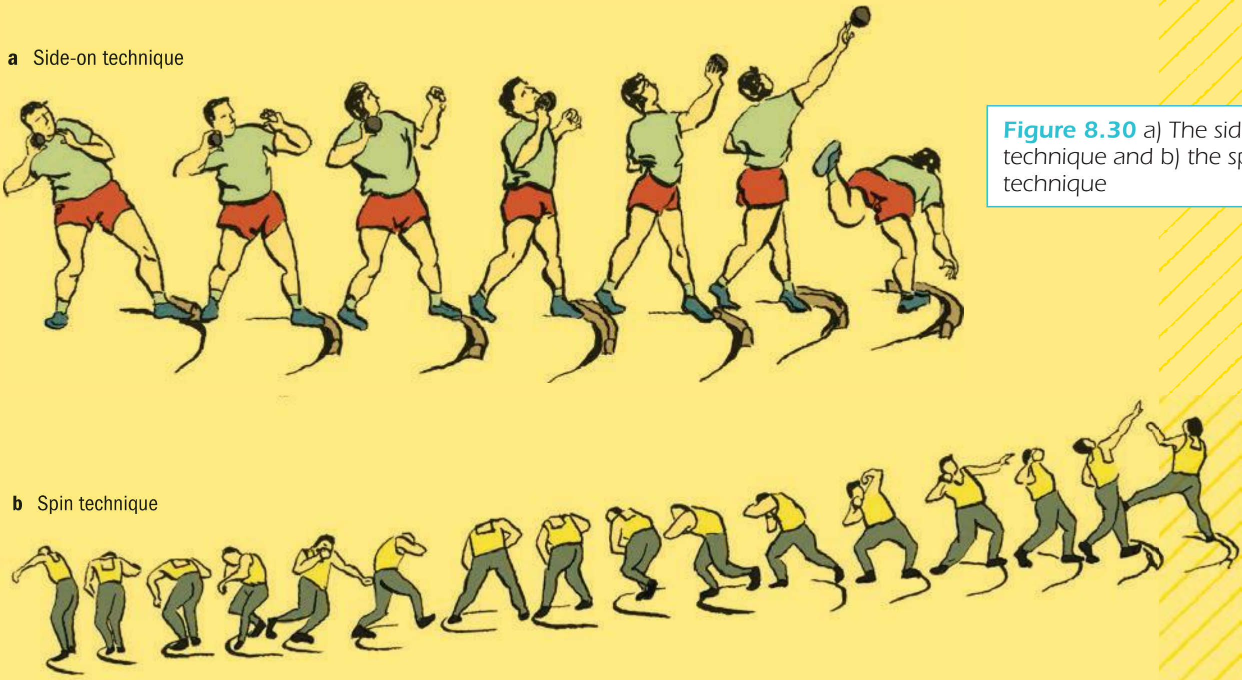

Figure 8.30 a) The side-on technique and b) the spin technique

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a What biomechanical principle is being applied by using the spin in a shot-put action?
b Briefly explain how the spin in the circle brings about improved performance.
c What would be the ideal angle of projection in the shot-put? List two other factors that might affect the flight path of the shotput.

2

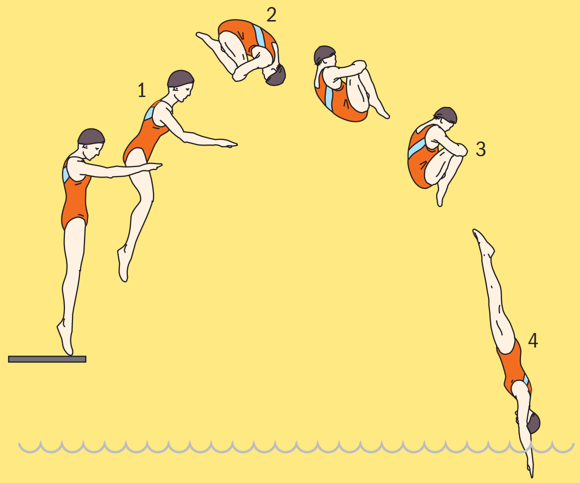

Figure 8.31 Executing a forward somersault

a What does the diver above do to start spinning forwards after jumping off the diving board?
b Describe the difference between the angular velocity and inertia at Stages 2 and 4 of the dive.
c If the diver realised they were spinning too quickly and would not be able to enter the water as planned, what could they do to slow their rotation?

3 Grant Hackett set the world 800-metre swimming record in 2005.

a The diagrams below show Hackett and an opponent from the front during the last 50 metres of the 800-metre swim. Hackett has a higher arm lift out of the water, even though his arm length and that of his opponent are identical. Outline how this would be advantageous for Hackett.

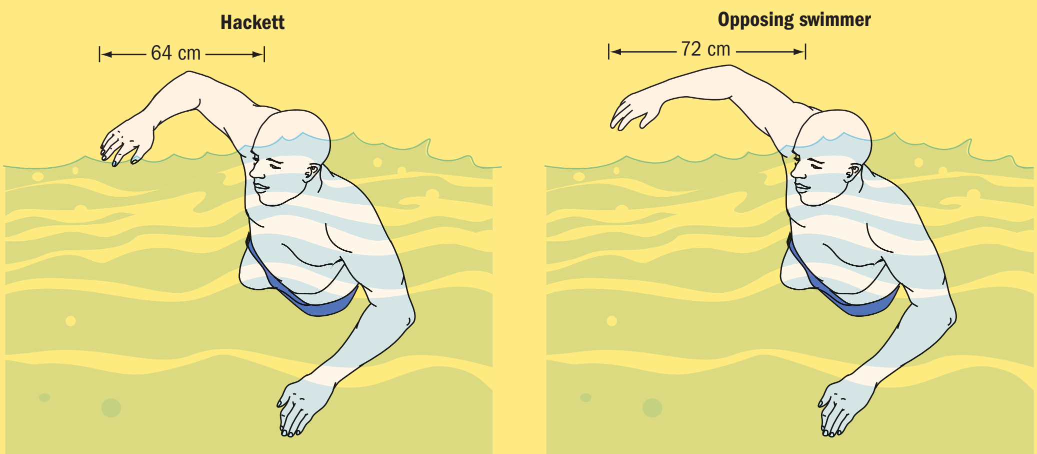

Figure 8.32 Hackett (left) has a higher arm lift

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b Hackett wore one of the new S2000 swimsuits, with vertical stripes printed with water-repellent resin. How did this swimsuit improve his performances, compared with not wearing a swimsuit at all? From the diagram on page 155, discuss any other measures he took to ensure he swam through the water at the fastest possible pace.

4 The graph in Figure 8.33 represents momentum, inertia and angular velocity for a springboard diver.

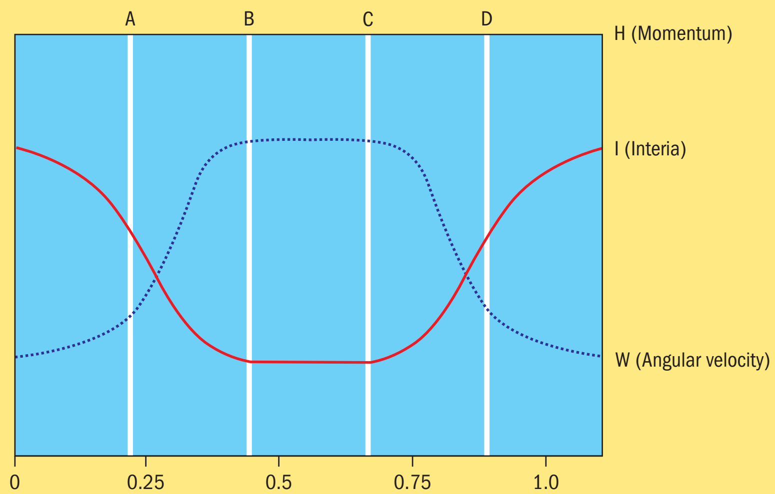

Figure 8.33

a Copy Figure 8.33 and draw or describe the diver's body position and orientation at Points A, B, C and D.

b If the diver is rotating faster than anticipated and likely to not have a clean entry into the water, what can she do to slow this down and minimise errors on entry? Discuss with reference to body parts that can be used to change inertia and angular velocity

c Discuss how momentum is conserved from the time the diver takes off from the platform ten metres above the pool.

d Discuss a strategy she could use to ensure she returns to the surface of the water as quickly as possible after entering the water and completing the dive. Make sure you use the principle of buoyancy in your discussion.

>> essay

1 Discuss how biomechanical principles are used when designing sporting equipment for beginners or young children, compared to the same equipment used by adults. Name the principles involved and how they are used to bring about improved performance for those using the modified equipment.

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9 Analysing basic movement patterns

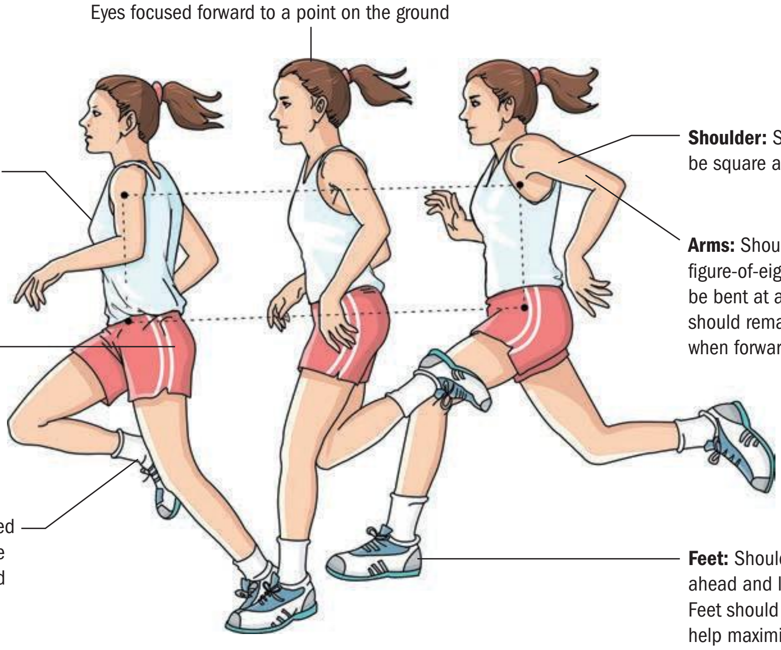
When analysing movement patterns, remember that many of the biomechanical principles you have learnt can be applied to more than one movement pattern. For example, the principle of force production applies to throwing, striking, stopping and running. Similarly, balance and stability are crucial to all of the movements we perform. We need to understand that there are different skills within each movement pattern depending on which sport is being analysed; for example, striking can consist of skills using the hand, foot, sticks, racquets or clubs. In this chapter, we will focus on analysing the efficiency of a variety of movement techniques using biomechanical principles related to running, throwing, striking and stopping.

The movement pattern of running

When we run, the foot hits the ground with a force more than three times our own body weight. Correct running technique is important to minimise injury and to reduce unnecessary movement of the body, allowing us to conserve energy and run efficiently.

Correct running technique varies slightly depending on the type of running. For example, recreational running does not require the same technique as the 100-metre sprint.

Figure 9.1 Correct running technique



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Likewise, running around curves requires a slight leaning of the body and different arm action to running in a straight line.

There are two important aspects to consider in any form of running. First, a runner should run 'tall'. This helps them to run light, which is essential for an efficient running technique. Second, the runner needs to minimise any vertical drop of the body; their head and hips should not move up and down excessively. Every time the body drops it must be lifted back up against the force of gravity, which is tiring for a runner. Instead, the arms and legs should be left to do the work.

Coursework

Video analysis

Take some video footage of class members running casually; for example, jogging to warm up in a practical class.

1. What critical features do you hope to see in a general running pattern?
2. Do you detect any errors in the running pattern? Note these down.
3. What differences in technique do you notice between class members?
4. If you could provide one of the class members with any feedback, what would it be?

Qualitative analysis of sprint running

In sprint running, success depends on the athlete's ability to coordinate the action of the legs, arms and trunk, although power also plays an important part in the success of the performance. In sprinting, power is generated in the brief time it takes for the foot to come into contact with the ground, so explosive extensions of the hip, knee and ankle joints help prepare the foot to generate the required power.

The speed of the runner is also directly related to the length and frequency of the stride. The greater the push-off from the ground, the longer the stride length tends to be. This means the runner can return their foot to the ground faster and power can be applied more frequently.

There are many biomechanical principles that contribute to efficiency of movement. In order to help identify these, we will work through the six-step analysis process.

Step 1 Performance objective

In sprinting, the overall objective is to move the body over a prescribed distance within a time constraint.

Step 2 Breakdown of movement phases

- Foot rise begins just after the last observable contact with the ground, and ends the moment the foot finishes its rise toward the buttocks.
- Knee drive begins as soon as hip flexion starts, and ends just before the foot contacts the ground again.
- Foot contact begins with the first observable contact with the ground, and ends with the last observable contact with the ground.

Step 3 Mechanical purpose of each movement phase

- Foot rise: to bring the foot toward the buttocks with minimal arc.
- Knee drive: to propel the knee slightly below horizontal.
- Foot contact: to generate maximum power.

Step 4 Biomechanical factors and principles of each movement phase

The foot rise

As we know from previous chapters, it is much easier to move a shorter lever than a longer one (refer to Chapter 8). In sprinting, an athlete should aim to reduce the arc travelled by the foot from the ground to the buttocks. Following this pattern and lifting the foot as close to the buttocks as possible effectively shortens the lever, decreasing the moment of inertia and making the leg easier to move.

Shortening the lever length in running also allows the runner to bring the leg through more quickly for the next stride. This increases the stride rate and makes it easier to increase the stride length.

Achieving an efficient running technique requires a great deal of strength in the hamstrings, which is why the high foot lift towards the buttocks is reserved for shorter distances and sprint running. Tired runners will often bring the foot up to the buttocks in an arc, which lengthens the lever and slows down the stride rate.

KEEP IT REAL!

Why is it that African runners are so successful at middle-distance events such as the 3000 metres, 5000 metres—and even the 10 000 metres? It is partly due to their biological make-up and training environment, but it can also be attributed to the way they perform the skill.

The next time you watch an international athletics event, note how high runners, like the Kenyans, lift their feet after leaving the track: their feet almost hit their buttocks. The extremely short lever they are able to make reduces the arc of the foot as it is brought towards the buttocks, making the leg easier and faster to move.

What is remarkable is that African runners are able to consistently produce this technique over longer distances.

The knee drive

The lift of the knee in the recovery phase, which is a definite ‘drive’ in sprinting, should be almost parallel with the ground. This allows for greater range of movement and a longer stride length. Lengthening the stride allows for slightly longer foot contact with the ground, which is beneficial for generating power. However, over-extension of the lead leg will lengthen the lever, increasing the moment of inertia and slowing the angular velocity of the foot before it strikes the ground. An athlete must make a compromise on this part of their technique.

Although high knee drive is important in sprinting, it can be counterproductive if taken too far. A knee brought to a position higher than parallel to the ground can cause the runner to take too long to return the foot to the ground, thus reducing the stride rate and increasing energy expenditure. It also causes the hips to rotate too much, reducing the efficiency of the movement.

The foot contact

As acceleration is proportional to the size of force acting on the body (Newton’s second law of motion; see Chapter 8), the ‘drive’ off the ground at the completion of each stride is a determining factor in the runner’s acceleration.

When the foot actually hits the ground in the driving phase, the runner needs to generate maximum ground reaction force by thrusting downwards and backwards against the track. The forceful extension of the hip, knee and ankle joints helps this action, and causes the body to be propelled forwards and upwards into the next stride, as shown in Figure 9.2. Incomplete extension of these joints is one of the most common problems detected in sprint analyses.

Placement of the foot is also critical for the runner to maintain their velocity. If the foot lands in front of the body’s centre of gravity it acts as a brake, slowing the body down.

ground reaction force
any force exerted by the ground on a body in contact with it

centre of gravity
the point through which an object’s total weight appears to act without causing rotation

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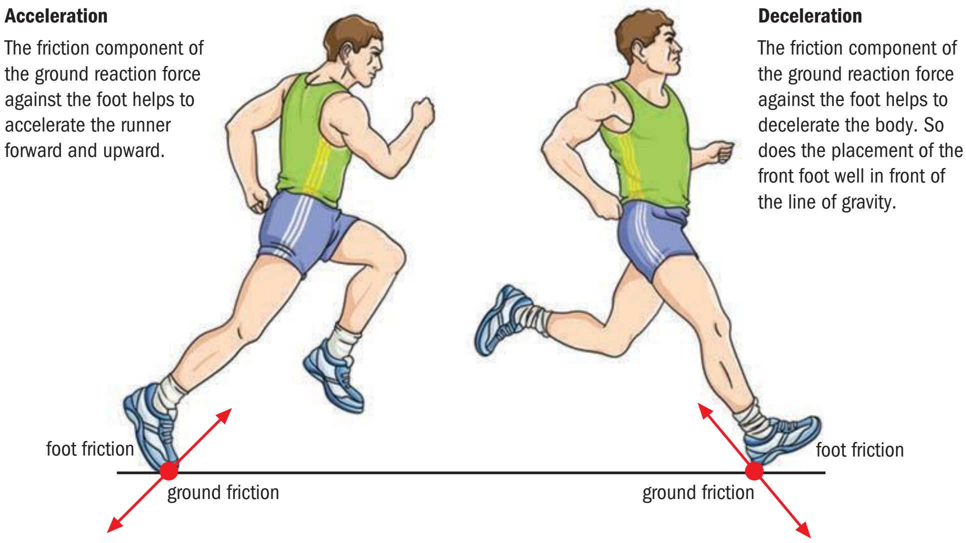

Figure 9.2 Ground reaction forces of a sprint runner

Therefore, once maximum acceleration has been achieved, foot placement as close as possible beneath the centre of gravity is required for an efficient running technique.

Step 5 Critical features

The foot rise

- Following contact with the ground, the hip extends backwards.
- The knee flexes to around 90° and this angle decreases as the foot is brought towards the buttocks.
- Toes should be kept flexed at around 90°.

The knee lift

- Hip should flex so that the knee is just below horizontal on the ground.
- Hip, knee and ankle joints should not fully extend when preparing the foot to contact the ground.
- You should expect to see a longer rather than shorter stride length.

The foot contact

- Contact should be with the front of the foot.
- The hip, knee and ankle should extend forcefully against the ground.
- The foot should contact the ground directly under or slightly in front of the hip.

Step 6 Select an observation point

In this particular analysis, we are primarily focusing on the movements of the legs as the athlete runs. Because it is hard to determine stride length, foot arc, foot contact and plane of the knee from a front-on position, it is best to observe the subject side-on.

As we are only concerned with leg movement in a non-competitive environment, it might be better to observe the athlete from a closer viewpoint. If we were analysing leg, trunk, head and arm movements it would be best to observe them from a more distant point.

Frictional forces in running

In running, there are two aspects of friction for an athlete to consider. Air resistance and frictional forces of the feet play a large part in an athlete's overall performance. Millions of dollars have been spent to design running shoes and suits that give athletes a competitive edge and help them perform at their best. Even for beginners, selecting correct footwear for the surface they are running on aids their performance and reduces injury risk.

Recommended shoe characteristics

KEEP IT REAL!

Conventional training shoe

- Relatively firm midsole
- Neutral heel flare
- Firm heel cup that completely encloses rear foot. In non-hyperpronating/supinating athletes this feature can be reduced to minimise weight
- External heel counter. In non-hyperpronating/supinating athletes this feature is not vital
- Curved or straight combination last
- Hard-wearing outsole with appropriate grip
- Relatively inelastic, porous shoe upper
- Notched Achilles tab
- Adequate toe box that has no pressure points
- Midsole designed to bend behind metatarsal heads.

Mid-foot strike shoe

- All the features listed above
- Firm midsole around the mid-foot
- Heel cup that continues to about mid-foot.

Stable shoe for pronators

- Firm midsole that is not easily compressed with the thumb
- Firm heel cup that continues to about mid-foot and cannot be deformed by squeezing it between the thumb and the first finger
- External heel counter
- Straight board or combination last
- Relatively inelastic shoe upper
- Neutral heel flare on the lateral edge of heel. (If this is not available, the shoe should have minimal heel flaring)
- Notched Achilles tab
- Adequate toe box that has no pressure points
- Midsole designed to bend behind metatarsal heads

Racing shoe

- Lightweight
- Curved slip last
- Lightweight midsole that still provides some resistance to compression
- Neutral heel flare
- Heel cup constructed of lightweight material
- Generally no heel counter
- Lightweight outsole. (It doesn't matter if this is not hard-wearing)
- Lightweight porous shoe upper
- Notched Achilles tab
- Adequate toe box that has no pressure points
- Midsole designed to bend behind the metatarsal heads

supination
when the foot rolls toward the outside, with more weight placed over the outer toes

pronation
an inward roll of the foot as the outer edge of the heel strikes the ground

In track events, the use of running spikes on the soles of shoes increases friction between the foot and the ground. This increases the surface area in contact with the ground and provides a more stable base for the runner to apply force. Conversely, the introduction of running suits like that shown in Figure 9.3 were designed to minimise friction (or drag) for sprint runners.

Figure 9.3 Cathy Freeman's hooded bodysuit minimised friction

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Checkpoints

Observe some video footage from the Olympic Games 20 years ago, and compare it to footage of a modern-day sprint runner. (For footage, try your school library, the Museum of the Moving Image, YouTube or Google.)

1. What are the main differences between the techniques you see in past footage and those used by athletes today?
2. Select three differences in technique. Explain in biomechanical terms how they help the modern runner to achieve better performances.
3. In pairs or small groups, write down any errors in technique you detect in any of the footage. Discuss this as a class.
4. List any differences you can see in the technology used; for example, footwear, starting blocks, and so on. Using your knowledge of biomechanical principles, explain how changes in technology have helped today's runners.

Catchy fact

Sometimes records are broken in world-class sprinting events, but they do not become records because of wind assistance. For example, in the 100-metre sprint, if the wind is deemed to advantage the athlete at two metres per second or more, the time is considered illegal. Even though the time run may be better than the previous record, it is not awarded to the sprinter.

Biomechanics of the sprint start

The principles of force production and balance play a significant role in the sprint start. The sprint start is one of the most biomechanically examined sporting techniques, and is critical to the success of an athlete's overall performance.

Sprinters use starting blocks to gain a mechanical advantage, rather than using a standing start. By using blocks, the sprinter can apply a greater reaction force, which gives them better projection off the start line. There are three main types of crouch start: the bullet (or bunch), the medium, and the elongated. Although the bunch start gets the sprinter off the blocks more quickly, the sprinter has less velocity than in the medium or elongated start.

Although current research favours the medium start, there are other factors that need to be considered; for example, the differences between male and female athletes in strength and anatomical structure, the optimum angle for each starting block, and whether spikes affect how your foot should be positioned on the blocks.

Another biomechanical factor comes into play when analysing the sprint start. Each different starting position alters the body's centre of gravity. When a runner leans forward in the blocks, they inadvertently position their centre of gravity forward. This means that their line of gravity falls nearer the edge of the base of support created by the fingers. Although the athlete is still balanced in this position, the moment of inertia is decreased and only a small force is needed to rotate them forwards, helping the athlete to gain a quick start.

a

b

c

Figure 9.4 Three types of crouch start: a) bullet, b) medium and c) elongated

line of gravity
theoretical line drawn from the centre of gravity to the base of support

base of support
the area upon which a body is supported on the ground

Coursework

Equipment: starting blocks, markers, measuring tape, stopwatch

Procedure

1. Work with a partner to investigate different sprint starts by performing three crouch starts for the
   - Standing start
   - Bullet (or bunch)

- Medium
- Elongated

Also experiment with the angle of starting blocks for each crouch-start position.

2 Record your time over 10 metres for each start.

3 Which technique recorded the fastest time over 10 metres? Why?

4 Did you establish an optimum angle for using the starting blocks? Explain your answer.

5 Using stick figures, predict where your centre of gravity was in the 'set' position for each start. Did this have an effect on your start times? Explain your answer.

6 Explain how Newton's third law affects a sprinter's start.

7 Keeping biomechanical principles in mind, why do male and female athletes need to consider their anatomical differences when choosing an appropriate start style?

Checkpoints

1 List three reasons why good running technique is important.

2 What difference might there be in the performance objectives of a casual runner compared to a sprint runner?

3 Summarise the biomechanical principles involved in the running movement pattern and make a brief statement about each one.

4 What two frictional forces must a runner consider? Explain your answer.

5 How is balance used in the sprint start?

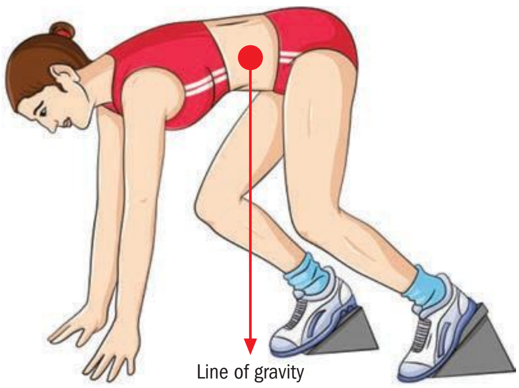

Figure 9.5 The line of gravity is close to the edge of the base of support

The movement pattern of throwing

The movement pattern of throwing can be adapted to perform skills in a number of sports, from throwing a tennis ball or passing a netball, to more complicated movements such as throwing a javelin or putting a shot. Due to the nature of the movement pattern, most errors relating to throw-like movements are usually a result of either poor timing, or lack of power or strength.

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Poor timing

Often the sequence and timing of body segments is incorrect; for example, stepping forward on the same foot as the throwing arm. This type of error interferes with summation of momentum.

summation of momentum
the sequential movement of body parts to produce maximal speed

Lack of power or strength

Lack of power or strength will often result in the athlete performing two or more sequences of body movements together, or carrying the throwing implement close to the midline of the body. For example, a weaker player will try to release a basketball with the twist of their trunk and the ball tucked close to their chest. This action alters the summation of momentum, and although this action reduces the moment of inertia, it may not allow for the greatest speed of release.

Qualitative analysis of throwing

The overall performance objective for throwing depends on the actual skill being performed. Some skills require throwing for accuracy, some for distance and others require both. Unless accuracy is the major objective, the mechanical purpose for each phase of a throwing skill is to develop high velocity at the end of each segmental link. There are six body segments to focus on when analysing a throw-like movement pattern.

Pelvis

Following complete foot contact with the ground, the pelvis begins medial rotation around the hip joint.

medial
towards the midline of the body

distal
situated farthest from point of attachment

proximal
situated nearest to point of attachment

Thorax

Pelvic rotation continues as the thorax begins rotating around the vertebral column. This rotation causes the upper extremity and the projectile to 'lag back'.

Shoulder

As the thorax is rotating, the throwing shoulder is abducted to an angle of around 90°.

Arm

The elbow is flexed to an angle of 90°. Once the rotational direction of the thorax is changed, the elbow accelerates quickly through extension, followed by rotation of the shoulder. (This is the only time a distal segment moves before a proximal segment.)

Forearm

The forearm pronates.

Hand

The wrist goes from being hyper-extended to fully extended but does not 'snap' into flexion until the release of the object. Figure 8.6 on page 140 demonstrates the correct technique of a throw-like movement using these body segments. It helps to divide the throw into three discrete parts to analyse it:

- Preparing to throw: Begins with the first observable foot contact with the ground from the lead leg, and ends with the first observable change in rotational direction of the thorax.
- Release phase: Begins with the first observable change in rotational direction of the thorax, and ends with the flexion of the wrist.
- Follow-through: Begins with the release of the object, and ends when the object has achieved its intended course.

Biomechanical principles of throw-like movements

While principles such as projectile motion, spin, flattening the arc and impulse are all related to various throwing skills, it is summation of momentum that is most common to all throw-like movement patterns.

Summation of momentum

In applying the principle of summation of momentum, the athlete must ensure that each larger, more proximal segment of the body, such as the elbow, is moved before the smaller, more distal segment, such as the wrist. Ideally, one segment begins to move as the preceding segment ends its motion. Getting this segmental timing right helps to increase maximal velocity when an object is released, helping it to travel further.

As well as using summation of momentum, an athlete wanting to increase the velocity of the object being released can also:

- use more body segments throughout the movement; for example, stepping forward when throwing
- increase the range over which the segments move; for example, bowling a cricket ball with a straight arm
- use muscle elasticity to generate force; for example, stretching chest and upper arm muscles in a throw.

Summation of momentum varies slightly when the objective is to throw for accuracy. In such cases, body segments can be moved simultaneously rather than sequentially; for example, moving the shoulder, elbow and wrist at the same time when throwing a dart. The most efficient sequence and timing of body parts will also vary depending on the size and mass of the object to be thrown.

When performing any throwing activity, it is important that the athlete completely follows through to ensure there is no deceleration of the end lever before release. The concept of following through also helps apply the principle of flattening the arc, which leads to greater accuracy.

Coursework

Observing throwing techniques

1 Working in pairs, nominate a thrower and an observer. Use the following objects to perform an overarm throw for greatest distance: a tennis ball, a softball, a volleyball, a basketball and a medicine ball. Then complete the following.
   - **a** Did the order of the moving segments vary from ball to ball? Explain your answer.
   - **b** Did one joint movement ever stop before another began? Explain your answer.
   - **c** Did two or more segments start moving simultaneously? Explain your answer.
   - **d** With which ball were you least successful in using correct technique? Using biomechanical principles, explain why this was so.

2 Throw and catch a tennis ball with a partner using your non-preferred hand. Based on the knowledge you have of throwing technique, attempt to identify errors being made.

3 Where would the best viewing point be to analyse the throwing skills involved?

4 Throw a softball to a partner using a side-arm, overarm and underarm throwing pattern. For each throw, list and compare the sequential body movements and the movements that occur simultaneously.

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Projectile motion and throwing

In Chapter 8 we learnt that increasing the velocity of a projectile at the time it is released increases the distance that it travels. However, the optimum angle of projection is dependent on the following factors.

Physical attributes of the individual

The amount of power an athlete is able to generate will affect the technique used in a performance. A weaker performer produces a slower speed of release, and generally requires a higher angle of release. While the object will not travel as far or as quickly, it creates a longer flight time. Although using a higher flight path is not ideal, it may be appropriate for the individual given their stage of development. Considering the use of modified (smaller or lighter) equipment is one way of allowing the athlete to approximate a model performance more closely.

The type of skill being performed

The overall performance objective directly influences the optimal angle at which an object is released. For example, when fielding in baseball the aim is to throw the ball for maximum accuracy and speed. In this case, the angle of projection will be much less than 45 degrees. However, if a cricket outfielder were to return the ball to the keeper using the same angle of projection as a baseballer, the ball would fall far short of its target. The outfielder would need to release the ball closer to 45 degrees; see Table 9.1.

Angle of projection

The angle of projection is also affected by the height of release. This biomechanical principle is particularly relevant to throwing, because objects are almost always projected from a point higher than their intended landing area. We often throw an object to ground level from a standing position, as in discus and shotput. This means that to achieve maximum distance, the angle of release generally needs to be less than 45 degrees.

There are sporting situations where an object is projected from a lower point than its landing area. Shooting a netball goal, for example, requires a larger angle of projection due to the height of release below the goal.

Given these factors, it is important when conducting qualitative analysis to consider the physical height and strength of the performer, as well as the skill being performed. This highlights the need for a sound knowledge base when conducting qualitative analysis.

Table 9.1 Effects of angle of projection on flight trajectories

Angle of projection	Effect on distance travelled	Effect on flight time
45 degrees (if height projection is zero)	Will achieve greatest horizontal distance	No effect
Greater than 45 degrees	Greater heights but shorter distances	Longer flight times
Less than 45 degrees	Lower heights and shorter distances	Shorter flight times

Coursework

Investigating flight paths of projectiles

Equipment: tennis balls, basketballs, vortexes, javelins, shotputs (or any other throwing implements), measuring tapes, boxes of various heights

Procedure

Perform three attempts at each trial, using at least three different angles of release: 45 degrees, greater than 45 degrees, less than 45 degrees.

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Trial 1: Release a tennis ball while standing on the ground using different angles of projection.

Trial 2: Release a tennis ball from various heights using the same angle of projection.

Trial 3: Release a tennis ball from various heights using different angles of projection

Trial 4: Try to achieve the maximum throwing distance with various throwing implements while standing on the ground.

1 Record distances thrown for each attempt in each trial.

2 Draw a table or tables to represent your results.

3 a In Trial 1, what angle of projection achieved the greatest throwing distance?
  b Compare your results with those of other class members. How might you account for any differences?

4 a In Trial 2, what height of release achieved the greatest throwing distance?
  b What angle of projection did you use to achieve this?
  c How did this compare with throwing from ground level?

5 a Rank the throwing implements you used in Trial 4 from needing the greatest angle of projection to needing the least angle of projection when throwing for maximum distance.
  b Compare the results of the tallest and shortest person in the class. Did height difference have any effect on the outcome of their results? Explain your answer.
  c What other biomechanical factors may have affected the distance these objects travelled? Explain your answer.

6 Predict the angle of projection the following skills would require: greater than 45 degrees, less than 45 degrees or equal to 45 degrees.
  a Soccer throw in from the side line
  b Lacrosse throw to a team-mate on the other side of the field
  c Throwing a tennis ball 10 metres from a sitting position
  d In a trench at ground level, throwing a grenade at enemy lines 50 metres away
  e Shooting a free throw in basketball

7 What effect do you think a pitching mound has on a baseball game? Explain your answer.

Spin

top spin
premature downward movement of a ball in flight due to the effects of air pressure

backspin
lifting effect of a ball in flight due to the effects of air pressure

side spin
turn of a ball in flight to left or right due to the effects of air pressure

Although we tend to associate spin with sports that use racquets, such as tennis, it is also an essential element in some games that use throw-like movement patterns if the skill is to be performed correctly. We see this in cricket, when a spin bowler comes on, and in baseball pitching. In these sports, spin is used as a tactic to move the ball from the regular straight line it might otherwise take.

In cricket, depending on the type of spin the bowler imparts to the ball, the ball can move towards the batsman (off-spin) or away from the batsman (leg spin) after the ball has made contact with the pitch. This makes it difficult for batsmen to predict the line the ball will take, so spin bowling is an effective way of taking wickets.

Spin bowlers such as Simon Katich have several choices of spin they can use; for example, the flipper and the wrong 'un, as well as conventional finger and wrist spin. Even pace bowlers can place some movement on the ball to create 'inswing' or 'outswing'.

As explained in Chapter 8, spin imparted on a ball is a result of the Magnus effect, a force that causes a deviation in the flight path of a ball. In the movement pattern of throwing, the use of side spin is much more prevalent than top spin or backspin. Side spin

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will create a movement to the left or right, depending on the direction of the spin imparted as it leaves the bowler's hand. A ball thrown with right spin, leaving the hand in an anti-clockwise direction, creates a low-pressure zone on its left-hand surface. This causes it to deviate to the left, both in flight and when it makes contact with the ground.

Coursework

Investigating ball movement

In an enclosed space, throw a foam ball several times to a partner using left and right side spin.

1 For each throw, draw a diagram of:
  - a the direction in which the ball is spinning
  - b the ball's movement path in the air
  - c the ball's movement path when it makes contact with the ground.

2 Using the principle of the Magnus effect, explain in your own words why the ball behaved as it did in each throw.

3 Keeping the Magnus effect in mind, why is it that cricket pace bowlers shine only one side of the ball?

4 Conduct a game of cricket with a tennis ball that is taped on one side, bowling with a very straight seam. Comment on the effect this has on batting and bowling performances.

Inertia

Given that an object's inertia is directly related to its mass, throwing patterns may alter depending on the object being projected. For example, throwing a shotput by using the same movement used for a tennis ball throw would increase the inertia too much, resulting in an ineffective throw and probable injury. By reducing the lever (the arm) and having the shot tucked into the neck close to the midline of the body, you can reduce inertia, making it easier to throw the shotput.

Impulse

As discussed in Chapter 8, impulse is the force that helps change the momentum of a body. In the movement pattern of throwing, impulse can be used to help generate more velocity when we release an object. This can be applied by using greater force when we throw; however, we may reach a point where we are applying all the force we have, but we still need the object to go further or faster. Applying the force that we have over a longer period of time is another way in which we can use impulse to help generate change in the momentum of the thrown object. For example, javelin throwers hold the javelin as far back as possible in their run up, using a straight arm. This means that the force on release is applied for the longest period of time possible. If they were to carry the javelin above their heads, they would only be applying half as much impulse and achieving much shorter distances. Discus throwers apply impulse by using a spin in their throwing technique.

Coursework

Examine the different shotput-throwing techniques depicted in Figure 9.6.

1 What is the performance objective of each technique?

2 Identify the biomechanical factors and discuss the biomechanical principles that apply to the shotput event.

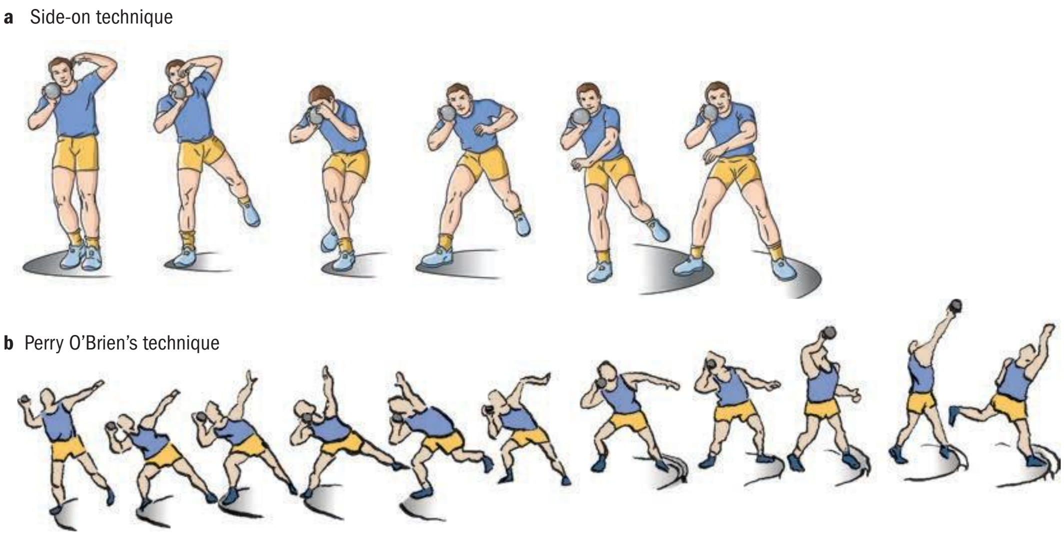
3 Select and list the critical features you notice from the drawings of each technique.

4 In a practical session, experiment with each technique and record your throwing distances.

5 Which technique produced the best results? Explain your answer.

6 Provide five other sporting examples where impulse is used to enhance a performance.

Figure 9.6 Two shotput techniques: the side-on technique (a) and the technique used by legendary US Shotputter Perry O'Brien (b)



Checkpoints

1 Explain in your own words why using a regular throwing action in shotput would be biomechanically inefficient.

2 What does it mean to 'summate our momentum' when we throw something? Explain in your own words why this produces more force.

3 Generally speaking, what are the two most likely causes of error in a throw-like movement pattern?

4 Explain why the best angle of projection can vary depending on the throwing skill being performed.

5 What changes in technique can an athlete make to decrease the moment of inertia in a throw-like movement?

The movement pattern of striking

Striking is a complex action involving many biomechanical principles, and is most associated with sports that use equipment, such as golf, tennis, baseball, cricket and hockey. However, there are other sports that use a striking pattern *without* implements; for example, soccer, Australian Rules football, volleyball, boxing and martial arts.

Common to most striking skills is the use of a stance and a stride before the player swings a bat (or their leg or arm), then a follow-through action. When analysing the movement pattern of striking, it is useful to divide the movement into the following four

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phases: stance, stride, swing and follow-through (Hay 1985). However, the stride phase is not applicable to golf, a hockey 'push' or serving a tennis ball.

Stance

Stance is an important phase in striking. It allows the player to maintain their balance and also places the body at a point that allows the player to best execute the skill they are performing. For example, a baseball player who is less experienced or has less strength is better off using an open stance, with their hips and shoulders rotated towards the front, as shown in Figure 9.7. This means the batter has less distance in which to swing the bat and more chance of making appropriate contact with the ball.

A closed stance provides more time for the hips, shoulders and arms to be rotated prior to impact with the ball, producing greater force at impact. The speed of the swing used in a closed stance needs to be very fast, making it suitable for strong players who have quick decision-making skills.

A square stance (standing side-on) is a compromise between the two. In some sports, such as putting in golf, it is desirable to use a square stance regardless of strength or experience.

The principles of balance and stability also come into play when dealing with the stance phase of a skill. Generally speaking, the wider apart the feet are placed during the stance phase, the greater the base of support and the more stable the athlete. However, with striking, the athlete must keep in mind their movement into the next phase. If the feet are too wide apart, transferring their weight into the stride phase can be more difficult.

An athlete's weight distribution can also affect the next phase of movement: the stride. Having more weight placed on the 'stride' foot can make it harder to lift and move this foot. It also places the centre of gravity a long way forward, making it more difficult to produce a forceful hip rotation, and resulting in less force production. Even for skills such as a tennis serve, where no stride phase follows, it is advantageous to place your weight on the back foot prior to making contact with the ball.

a Open stance: hips and shoulders are rotated towards the front

b Closed stance: hips and shoulders are rotated towards the rear

c Square stance: side-on to the object being struck

Figure 9.7 a) open, b) closed and c) square stances

Stride

In preparation for the swing phase, the stride is used to initiate forward movement of the athlete's weight. Skills such as a volleyball serve, depending on the style of the athlete, can incorporate more than one stride, while others avoid using a stride at all. The stride phase when batting in cricket varies according to the type of shot being played.

In some sports, it is better to keep the stride length short, around 30 centimetres. This keeps the athlete's line of gravity close to the back foot, helping generate forceful hip rotation. This generates greater velocity of the end lever when hitting or kicking a ball, making the ball travel further. It also reduces head movement, helping the athlete keep sight of the ball being struck. The smaller range of motion experienced with a shorter stride reduces the scope for errors, allowing the athlete to produce a more consistent action.

In soccer and football, the stride phase becomes particularly important with the run-up action used during play and when performing set shots. Using many strides helps to produce longer and more powerful kicks due to the player's increased momentum at impact.

Swing

Swing time is the time from when the supporting foot lands to the time contact is made with the ball. It is during this phase of a striking pattern that most biomechanical principles related to striking can be applied. Factors such as momentum, levers, elasticity and projectile motion all help determine the outcome of the athlete's performance.

Summation of momentum

Catchy fact

In professional baseball, once the batter's stride foot touches the ground, they have less than half a second to prepare their swing.

As with a throw-like movement pattern, the swing phase of striking requires sequential movement of body parts to execute the skill effectively (or summation of momentum). This may vary slightly depending on the task being performed, but usually requires movement from the larger, more proximal body parts to the smaller, more distal segments, and finally the external lever. For example, in baseball batting, the hips rotate first, followed by the shoulders. When the shoulders are approximately parallel with the hips, the arms move, followed by the wrists, causing the bat to be driven forcefully towards the ball; see Figure 9.8. The leading arm is kept straight throughout the swing to maximise the radius of the lever; this increases the bat's velocity at the point of impact with the ball.

The same principle applies to kicking movements. Greater force can be imparted to the ball by maximising the number of body parts used and by summating forces of the hip and trunk rotation, the hip flexion, knee extension and ankle plantarflexion.

Coursework

Participate in a game of softball in a practical class. Each time you bat, experiment with different stances.

1. Rank the stances from most to least effective.
2. Explain in your own words, and using biomechanical terms, why one stance worked better than another.
3. Observe other members of the class and their batting technique. Did anyone use a stride? If so, what impact did it have on their performance? If not, where did people tend to have their weight positioned? What impact did this have on their performance?
4. Try different stances, this time using a batting tee. What differences in technique did you observe between this and facing a pitcher?

Levers

The use of external levers is particularly relevant to striking patterns that use equipment, such as bats, clubs, racquets and sticks. Because high velocity at impact is such a critical factor in most striking skills, the use of a longer external lever can be beneficial. The longer resistance arm means that the end of the implement moves through a greater range, increasing its velocity (refer to Chapter 8).

But if the use of a longer external lever can be beneficial, why aren't tennis racquets two metres long? Using a longer lever (or greater resistance arm) means that the force arm

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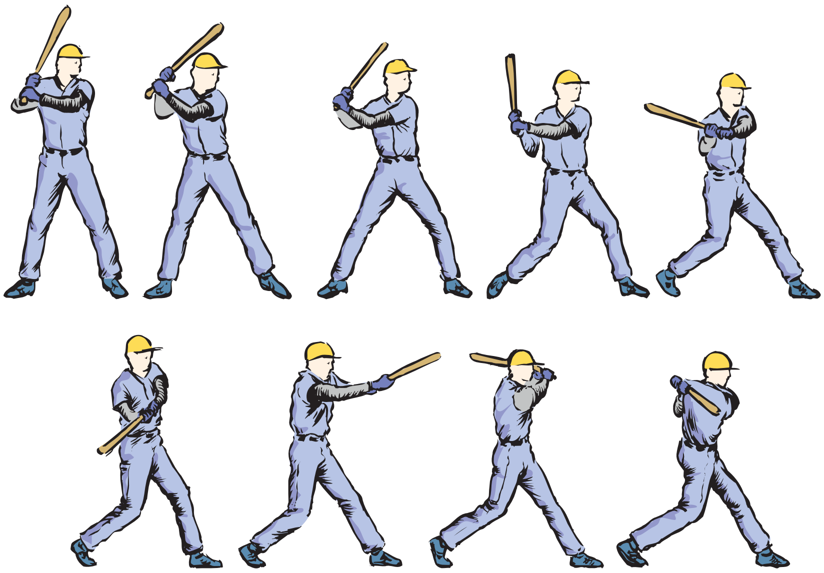

Figure 9.8
Good batting technique

is shorter, requiring a greater effort to swing it. Using a bat, club, racquet or stick that is too long for the athlete and the skill being performed makes the movement difficult to control and compromises speed.

Internal levers play an important role in many sports, and limb length is often the focus in talent searches. Having longer bones (or levers) works in much the same way as longer external levers: the limbs are able to move through a greater range, producing more velocity and force at impact.That is why we often see tall, long-limbed tennis players like Andy Roddick produce faster serves than shorter players such as Lleyton Hewitt. It is also why cricket pace bowlers tend to be taller and spin bowlers shorter.

Those of us not blessed with the right genes can still alter our technique to help produce a similar biomechanical effect. For example, in soccer and Australian Rules football, skilled players are able to lean backwards or sideways away from the ball as they swing their leg and make impact with the ball. This increases the leverage system and the velocity at the end of the foot (see Figure 9.10).

Catchy fact
Professional soccer players produce such high velocities when they kick that the ball can reach speeds of 35 metres per second!

KEEP IT REAL!

The National Talent Search Program was implemented by the Australian Institute of Sport to identify talented athletes over 12 years of age. The program assesses information related to psychological, physiological, sociological, kinaesthetic and skill/decision-making qualities. Because physical and physiological characteristics are relatively easy to evaluate and have stronger predictive powers, a great deal of weight is placed on these factors in the identification process. Once they have undergone testing, athletes are then guided to sports that they are best suited to, based on the results.

Conservation of momentum and elasticity

In Chapter 8 we learnt that momentum is always conserved in any collision because of the equal and opposite forces two objects exert on each other at impact. In a hockey drive, for example, when a player hits a stationary ball, at the moment of impact the stick slows down and the ball speeds up, thus gaining the momentum the stick has lost. The size of these forces exerted depends on the speed of each object, but also on their respective elasticity. As we know, more elastic surfaces result in less energy being lost at impact.

In volleyball, a game where the movement pattern is predominately striking, a ball is often spiked with such force that the receiver must keep their arms straight with little or no follow-through. If the arms were to meet the ball with any force, equal and opposite forces would send the ball off the arms at an uncontrollable angle. A good volleyball player also digs the ball on the flat, fleshy part of the forearm. As this part of the arm is less elastic, more energy is lost at impact, making the ball easier to control.

Coursework

Read the following questions prior to participating in a game of volleyball or a skills session. Using your knowledge of biomechanical principles and your experiences in the practical session, answer the following questions.

1. A volleyball player can use three serving actions: underarm, overarm, or jump serve. Experiment with each serving technique and determine which is most effective. Explain your findings.
2. Why do spikers try to hit the ball with a fully extended arm?
3. What biomechanical principles are associated with a spiking action? Explain each one briefly.
4. How does a volleyball player get a ball to 'float' on a serve?
5. Why does a blocker at the net angle their hands downwards when blocking a volleyball?
6. Explain the benefit of bending and extending the legs or arms when digging or setting a ball to a partner in a warm-up drill.

velocity of release
the speed of a projectile at the moment it is released

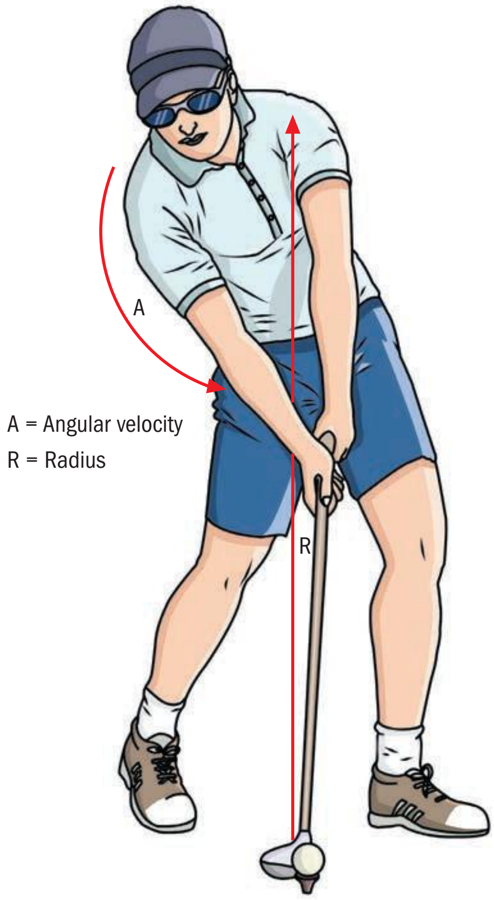

Figure 9.9 The angular velocity multiplied by the radius determines the speed of a golf club head

Projectile motion and striking

As with many sports that involve striking an object, the objective is to hit the ball with maximum velocity while maintaining a degree of accuracy. This is true for a golf drive, a tennis or volleyball serve, a shot at goal in hockey or kicking for distance on a football field. Some skills require more accuracy, while others, such as baseball, benefit more from a high velocity that projects the ball over a greater distance.

Velocity of release is the most important aspect of projectile motion in a striking-movement pattern. Because velocity is governed by the mass of the ball and the striking implement, as well as their respective velocities before impact, the athlete has some measure of control over these factors. Selecting equipment that is appropriate in weight and length gives the athlete a better chance of achieving maximal velocity.

The athlete can also control the velocity of the striking implement by simply swinging faster, which increases the angular velocity. The length of the lever (its radius from the axis) multiplied by the angular velocity gives the greatest speed to the head of any striking implement, as shown in Figure 9.9.

For skills where the foot is used to strike an object such as a ball, velocity can be increased by incorporating a run up. This increases the athlete's momentum and uses more body segments in the action, helping to produce a more forceful summation of momentum. A larger backswing of the kicking leg can also achieve the same effect. As the support foot is planted, the kicking leg is positioned well behind the body, with the hip hyper-extended and the knee flexed. Rotating the trunk at this point also helps to increase the length of the backswing and adds to the force of forward trunk rotation into the kick (see Figure 9.10).

In many striking skills, the height of release is out of the athlete's control; for example, the ball entering a softball batter's strike zone, or the delivery of a cricket ball. Height of release is therefore of relatively less importance. An exception to this is golf. Because golf is played on

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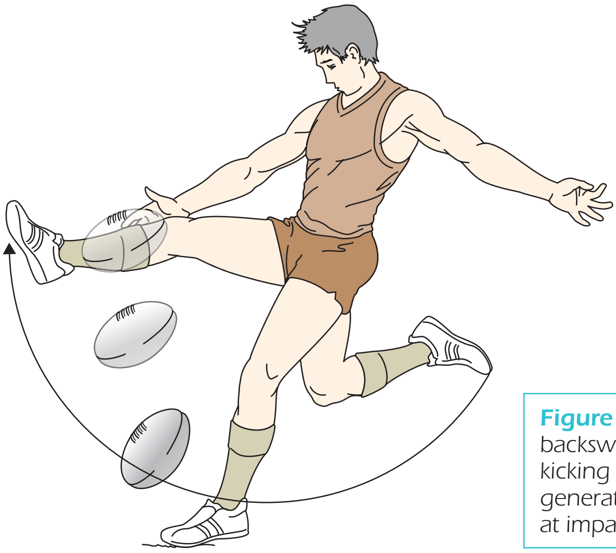

Figure 9.10 A larger backswing with the kicking leg helps to generate more velocity at impact

an undulating surface, the point of release may be higher or lower than the target, therefore correct club choice is critical to achieve optimal angle of release and the most appropriate flight path.

The angle of projection in the striking-movement pattern is specific to each sport. For example, in soccer, the ball generally travels from ground to ground, so an angle of release close to 45 degrees is best when kicking for distance. In volleyball, a player spiking the ball is trying to achieve a low angle of projection because they want the ball to travel downwards very sharply over a short distance. Tall players are at an advantage when performing this skill, as they have an increased height of release.

Spin

The principle of spin is the same whether you are throwing, hitting or kicking a ball. Tennis players, golfers and volleyball players all use the Magnus effect to curve the flight path of the ball to their advantage. When throwing, spin tends to be created by the movement of the fingers or wrist. When striking, spin results from the frictional force generated when an object (the ball) is hit off-centre; for example, kicking a torpedo in Australian Rules football. Or when the external lever is used as an extension of the body; for example, using the wrist to roll a tennis racquet to create top spin.

How much a ball spins depends on the direction and amount of spin placed on it, as well as the speed of its release. A spinning ball causes an uneven air flow around its boundary layer as it moves through the air. With top spin, it is more difficult for air to pass over the top surface of the ball because the ball is spinning in the same direction as it is travelling. This means that the top boundary layer of the ball hits the oncoming air head-on, causing the air to slow down (and creating an area of high pressure). At the bottom of the ball it is easier for air to move over the boundary layer, meaning it can pass more quickly, creating an area of low pressure (see Figure 9.11). This causes the ball to accelerate downwards faster than a ball hit without spin. Top spin is used a lot in sports where the ball is required to travel at high velocity but still fall within a boundary, such as tennis, volleyball and table tennis.

Backspin works in the opposite way, creating a lifting force instead of a downward force; see Figure 9.11. For this reason, backspin is used when we need to project a ball over a long horizontal distance, as in a golf drive, or for accurate ball placement, as in a tennis drop shot. In kicking, a soccer player uses the Magnus effect to their advantage when taking free kicks or corners. Placing side spin on the ball allows them to curve its flight path around defensive players. (See pages 149–152 for more about spin.)

Coursework

During a practical class, participate in a game of golf at a golf course or at a driving range.

Equipment: a range of golf clubs

Procedure

Experiment with each club. Take notes about the effects different clubs have on the flight and distance the ball travels.

1. What did you notice about the different clubs and their relative length? Explain how the lever length affected the distance the ball travelled.
2. What did you notice about the different clubs and their clubfaces? Explain how the clubface can affect the projectile motion. Use diagrams to illustrate your examples.
3. Explain why the elevated tee (such as a tee 50 metres higher than the green) would influence your club choice on a short hole less than 150 metres from the pin.
4. You will have noticed that some balls curve to the right or left during flight. For a right-handed golfer, the left curve is called a *hook* and the right curve is called a *slice*. From your understanding of spin, explain how a golf ball can hook or slice.
5. Explain why most serious golfers have their golf clubs custom made.

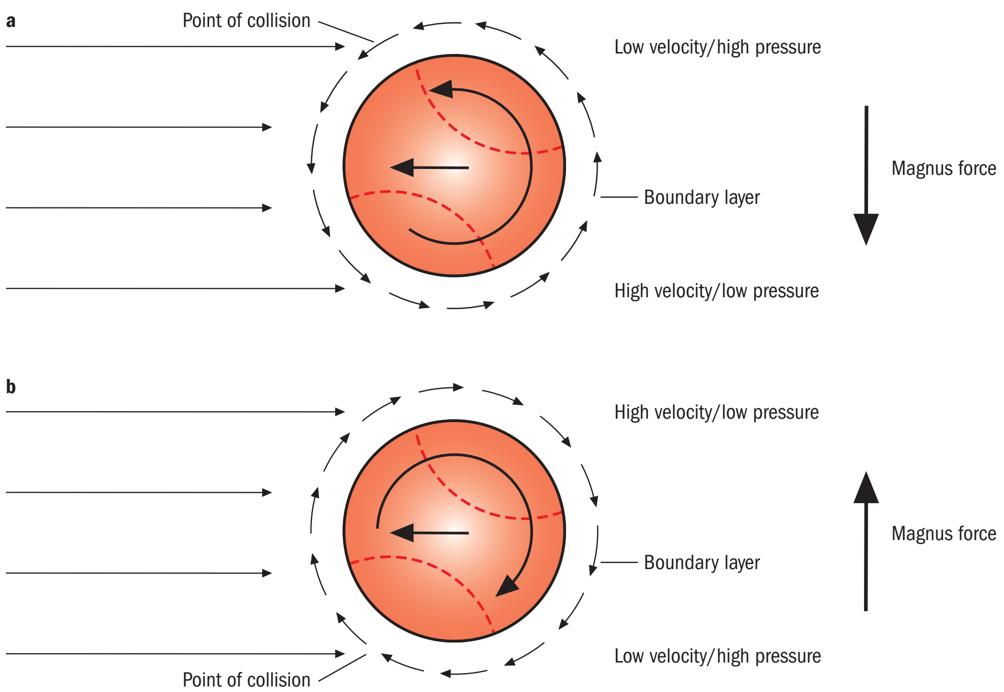

Figure 9.11 The Magnus effect on a ball hit with (a) top spin and (b) backspin

Balance

In the swing phase of a kicking movement, the arms are primarily used to balance the body. For example, in soccer and Australian Rules football, players extend their arms out to the sides of their body as they swing their leg through to make contact with the ball, helping to keep the centre of gravity over the support foot. This action increases the moment of inertia of the trunk, making it more resistant to sideways rotation (rotating around the spine). As the kicking foot makes contact with the ball, the opposite arm moves forwards and upwards across the body to help keep the trunk down and the body in balance.

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The follow-through

After striking an object, the body has a natural tendency to keep moving. An athlete can use this natural movement to help improve the accuracy of the performance by keeping the hand or external lever moving in a straight line at the point of contact and release (using the principle of flattening the arc). If the follow-through is not kept in a straight line, deviations in movement are likely, such as 'hooking' a ball. Carrying the movement through past the point of contact also helps to ensure that force is maintained throughout the entire range of movement.

Checkpoints

1. Explain in your own words how force production can be affected by stance when performing a striking skill.
2. What advantage does a shorter stride length give an athlete?
3. Summarise the biomechanical principles that can be applied to the swing phase of a striking pattern. Write a brief statement about each one.
4. Explain why it is important to follow through when performing a striking movement pattern.

The movement pattern of stopping

We don't think of stopping as a movement pattern, but as something that happens naturally at the conclusion of a race or after a skill has been executed. Stopping actually requires similar biomechanical principles to getting the body started—except that it uses them in the opposite way.

Starting to walk requires a forward lean of the body to position the line of gravity in front of one foot to make the body overbalance in a forward direction. For fast-forward movement, the centre of gravity is as low and as far forward as possible for the initial push-off; for example, swim starts or sprint starts. However, the body requires a backward lean when stopping to slow it down (or decelerate). Therefore, the gravity line is moved as far back from the leading edge of the base of support as frictional forces will allow. The leading foot is planted ahead of the line of gravity, creating a backward ground reaction force that causes the subject to slow down (see Figure 9.12). Because friction gives some resistance to this change in movement, it may take several steps to slow and stop the body completely.

The same backward lean and foot plant can be seen in athletes about to change direction. We often see this in tennis, netball or football, where sudden changes of movement are necessary. The ground reaction forces respond in the opposite direction to the foot that is applying force to the ground, allowing the athlete to stop and change direction from side to side as well as front to back.

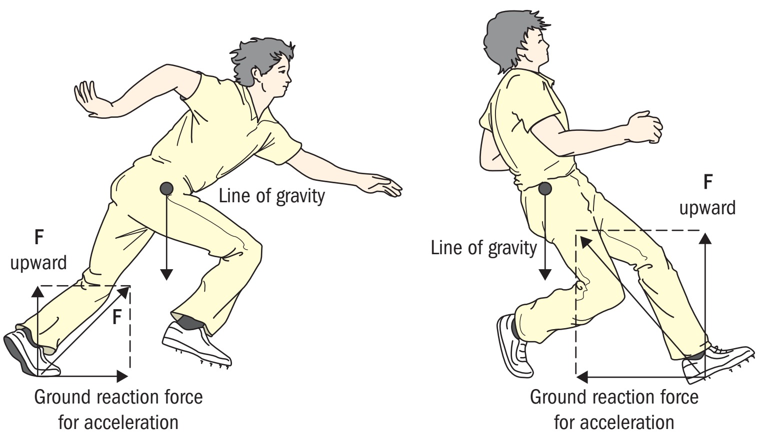

Figure 9.12 The body's line of gravity is shifted towards the leading base edge for acceleration, and away from the leading edge for deceleration

Catchy fact
Walking is actually a series of controlled falls.

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angular motion the motion of a body moving around an axis.

Thanks to Newton's third law of angular motion, discussed in Chapter 8, we know that for every torque there is an equal and opposite torque. This principle can be applied to events that require torque to stop, such as the long jump. Balance is also a biomechanical factor in such events. To stop the body rotating forward and avoid a face plant, the athlete extends their legs and plants their heels forward. In reaction to this, the upper body is thrust forward. By flexing the hips and knees, the body's momentum carries forward without the risk of it losing balance backwards. This reaction allows the jumper to achieve greater distances because heel plant can be delayed without risk of falling backward.

Coursework

1 Run as fast as you can to a spot 15 metres away. Stop on it while maintaining your balance. Have a partner observe your foot positioning and body lean as you approach the line and as you stop at it. Were you able to stop on the line without losing balance? Explain why or why not.

2 In baseball, the batter is allowed to overrun first base, unlike any other base. What advantage does this give the batter? If the batter continues to run straight onto second base, what changes might they have to make to their running direction and pattern of movement?

3 Recall the last time you saw someone nearly bump into another object or person. What adjustments did the person have to make to avoid a collision?

Checkpoints

1 Whenever an athlete is moving forwards and needs to slow down or stop, backward ground reaction forces need to be applied. This is the case in running and long jump, and it also true in skating, surfing and skiing.

  a Research a recreational sport or an extreme sport. Discuss the biomechanical principles involved in stopping or changing direction in that sport. Use diagrams to explain your work.

  b Present your research to the class. Use visuals in your presentation to help explain your findings.

Inertia and impulse

The more mass an object has, the more difficult it is to stop, as it has greater inertia. With angular motion, the ease of stopping the object also depends on how the mass of the object is distributed around the axis. For example, in sports such as dance, skating and diving, which use spinning skills, the tighter the body parts are tucked in, the less inertia and the faster the body spins. In order to stop the rotation, body parts need to be opened out to increase inertia and slow the body rotation.

In sport we often need to slow down or stop moving objects; this can be achieved by creating a greater amount of opposing force to the object, or increasing the amount of time that the force opposes the motion (or impulse). For example, when catching a ball, you generally bend your elbows and 'give' with the ball. This reduces the force of impact and increases the amount of time your hands have to exert a force on the ball to stop it. The ball's momentum is slowed down and it is caught in a safer, more manageable manner.

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Checkpoints

1 Explain how an athlete can apply the biomechanical principles of balance and stability to help stop or decelerate.

2 What effect does over-striding at the end of a running race have?

3 Explain how Newton's third law of angular motion can assist in stopping or changing direction. Provide a sporting example to support your answer.

4 What factors affect an object's moment of inertia? How can we apply this principle to the movement pattern of stopping?

5 Explain the role frictional forces have on stopping an object.

Catchy fact

Wet weather can cause the stopping distance of a bicycle to double. Pumping brakes during wet weather reduces the water on the rim and reduces the stopping distance.

Friction

Friction is a key biomechanical factor in the movement pattern of stopping. The friction between two surfaces causes an object to slow down and eventually stop. In surfing, for example, stepping down on the tail of the board acts as a braking mechanism because of friction between the board and the water.

In cycling, braking occurs due to the frictional force of the rubber brake pad on the rim of the wheel. Because of inertia, the body tends to keep travelling forwards when brakes are applied, leaving the cyclist positioned further over the front wheel. Braking needs to be balanced between the front and rear wheels to avoid going over the handlebars.

Air resistance can decelerate an object through the drag effect that low-pressure turbulence has on projectile objects. Drag can be minimised by streamlining body position; for example, leaning forward while cycling. This principle can also be applied to field events where objects are thrown. Drag has an effect on such things as a discus throw. By streamlining the discus, for example, drag is minimised and the discus will travel further. In your next practical session, test out this principle by throwing a frisbee at various angles.

Summary of biomechanical principles

The information in Table 9.2 summarises the biomechanical principles discussed in this chapter, listing formulas, methods of intervention and application of intervention. Use the table to clarify your understanding of each biomechanical principle.

Table 9.2 Summary of biomechanical principles

Principle	Formula	Methods of intervention	Application of intervention
Newtons 1st law: Rotational inertia	I = mr	Decrease inertia Change mass of object or limb length striking object	Supplementary weights training to make limb bigger
Newtons 2nd law: Acceleration	F = ma	Change mass of object or limb striking it Improve acceleration by improved segmental interaction	Supplementary weight training Coaching intervention to improve segmental interaction
Impulse	Impulse = Ft	Increase time in contact with an object at impact to increase power Decrease damage done in a collision by spreading the force over a longer time	Lean back when kicking Using a forward roll after falling at high speed
Newtons 3rd law	Action : Reaction	Larger muscles to place more force into object Improve technique	Supplementary weight training Coaching intervention to improve segmental interaction

Continued

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Principle	Formula	Methods of intervention	Application of intervention
Spin	Magnus effect	Change string tension for more or less spin Use boots with greater friction for more spin	Coaching intervention to change technique Equipment selection
Drag	Form drag Surface drag Wave drag	Improve air flow over object by changing the shape or the material used	Use compression swimsuits with low-resistance fabric Coaching intervention to improve streamlined shape
Stability and balance	Base of support vs placement of centre of gravity	Narrower stance raises centre of gravity, improving agility Wider base of support to improve stability through lower centre of gravity	Stand tall when running at pace Lower centre of gravity in preparation for a tackle
Lift	Bernoulli's principle	Change the amount of force applied and the shape to improve benefits through high and low pressure	Increase lift in swimmers by changing shape of stroke

Coursework

Qualitative analysis

Working through the entire analysis process from establishing an overall objective to re-evaluating the performer, conduct a quantitative analysis of a movement pattern and skill of your choice. Write down the skill you plan to observe and have a partner complete that skill while you videotape their performance. This is best achieved in pairs or small teams. Be sure to clearly document all information.

1. What is the overall performance objective of the skill?
2. Divide the skill into distinct phases and explain where each begins and ends.
3. What is the mechanical purpose for each phase?
4. Using a table format, write down the biomechanical factors associated with each phase and discuss the biomechanical principles. Make a list of the critical features that should be observed in the performance. (You may need to do further research on this.)
5. After viewing the tape several times, compare what you observed with your list of critical features. Remember to target the cause of the problem and try to use biomechanical terms to explain the errors.
6. Communicate to your partner any errors you detected in their performance. Offer some strategies for improvement; for example, movements they can alter biomechanically and any technical drills they can practice. Remember to record this information.
7. After considerable practice time, re-evaluate your partner. Comment on both the results you observe as well as your own performance as an analyst. What factors contributed to the success or failure of the performance? In future analyses that you conduct, what might you do differently to improve the qualitative analysis process?

TEST YOUR KNOWLEDGE

>> Essay question

1. Use the qualitative analysis in the Coursework section to produce a report linking biomechanical processes together.

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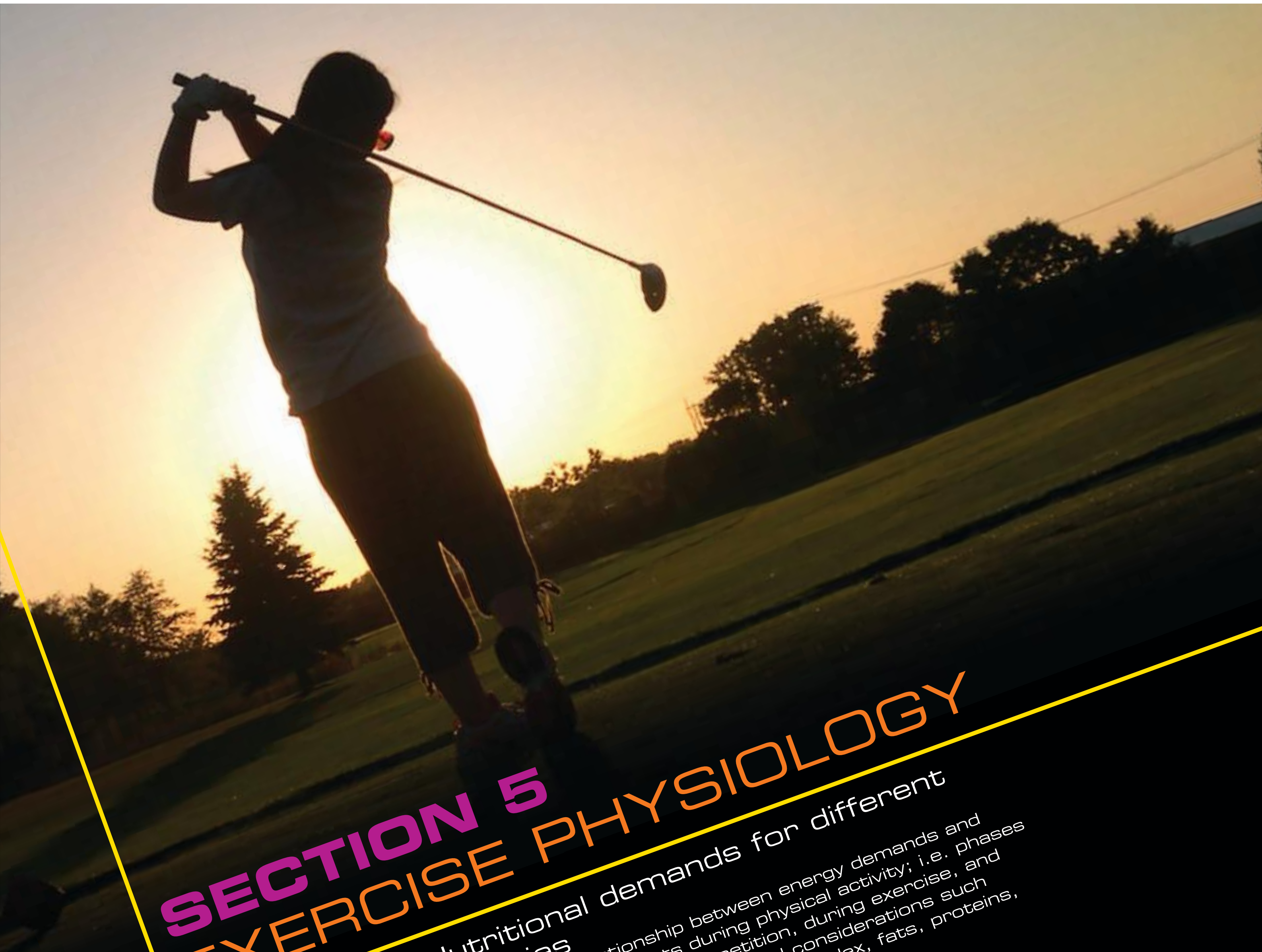

SECTION 5
EXERCISE PHYSIOLOGY

Chapter 10 Nutritional demands for different activities

3A.15 Describe the relationship between energy demands and nutritional requirements during physical activity; i.e. phases of activity such as pre-competition, during exercise, and for recovery. Consider nutritional considerations such as the balanced diet, the glycaemic index, fats, proteins, carbohydrates and fluid replacement.

Chapter 11 Environmental conditions and performance

3A.16 Evaluate the implications of preparing and performing in varying environmental conditions; i.e. heat, humidity, altitude and cold.

Chapter 12 Legal and illegal performance-enhancement strategies

3A.17 Explain the physiological changes brought on by the use of performance enhancers; i.e. dietary supplements, anabolic steroids.

Chapter 13 Fatigue and recovery

Although not specified in the course outline, students need to understand fatigue and recovery mechanisms, especially legal performance-enhancement strategies, the effect of fatigue on muscle function and how to counteract it, and how to offset fatigue through diet.

Chapter 14 Training programs

3B.8 Critically evaluate training programs designed to improve performance in relation to periodisation; i.e. micro cycle, macro cycle, pre-season, in-season, off-season, as well as specific energy system requirements, peaking, overtraining, injured athletes, tapering, recovery and maintenance.

10 Nutritional demands for different activities

Professor Louise Burke has directed the Department of Sports Nutrition at the Australian Institute of Sport since 1990. She is world-renowned for her work in sports nutrition for performance enhancement, and is chief advisor to many national sporting organisations. The following advice has been offered by her department regarding pre-exercise, exercise and recovery nutritional practices.

Pre-exercise

The pre-event meal might mean the difference between winning and losing, but it is important to remember that food eaten throughout the training week and foods and fluids consumed during the event are also critical. Meals consumed before exercise should be seen as an opportunity to 'top up' carbohydrate and fluid levels.

Food consumed before exercise is only useful after it has been digested and absorbed and this needs to coincide with the exercise period. Digestion rates depend on the type and quantity of food consumed. Foods higher in fat, protein and fibre generally tend to take longer to digest than other foods, and may increase the risk of gastric upsets during exercise. It is recommended to have a meal about three to four hours before exercise, or a light snack about one to two hours before exercise.

Pre-exercise foods should increase carbohydrate levels, be low in fat and moderate in fibre to aid digestion and reduce the risk of gastrointestinal upsets. During long-lasting workloads or high-intensity intermittent training sessions, it may be important to increase both carbohydrate and fluid intake. A list of suggested pre-exercise foods is listed in Table 10.1.

KEEP IT REAL!

Ironman and ASICS Ambassador, Jason Sortis, has won the Western Australian Ironman Triathlon in a record-breaking time.

Shortis smashed his own personal best by 13 minutes in the race which comprised of a 3.8 km swim, a 180 km bike ride followed by a marathon (42 km) running leg. The Queensland triathlete finished in an astounding national and course record time of 8 hours 3 minutes 56 seconds to reclaim the title he held in 2004.

Of the five ironman races he has entered this year, Shortis won in Malaysia in February, finished third only five weeks later in the Australian titles, was eighth in Germany and fourth in Korea before winning in Western Australia. The 36-year-old now has his sights set on a top-four finish in the prestigious Hawaiian Ironman next October after a spectacular finish to his 2006 competition calendar.

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Table 10.1 Suggested pre-exercise foods

3–4 hours before exercise	1–2 hours before exercise	Less than an hour before exercise, or during an event
Crumpets with jam or honey + flavoured milk	Liquid meal supplement	Sports drink
Baked potato + cottage cheese filling + glass of milk	Milkshake or fruit smoothie	Carbohydrate gel
Baked beans on toast	Sports bars (check labels for carbohydrate and protein content)	Cordial
Breakfast cereal with milk	Breakfast cereal with milk	Sports bars
Bread roll with cheese or meat filling + banana	Cereal bars	Jelly lollies
3–4 hours before exercise	**1–2 hours before exercise**	**Less than an hour before exercise, or during an event**
Fruit salad with fruit-flavoured yoghurt	Fruit-flavoured yoghurt	
Pasta or rice with a sauce based on low-fat ingredients (e.g. tomato, vegetables, lean meat)	Fruit	

Dept of Sports Nutrition, AIS, © Australian Sports Commission 2004

Carbohydrate loading

Most sports enthusiasts would have heard of carbohydrate loading. Most people believe that any sportsperson would benefit by 'carbing up', and that the way to do this is to overindulge in carbohydrates in the days leading up to a competition. Carbohydrate loading needs to be considered in conjunction with the glycaemic index, which is discussed in greater detail later in this chapter.

Figure 10.1 Surf lifesavers regularly carbohydrate-load to maximise their performances

Carbohydrate loading is a strategy involving changes to training and nutrition to maximise muscle and liver glycogen (carbohydrate) stores prior to endurance competition. Carbohydrate loading does not benefit all athletes. Anyone exercising continuously for 90 minutes or longer is likely to benefit from carbohydrate loading; essentially, it is endurance athletes who typically consider this performance-enhancing practice. Athletes taking part in road cycling, marathon running,

glycogen major carbohydrate storage form in the body

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longer-distance triathlon, cross-country skiing and endurance swimming benefit from carbohydrate loading.

Shorter-term exercise is unlikely to benefit from carbohydrate loading, as the body's usual carbohydrate stores are adequate to cope with the energy demands.

Carbohydrate loading is not a practical dietary practice in team sports, where games are played every three to four days and adequate refuelling opportunities exist. Although it might be argued that players in soccer and AFL have heavy demands on their muscle fuel stores, it would be impossible to achieve a full carbohydrate protocol within the weekly schedule of training and games.

glycogen synthase
enzyme responsible for converting glucose into glycogen in the process of glucogenesis

supercompensation
elevated amounts of glycogen stored in the muscles and liver following periods where this is in short supply or used in response to exercise bouts

Carbohydrate loading was originally developed in Sweden in the late 1960s for cross-country runners and skiers. Originally, carbohydrate loading involved a depletion phase that included three to four consecutive hard training days while on a low-carbohydrate diet. The depletion phase was thought necessary to stimulate the enzyme glycogen synthase. The depletion phase was followed by a loading phase in the lead-up to competition, which involved three to four days of rest combined with a high-carbohydrate diet. The extra carbohydrate, combined with the now-activated glycogen synthase, was shown to boost carbohydrate, stores beyond their usual resting levels, which is known as the supercompensation effect.

This strategy, while increasing carbohydrates available for performance, led to significant disruptions to preparation. It has been refined so that modern-day carbohydrate loading is now more manageable and less disruptive for athletes.

Muscle glycogen levels are normally in the range of 100 to 120 mmol/kg ww (wet weight). Carbohydrate loading enables muscle glycogen levels to increase to around 150 to 200 mmol/kg ww (millimoles per kilogram of wet weight of muscle). This extra supply of carbohydrate has been demonstrated to improve endurance exercise because athletes can exercise at their optimal pace for a longer time. While carbohydrate loading can only improve performance over a set distance by three to five per cent, this might give endurance athletes an the edge over their opponents by delaying fatigue.

tapering
reducing training volume and duration (but not intensity) in the week leading up to a major competition

Today's endurance athletes use a modified carbohydrate-loading method. Ongoing research has demonstrated that the depletion phase is no longer needed and the disruption to preparation is unnecessary and damaging. Today, three to four days of exercise taper while following a high-carbohydrate diet (seven to 10 grams per kilogram of body weight) is sufficient to elevate muscle glycogen levels prior to a game. Exercise tapering is a decrease in training load that is common before a game to facilitate recovery and optimum fuel storage. This tapering also lessens the likelihood of injury and ensures that athletes are fully recovered prior to producing maximal efforts during games.

Carbohydrate loading attempts to prolong carbohydrates as the main fuel and delay the body's reliance on fats. Breaking down fats (known as catabolism) decreases power output because fat mobilisation and aerobic breakdown are significantly slower than that of carbohydrate. Marathon runners use the term 'hitting the wall' to describe the feelings of pain and fatigue associated with glycogen depletion.

Many athletes who attempt to carbohydrate load fail to achieve their goal because they don't consult a sports nutritionist. The most common facts, which are not always properly understood, are:

- carbohydrate loading requires an exercise taper
- athletes can find it hard to train lightly for three to four days before competition
- failing to rest will compromise carbohydrate loading
- many athletes fail to eat enough carbohydrate (the recommended uptake is seven to 10 grams per kilogram of body weight)
- working with a sports dietitian or using a carbohydrate counter can be useful.

To consume the correct amount of carbohydrate, it is necessary to cut back on fibre and make use of compact sources of carbohydrate such as sugar, cordial, soft drink, sports drink, jam, honey, jelly and tinned fruit. Athletes who include too many high-fibre foods in their carbohydrate loading menu may suffer stomach upsets or find the food too bulky to consume.

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Carbohydrate loading usually causes body mass to increase by approximately two kilograms in an average 70-kilogram athlete. This extra weight is due to extra muscle glycogen and water (2.7 grams of water is stored for each gram of muscle glycogen added). As well as feelings of being 'heavy', the extra weight directly adds to the energy cost of performing.

For some athletes, the weight gain may prevent them from carbohydrate loading adequately and continuing with suggested practices. The extra weight may negate the benefits gained from having extra glycogen to call on as a fuel. Consuming too many high-fat foods will make it difficult to consume sufficient carbohydrate. It may also result in body-fat gain. It is important to stick to high-carbohydrate, low-fat foods while carbohydrate loading. The benefits of increased water absorption associated with carbohydrate loading occur during glycogen breakdown when water is released, and contribute to temperature regulation and offsetting increased body temperatures.

Figure 10.2 is an example of a menu that would be suitable for a 70-kg athlete aiming to carbohydrate load. Note that it is important to consume snacks regularly when carbohydrate loading.

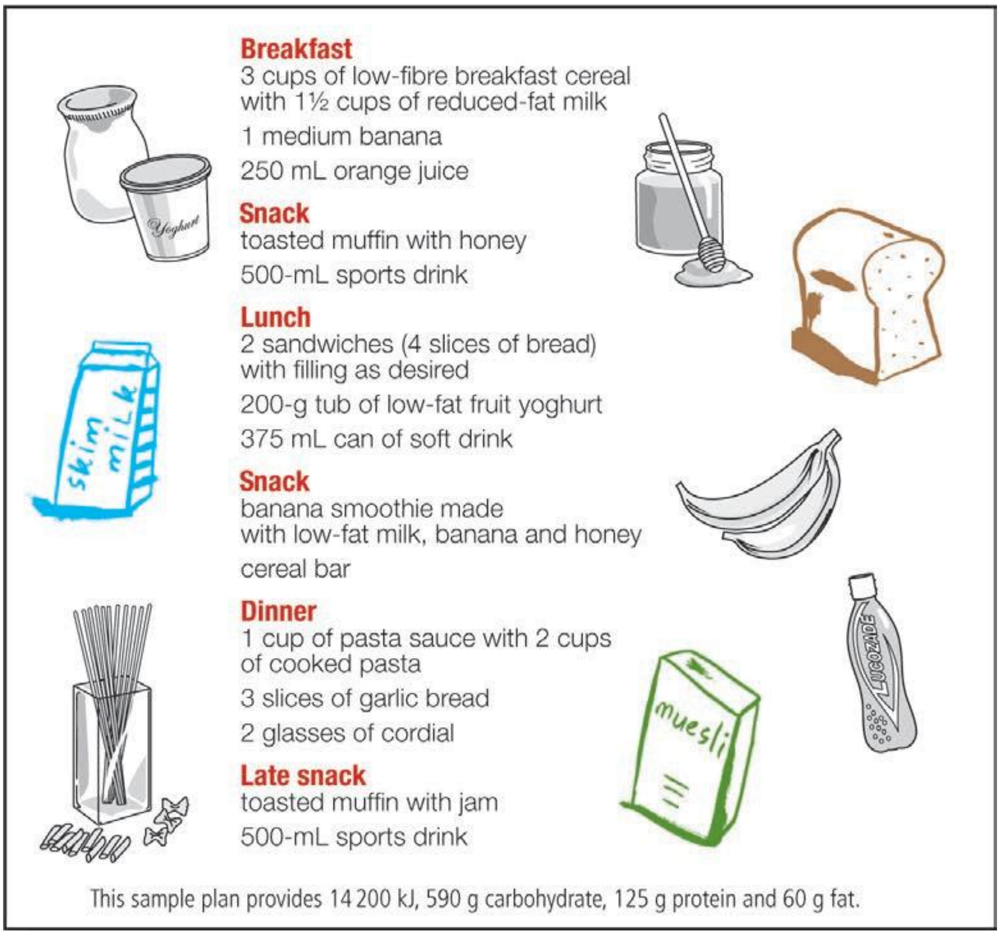

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Figure 10.2 What does a high carbohydrate diet look like?

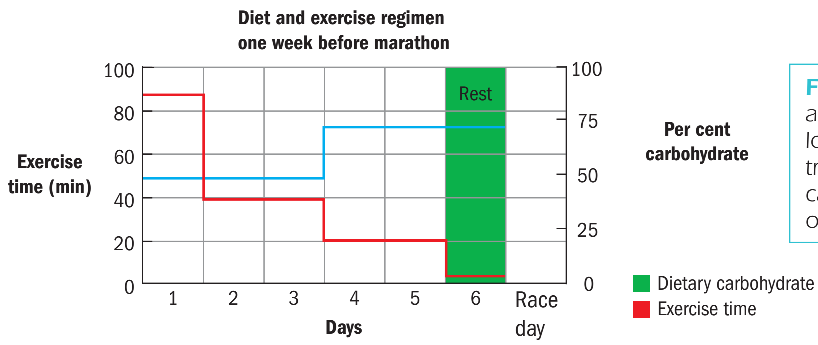

Figure 10.3 A modified approach to carbohydrate loading for a marathon; training time is decreased and carbohydrate intake is increased one week before a marathon

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Catchy fact
Type 2 diabetes (also known as 'adult onset' or 'non-insulin dependent diabetes') is rapidly increasing among the Australian population. People consuming high-carbohydrate (high-glycaemic) and low-fibre diets are almost three times as likely to suffer from Type 2 diabetes than people on low-glycaemic diets. High-carbohydrate diets consisting of low-glycaemic foods reduce the likelihood of obesity and coronary heart disease; they are also beneficial to people involved in anaerobic and aerobic training.

Checkpoints

1 Why is it difficult for team players such as footballers, netballers, hockey players and soccer players to carbohydrate-load?
2 Carbohydrate loading has an associated weight gain via water retention. Outline the circumstances where this might be an advantage.
3 Why should high-GI foods be avoided before competing in endurance events?

Exercise and sporting competitions

Australian Rules football

Competition demands

In AFL, there is one game per week, usually played on the weekend, but it could also be on a Monday or Friday night. Most clubs schedule three or four training sessions between games. The AFL season consists of 22 games from March to August, followed by four weeks of finals in September. The national competition involves interstate travel, with some games being played at night under lights. A supplementary night competition and pre-season match competitions start in January and may add another six matches to the year's tally.

An Australian Rules football match lasts about two hours, with the physiological demands varying considerably between field positions. On-ball players (ruck rover, follower, wing player) can run 12 to 20 kilometres in a game, from low-intensity jogging to high-intensity sprints of less than 60 metres. Full backs and full forwards typically perform more short sprints and cover less distance.

Dietary habits

According to two dietary surveys, one done in 1988 with 56 AFL players, and one done in 1999 with 40 AFL players, the dietary habits of footballers have improved during those ten years, with less dietary fat and alcohol consumed in 1999 compared with in 1988. The intake of carbohydrate and protein had increased. The daily energy intake has not changed over this period. It is likely that the addition of sports dietitians to most AFL clubs has improved players' dietary habits.

Table 10.2 Change in daily macronutrient intake of Australian Rules footballers

	1988	1999
Energy (MJ)	14.2	13.2
Carbohydrate (g)	373 ± 94	415 ± 18
Carbohydrate (g/kg)	4.5 ± 1.1	4.8 ± 0.2
Carbohydrate (% energy)	44	51.7
Protein (g)	126 ± 27	138.8 ± 4.5
Protein (g/kg)	1.5 ± 0.4	1.6 ± 0.05
Protein (% energy)	15	18.1
Fat (g)	141 ± 33	104 ± 5.6
Fat (% energy)	37.5	29.2
Alcohol (g)	20 ± 18	1.25 ± 0.6
Alcohol (% energy)	3.5	0.3

adapted from L. Burke, *The Complete Guide to Food for Sports Performance*, 2nd edition, Allen and Unwin, 2000

ISBN 9780170227124

Professional Australian Rules football players are at risk of low iron stores, as they lose iron through sweating and from the trauma caused by the impact of running. It is also possible that many players do not eat adequate quantities of foods that contain iron. Players consuming a wide variety of food rich in nutrients and quantity should meet all their requirements for iron and all other micronutrients. Some clubs regularly test their players' iron status to keep on top of this.

Pre-game nutrition

In professional Australian Rules football, the current AFL game schedule means that games can be held in the late afternoon, at night time or in the early afternoon. In these situations, many players will have a large meal three to four hours before the match, then a small meal to top up carbohydrate and fluid stores one to two hours prior to the game. Food choices such as breakfast cereals, sandwiches, white bread, pasta, muffins, fruit and liquid meal supplements are typical for a pre-game meal. With interstate travel, teams are given special meals on aeroplanes or at the team hotel to meet these requirements.

Training and game fluid intake

With additional games in a season and the pre-season competition, training sessions and matches are often conducted in warm conditions and now have a national competition. Fluid losses as high as 3.6 litres per game have been recorded in Australian Rules football matches; these fluids are not usually replaced during a game.

Water is usually provided during training; increasingly, more clubs are providing sports drink as well. Carbohydrate-containing fluids provide a supplementary fuel source when muscle glycogen stores are low, and may be more important in the latter stages of a game. In addition, sports drinks may increase the amount of fluid consumed, compared with water or cordial.

Recovery

Traditionally, football players have considered carbohydrate only on the eve of the match. Yet recovery from a match and between training sessions requires a high carbohydrate intake every day. It is likely that the game, combined with long training nights, will draw heavily on muscle glycogen stores, particularly for running players. Muscle damage and injury caused by body contact and tackling increase carbohydrate and protein requirements for glycogen restoration.

Active recovery should begin as soon as each exercise session finishes. A recovery snack followed by the resumption of the high-carbohydrate diet will aid the recovery process. AFL clubs will usually provide players with muffins, flavoured milk, jube lollies and bread rolls to aid recovery.

Figure 10.4 Nicholas Naitanui, a player with the West Coast Eagles

Jamie is an 18-year-old male who plays Australian Rules football. He has played with the seniors for a few years now and while the training has always been tough, over the past year there have been more training sessions than ever before. In particular, the number of bike and weights sessions has increased. Jamie was finding it increasingly difficult to maintain weight and was losing muscle mass. He was aware of his weight loss and spoke to the dietitian about how he suffers from nerves on match day, leaving him unable to eat much before, during or after games.

Prior to the training sessions, the dietitian measured Jamie's weight and body fat, and took circumference measurements of his arms and legs.

Table 10.3 Jamie's measurements

Date	11/11/00	30/11/00	15/1/01	4/3/01	31/5/01	29/7/01
Height (cm)	178					
Weight (kg)	79.0	79.0	79.2	79.0	77.5	76.8
Skinfold: 7 sites (mm)	51.9	45.1	47.7	48.9	42.7	42.2
Skinfold goal: 7 sites (mm)	45					

Table 10.4 Jamie's weekly training

Monday	11:30 am–1:00 pm 3:00 pm–5:00 pm	Advanced skills session training (running, drills, etc.)
Tuesday	9:00 am 4:00 pm	Individual skills Sprints
Wednesday	noon–1:00 pm	Training
Thursday	2:30 pm	Swimming
Friday	Evening	Game
Saturday	1:30 pm	Recovery swim session
Sunday		Rest or own training

Table 10.5 Jamie's food record (match day)

Breakfast	1 piece of toast with margarine and honey
11:00 am	Sports drink, 300 mL
Game	1 litre of sports drink
Post-game	1 muffin
Dinner	Large bowl of pasta with vegetables, followed by ice cream

Jamie's Dietary Plan

Jamie usually felt too nervous to eat breakfast on the morning of the game. The dietitian reassured Jamie that he did not have to eat a lot for breakfast, but that it was important to eat some carbohydrates to provide the muscles with enough fuel for the entire game.

The dietitian suggested trying liquid meals, which have the advantage of being high in energy and low in bulk. These included Sustagen Sport and homemade milkshakes. Light snacks such as bananas, muffins, fruit juice, fruit jelly, sports bars, pikelets, raisin bread and honey or jam sandwiches were included in the pre- and post-game snack list. Jamie refuelled after matches with easily digested carbohydrates, such as rolls with low-fat fillings (lean meat and cheese), muffins and jelly lollies.

For days other than match days, Jamie and the dietitian worked on having large regular meals and snacks and including nutritious milk drinks, as a convenient way to supply the carbohydrate and protein needed to maintain weight and put on muscle mass.

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Table 10.6 Jamie's sample meal plan

Breakfast	Toast with margarine and honey. Cereal with yoghurt, banana and milk
11:00 am	Liquid meal supplement and a cereal bar
Game	1 litre of sports drink
Post-game	Ham and cheese roll, jelly beans. More sports drink
Dinner	Large bowl of pasta with vegetables. Ice cream and tinned fruit

Jamie's weight returned to 79 kg, while maintaining his skinfold measurement around 45 mm. He felt a lot stronger in his training sessions.

Andrea Brakhuis and the Department of Sports Nutrition, AIS

Swimming

With swim training, typically six to 12 sessions are undertaken each week, with the distance covered in each session ranging from 1000 to 2000 metres of quality work for a sprinter in taper phase to 10 kilometres for a distance swimmer in the base phase of training. At the elite level, workloads can involve two to three daily sessions, adding up to six hours of training per day. In addition, swimmers may undertake some land-based aerobic training such as running or cycling as well as weight-training sessions. Training commitments are usually smaller at club or school levels.

Competition

Olympic swimming events last from 20 seconds to 15 minutes, making it a highly anaerobic sport, with aerobic metabolism becoming more important as the race distance increases. Although each event may be brief, swim competitions are usually held over three to seven days, with swimmers typically competing in heats in the mornings and finals in the evening. In minor carnivals, swimmers may enter a large number of events and be required to swim two or three times in one day, with 20 minutes to several hours between events.

Other issues

Many top swimmers are in their teens. Male adolescence is a period of heavy growth and muscular development, requiring high-energy support. For males, the addition of an intense training program means male swimmers can have trouble eating enough kilojoules to meet energy needs. Adolescence for females brings hormonal changes, which promote an increase in body fat. Despite heavy training loads, many female swimmers can struggle to maintain low body fat levels. Long training hours restrict a swimmer's lifestyle. This can either reduce the opportunities to eat in a busy daily schedule or raise the importance of eating for comfort or entertainment.

Figure 10.5 Elite level workloads can involve three daily sessions

Daily recovery

Strenuous daily training requires a high-energy, high-carbohydrate diet. Swimmers who fail to consume enough carbohydrates will fail to recover adequately between training sessions, resulting in fatigue, loss of body weight and poor performance. Additional energy requirements for growth may compound the problem. Swimmers with high-energy requirements need to increase the number of snacks during the day and make use of energy-dense foods. It is good to have nutritious carbohydrate-rich snacks on hand to eat straight after training to start the refuelling process. This is especially important for swimmers who travel long distances from the pool to work or home, and have to wait until the next meal can be consumed.

Fluid needs in training

High-intensity exercise in the humid environment of a heated indoor pool, or outdoors in the sun, can lead to moderate sweat losses, which can be masked when the swimmer is already wet. Smart swimmers bring drink bottles to the pool deck and drink between sets. Sports drinks provide an additional fuel supply for longer training sessions. A fluid-balance study undertaken on the Australian Swimming Team in Atlanta in 1995 measured an average sweat loss of 125 mL per kilometre in training, or about 600 mL per workout. These swimmers were provided with both water and sports drinks at the session and managed an average intake that perfectly matched their losses (125 mL per km). Of course, some swimmers were better at matching losses than others. During anaerobic threshold sets at higher intensities, sweat losses increased to 170 mL/km and must be matched by equal fluid intake.

Sports waters and sports drinks

Sports drinks

There are many different claims made by manufacturers of sports drinks, but it is difficult to make comparisons because the products are always changing. Check the *AIS* supplements program fact sheet on sports drinks for the latest information.

Summary of nutrition and hydration guidelines for athletes

An athlete's nutrition and hydration requirements vary depending on whether they are pre, during or post-competion, as summarised in Table 10.7.

Table 10.7 Nutrition and hydration guidelines for athletes

3–4 days prior to competition	3–4 hours before competition	1–2 hours before and during competition	Post-competition
Nutrition			
Carbohydrate loading for longer-duration events	Low-GI foods to provide slow release of glycogen	High-GI foods to boost readily available glycogen	Initially require high-GI foods
Reduce fats and high protein foods (1–2 days before competition)			Salty foods to help sodium replacement
Examples: pasta, bread	Examples: crumpets with jam or honey, baked beans on toast, breakfast cereal with milk, fruit salad and yoghurt, pasta and vegetables	Examples: liquid meal supplement, fruit smoothie, sports bars, fruit-flavoured yoghurt, fruit, sports drink, jelly lollies, carbohydrate gel	Examples: banana sandwich on wholemeal bread, high sugar drinks
Hydration			
	Consume 200–600 mL prior to competition. Have fluid with all meals and snacks	Use 200 mL per 15 minutes of exercise as guide to rehydration	Will need to drink 150% of any fluid deficit in the 4–6 hours after exercise to account for ongoing sweat and urinary losses
	Use body weight pre- and post-game to determine post-game fluid quantities		Use body weight pre- and post-game to determine post-game fluid quantities

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Examples: water and sports drinks are the best option	Examples: water and sports drinks are the best option	Examples: water and sports drinks are the best option	Examples: water and sports drinks are the best option
Non-nutritional intervention			
Physiological aids	Aim to enhance the physiological processes that occur naturally in the body		Examples: altitude training and physiotherapy
Mechanical aids	Designed to improve energy and biomechanical efficiency		Examples: specialised equipment and clothing
Pharmacological and hormonal aids	Broad category that covers a range of substances that are generally considered illegal when taken for the purpose of improving sports performance		Examples: anabolic steroids and human growth hormone
Psychological aids	Activities and skills that aim to improve mental strength		Examples: mental imagery and goal setting

Iron status

An iron imbalance may occur in swimmers undertaking heavy training who fail to consume sufficient iron. Iron levels should be checked regularly when in heavy training. Iron-rich foods such as lean red meat and breakfast cereals fortified with iron should be included regularly in the swimmer's diet. Iron-rich plant foods such as wholegrain cereals, spinach and legumes should be combined with animal iron sources such as wholegrain pasta with bolognese sauce.

Competition nutrition

Muscle glycogen stores can be filled by 24 hours of rest and a high-carbohydrate diet. Swimmers undertaking a long taper may need to reduce total energy intake to match their reduced workload, otherwise they will gain body fat. Fluid levels and carbohydrate stores need to be replenished between events, and between heats and semi-finals or finals. Drink a carbohydrate-containing fluid such as a sports drink, fruit juice or soft drink when there is only a short interval between races. Snacks such as yoghurt, fruit, cereal bars or sandwiches are suitable for longer gaps between races, or for recovery at the end of a session. Between day heats and evening final sessions, most swimmers eat a high-carbohydrate lunch and have a nap. On waking, a carbohydrate-rich snack is eaten before returning to the pool.

Catchy fact

Taking Vitamin C with a meal improves iron absorption; for example, a glass of orange juice after breakfast cereal. Drinking a sports drink during training and having a recovery snack afterwards helps to reduce the stress on the immune system.

KEEP IT REAL!

Grant was a young up and coming swimmer who began to struggle with fatigue after joining the elite training squad. As Grant's training sessions increased to 12 per week, his times began to drop off and he struggled to maintain weight.

A sports dietitian examined Grant's diet and found additional carbohydrate was needed to cover Grant's extra training needs. In particular, more carbohydrate was needed for Grant to replenish muscle glycogen stores between sessions. At 80 kg, a daily intake of 600 g to 800 g of carbohydrate each day was required.

Although Grant loved to eat high-carbohydrate foods such as bread, cereal, fruit, potato, rice and pasta, he struggled to consume sufficient quantities of these bulky foods each day. Grant's dilemma was solved by increasing the number of meals consumed and making use of portable, easy-to-eat snacks.

With some planning and preparation Grant made sure he always had access to quick, easy-to eat, high-carbohydrate snacks such as smoothies, liquid meal supplements, cereal bars, sports drinks, yoghurt, fruit and bread. He started having carbohydrate-rich foods and drinks immediately after each training session so that muscle glycogen storage was activated as quickly as possible. Grant's intake was increased to 800 g to 900 g of carbohydrate and 21 000 to 23 000 kilojoules each day. Within three weeks, Grant had regained some weight and was feeling a new energy at training.

KEEP IT REAL!

Table 10.8 Sample high-carbohydrate (high-energy) eating plan for Grant

Pre-training	Cereal bar and carton of fruit-flavoured yoghurt
During training	Sports drink
Breakfast	Brought from home and eaten at the pool after training: two large bowls of cereal with banana and milk, 500 mL fruit juice
Mid-morning	500 mL liquid meal supplement (e.g. PowerBar Protein plus powder) large piece of muesli slice, grab-pack of mixed dried fruit and nuts
Lunch	Three rolls with salad and meat/egg/chicken/cheese, two small cartons of fruit-flavoured yoghurt,fruit juice
Before training	250 mL liquid meal supplement
After training	Sports drink, plus two cereal bars on way home from pool
Dinner	Large serve of rice, pasta or potatoes Stir fry with lean meat or fish or skinless chicken and vegetables Bread or bread rolls Fruit juice
Desert	Custard and jelly
Before bed	Fruit smoothie with skim milk, fruit, ice cream and skim-milk powder

Adapted from Louise Burke and the Department of Sports Nutrition, AIS

Checkpoints

1 If a player wanted to decrease their percentage of body fat in an effort to 'make skinfolds', outline a dietary and training combination that would allow them to achieve this.

2 'Swimmers wouldn't sweat a great deal because they train and compete in constant water temperatures.'

- **a** Briefly discuss this statement and its implications for optimal performance for swimmers involved in training sessions that last 30 minutes or more.
- **b** Swimmers often go straight from the pool to school. What dietary modifications should they consider to ensure adequate recovery from training sessions and increased abilities to concentrate and perform at school?

3 Protein often makes up a larger percentage of total dietary intake for players involved in contact sports such as football, martial arts, rugby, etc., than players in non-contact sports. Briefly discuss why this is the case. Discuss the role protein plays in recovery, other than building muscle.

4 Some athletes are vegetarians.

- **a** What foods must they eat to obtain iron in their diet?
- **b** What role does iron play in assisting an athlete?
- **c** What symptoms would an athlete suffering from iron deficiency display that might signal their deficiency to the coach?

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Post-exercise and recovery

According to Louise Bourke (1995), nutritional recovery priorities include:

- restoring fuel expended from the muscles and liver
- replacing the fluid and electrolytes lost in sweat
- manufacturing new muscle protein, red blood cells and other cellular components as part of the repair and adaptation process.

Athletes must provide their bodies with all the nutrients they need, in a timely and efficient manner, to optimise the desired recovery processes following each session. State-of-the-art guidelines for refueling, rehydration and muscle repair are presented below.

Catchy fact
Carbohydrate intake can be beneficial to the immune system. It reduces the stress-hormone response to exercise, minimising its effect on the immune system. Carbohydrates also supply glucose to fuel the activity of many of the white cells in the immune system.

electrolytes
mineral salts

Refueling

Muscles can restore glycogen levels by about five per cent per hour, provided sufficient carbohydrate is eaten. Depending on the training workloads and the need to fuel up to perform, a serious athlete may need to consume 6 to 10 g of carbohydrate per kilogram of body weight each day (300–700 g per day). Athletes should consume carbohydrates as soon as possible after an exhausting workout, either at their next meal or as a light snack, to prepare for the next workout.

Rehydration

Most athletes complete training or competitions with some level of fluid deficit; comparing pre- and post-session body weights can provide an approximate fluid deficit. During hot and humid conditions or after strenuous sessions, fluid losses are usually large and require concerted efforts to rehydrate.

Catchy fact
Protein needs to be consumed with carbohydrate foods to maximise the muscle rebuilding effect. Carbohydrate intake stimulates an insulin response, which stimulates the increase in protein uptake and rebuilding.

Muscle repair and building

Prolonged and high-intensity workloads cause a substantial breakdown of muscle protein. During the recovery phase there is a reduction in catabolic (breakdown) processes and a gradual increase in anabolic (building) processes. Early intake of essential amino acids helps to promote the increase in protein rebuilding. Protein consumed immediately after a training session is taken up more effectively by muscle rebuilding processes than protein consumed in the hours afterwards. For resistance training work-outs, such as weight training, protein should be consumed immediately before the session.

For athletes such as swimmers, who undertake two or more training sessions each day, eating for recovery plays an important role in their daily nutrient uptake. Meals must be eaten straight after the work-out, or special recovery snacks must be consumed in order to cover nutrient needs until the next meal can be eaten.

Athletes with high-energy needs require snacks to contribute towards to their total daily kilojoule needs. When there is a large kilojoule budget to play with, it may not matter too much if the snacks only look after the key recovery nutrients, such as carbohydrate, or contain extra kilojoules from fat. For athletes such as footballers, whose skinfold goals require careful kilojoule monitoring, recovery snacks should be low in fat. Snacks that can supply special needs for calcium, iron or other nutrients may double up as recovery snacks and good overall choices.

Some athletes consume lollies as a means of taking in simple carbohydrates and meeting their refueling goals. However, lollies do not provide protein, fluid or other nutrients that are important in other recovery processes. Figure 10.6 shows ideas for snacks providing carbohydrate, as well as carbohydrate-protein combinations.

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Carbohydrate-rich recovery snacks (50 g CHO portions):

- 700–800 mL sports drink
- 2 sports gels
- 500 mL fruit juice or soft drink
- 300 mL carbohydrate loader drink
- 60–70 g packet jelly beans or jubes
- 2 slices toast/bread with jam or honey or banana topping
- 1 large chocolate bar (80 g)
- 2 cereal bars
- 1 cup thick vegetable soup + large bread roll
- 115 g (1 large or 2 small) muffins, fruit buns or scones
- 300 g creamed rice
- 300 g (large) baked potato with salsa filling
- 100 g pancakes (2 stack) and 30 g syrup

Nutritious carbohydrate-protein recovery snacks, containing 50 g CHO and sources of protein and micronutrients:

- 250–300 mL liquid meal supplement
- 250–300 mL milk shake or fruit smoothie
- 1–2 sports bars (check labels for carbohydrate and protein content)
- 1 large bowl (2 cups) breakfast cereal with milk
- 1 large or 2 small cereal bars and a 200 g carton fruit-flavoured yoghurt
- 220 g baked beans on two slices of toast
- 1 bread roll with cheese/meat filling and a large banana
- 300 g (bowl) fruit salad with 200 g fruit-flavoured yoghurt
- 2 crumpets with thick spread peanut butter and 200 mL flavoured milk
- 300 g (large) baked potato with cottage cheese filling and a glass of milk
- 200 g (1/3–1/4 pizza) with chicken or meat and vegetables

Figure 10.6 Recovery snacks

Coursework: Data collection and analysis

The aim of this activity is to reflect on food-intake patterns for various class members. It would be ideal to divide the class into two groups.

- Group A: students who train for or play sports more than twice per week
- Group B: students who have lesser sporting involvement.

Students are required to keep a log of their food and fluid intake over a one-week period. This should include the following information, where relevant.

Table 10.9

Pre-training	
During training	
Breakfast	
Mid-morning or recess	
Lunch	
Before training	
After training or after school	
Dinner	
Dessert	
Before bed	

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1 Work in groups to calculate the amount of carbohydrate, protein, fat and fluids you each consume on a daily and weekly basis, then compare your results to students in the other groups. Key considerations should include the following.

- **a** What are the main differences between the two groups?
- **b** Do any students have a fluid 'imbalance' based on the amount of training or activity they participate in?
- **c** Some people believe it's not good to consume food prior to going to bed. Why do you think they have this belief? Outline why this makes good sense in some circumstances.

The glycaemic index

The glycaemic index (or GI) is a ranking for carbohydrates on a scale from 0 to 100, according to the extent that they raise blood-sugar levels after eating. High-GI foods are those that are rapidly digested and absorbed, and are often most useful as a dietary recovery strategy. Low-GI foods are slowly digested and absorbed, and are most useful for providing extended and endurance activities with on-going energy sources. These are often consumed as pre-endurance foods. Low-GI foods consumed prior to participating in endurance activities that last longer than 60 minutes will lead to minimal changes in blood glucose levels and insulin being secreted to regulate changed blood glucose. As a result, the level of free fatty acids available in the blood is relatively high and they are thus used first as a fuel source, leading to glycogen sparing.

Moderate- to high-GI foods, gels or drinks consumed during extended endurance activities increase carbohydrate availability and enhance performances. It is worth noting that insulin response to high-GI foods is suppressed during these exercise intensities.

Proteins and fats contain no carbohydrate, and have minimal effect on glucose production. These foods are considered low GI. Foods high in fibre increase the time it takes our bodies to break them down, so they are considered to have low GI. Sports drinks and other foods with a high concentration of glucose (thus needing no further breakdown) raise blood glucose levels quickly and are considered to be high GI. Fruits (fructose) are slow to be broken down, as are most dairy products containing lactose, so both are considered to be low-GI foods. Sucrose has a medium release and a moderate-GI rating.

glycaemic index
a ranking of carbohydrates based on their immediate effect on blood glucose levels

blood sugar
the main sugar found in the blood, and the body's main source of energy

glycogen sparing
the ability to use fats earlier and faster during performance that accompanies aerobic or endurance training

glucose
a sugar produced by the metabolism (or breakdown) of carbohydrates; a major source of energy for most cells of the body

Table 10.10 The glycaemic index of common foods

High-GI foods (85–100)			
Breads, cereals and breakfast	Baguettes	Crunchy nut cornflakes	Puffed wheat
	Bagels	Dark rye bread	Rice crackers
	White or wholemeal bread	Gluten-free bread and rice	Ricebubbles
Vegetables	Broad beans	Mashed potato	Pumpkins
Fruits	Dates	Bananas	Watermelon
Snacks	Corn cakes	Jelly beans / babies	Glucose-based sports drinks
	Fruit bars	Popcorn	Wafer biscuits
	Honey	Rice cakes	Waffles

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Moderate-GI foods – Index Foods (60–85)			
Breads, cereals and breakfast	Pancakes	Cornflakes	Basmati rice
	Toast	Whole wheat rye bread	Brown rice
	Crumpets	Rye crispbreads	Oatmeal
Vegetables	Broad beans	Carrots	Potatoes
Fruits	Dried figs	Oranges, pineapples	Canned fruit ~ pears, peaches, etc
Snacks	Ice cream	Oatmeal biscuits	Potato chips
	Muesli bars	Pea soup	Raisins
	Muffins	Plain cake	Potato chips
Low-GI foods(<60)			
Breads, cereals and breakfast	Barley	Rice bran	Toasted muesli
	Grain breads	Rice noodles	Apple juice
	Oats and oat bran	Yoghurt	Seeded breads
Vegetables	Baked beans	Lentils	Sweet potatoes
Fruits	Dried apples, apricots	Pears	Peaches
Snacks	Apple juice	Hot chocolate	Milo in skim milk
	Cashew nuts	Skim milk	Tortillas (corn and wheat)
	Corn chips	Peanuts	Yoghurt ~ Low fat

Energy systems

respiration
metabolic processes in cells leading to the production of energy by the breakdown of organic substances

Glycogen, free fatty acids and amino acids are transported to the cells, where they are broken down into carbon dioxide (CO_2) and water (H_2O), releasing chemical energy via respiration. This energy is transformed into mechanical energy when it is used by the muscles to contract. Energy released during respiration cannot be used directly to perform work and is used to create adenosine triphosphate (ATP), which is stored at muscles around the body. There are three pathways (or energy systems) responsible for the recycling of ATP and the supply of energy. All three energy systems contribute to energy production during exercise to varying amounts, depending upon:

- the duration of the exercise
- the intensity of the exercise
- the availability of oxygen
- the availability and restoration of chemical or food fuels.

Table 10.11 shows that during moderate intensity exercise equal amounts of fats and carbohydrate supply energy for activity. As exercise continues beyond one hour, there is greater use of fats and progressive depletion of glycogen. At the end of prolonged exercise, fat circulating in blood as free fatty acids provides 80 to 95 per cent of the energy until liver glycogen is fully depleted, which takes three or more hours.

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Table 10.11 Energy systems and food fuels at various exercise intensities and durations

Intensity	Total event duration	Dominant energy system	Food / chemical fuel
Rest	Not applicable	Aerobic	Glucose and FFAs
Submaximal	30 seconds	Aerobic	Glucose and FFAs
Submaximal	30 minutes	Aerobic	CHO
Submaximal	3+ hours	Aerobic	FFAs
Maximal	1–3 seconds	ATP–PC	Stored ATP
Maximal	5 seconds	ATP–PC	Remaining stored ATP–PC
Maximal	30 seconds	Lactic Acid	CHO
Maximal	75 seconds	50% ATP–PC and lactic acid 50% aerobic	CHO

CHO = Carbohydrate
FFAs = Free fatty acids

free fatty acids (FFAs)
energy storage molecules; a byproduct of the breakdown of fats

Table 10.12 shows the effect that fuel depletion and exercise intensity have on the major fuels called upon to resynthesise ATP and provide energy for muscular contractions. ATP is energy!

Table 10.12 Percentage contribution of various fuel sources to ATP generation in athletics running events

Event	PC	Glycogen anaerobic	Glycogen aerobic	Blood glucose	Triglycerides (fatty acids)
100 m	50	50	–	–	–
200	25	65	10	–	–
400 m	12.5	62.5	25	–	–
800 m	6	50	44	–	–
1500 m	PC in the first few secs	25	75	–	–
5000 m	PC in the first few secs	12.5	87.5	–	–
10 000 m	PC in the first few secs	3	97	–	–
Marathon	–	–	75	5	20
Ultra-marathon (80 km)	–	–	35	5	60
24-hour race	–	–	10	2	88

The major source of energy that keeps every cell in the body going, including muscles, is called adenosine triphosphate (ATP) .This is the most important way we store and use

adenosine triphosphate (ATP)
a chemical compound formed with the energy released from food and stored in all cells, especially muscles

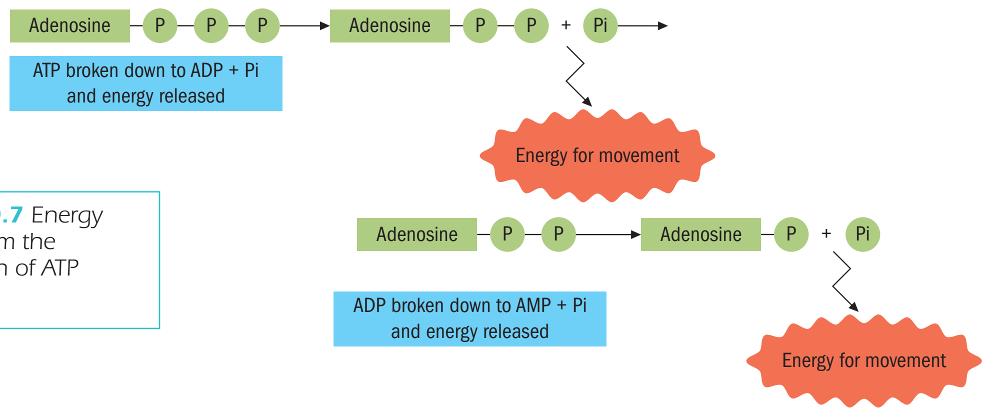

Figure 10.7 Energy release from the breakdown of ATP and ADP

adenosine diphosphate (ADP) substance produced from the breakdown of ATP to supply energy to working muscles

creatine phosphate (CP) compound that transfers phosphate and energy to ADP to generate ATP; source of energy for muscle tissue

energy-system interplay a situation where all three energy systems contribute to ATP production, with one system being the major ATP producer

energy. ATP consists of an adenosine molecule with three phosphates joined together in a row. ATP is a chemical fuel source. Energy released by breaking one of the phosphate bonds from ATP results in energy release for muscles to contract. Energy is released when phosphate splits off and adenosine triphosphate (ATP) is then broken down to adenosine diphosphate (ADP).

The chemical reaction that turns the energy contained in ATP into energy for use in muscular contraction can be summarised as follows:

- Chemically, ATP is an adenine nucleotide bound to three phosphates.
- There is a lot of energy stored in the bond between the second and third phosphate groups that can be used to fuel chemical reactions.
- When a cell needs energy, it breaks this bond, releases a large amount of energy and also forms adenosine diphosphate (ADP) and a free phosphate molecule.
- When the cell has excess energy, it stores this energy by forming ATP from ADP and phosphate.

Creatine phosphate (CP) is another chemical fuel source similar to ATP that contains a high-energy phosphate bond. Energy is constantly transferred when energy is released from the break down of CP, glucose, FFAs and amino acids and their bonded energy released.

As mentioned previously, there are three energy systems: two anaerobic and one aerobic. All three energy systems are activated at the start of exercise, with one of them being the major contributor towards ATP resynthesis and energy production depending on the intensity, duration and availability of fuels. When all three systems are working together, this is called energy-system interplay.

Checkpoints

1 Energy is provided from all three energy systems, as well as all three major food groups.

a When working submaximally for three hours or more, such as going for a jog, why do free fatty acids become the major fuel supplying energy?

b What is a major disadvantage in switching from carbohydrates to fats as a major fuel during an endurance event?

c Describe a strategy that performers in endurance events can use to delay the switch to fats as a major fuel. Refer to the Glycaemic Index in your response.

2 Explain the importance of retaining high blood-glucose levels during high-intensity interval sprints, and the likely effect decreased fuels stores will have on performance.

3 The swimmer profiled in Table 10.8 takes skim milk powder before going to bed.

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Many high-performance athletes consume larger amounts of skim milk powder than the average Australian. Of what benefit is this practice to their performances?

4 **a** Under what exercise or performance conditions do proteins become the major fuel providers?

b What could we expect to see occurring to performance levels when proteins become the major fuel providers? Why would this occur?

What is a balanced diet?

A balanced diet contains a wide variety of foods, including nutrients. Athletes' needs vary: a balanced diet for an endurance athlete will not be a balanced diet for a sprinter. As mentioned previously, different foods provide different fuels and nutrients, and these are used for different functions.

The food pyramid

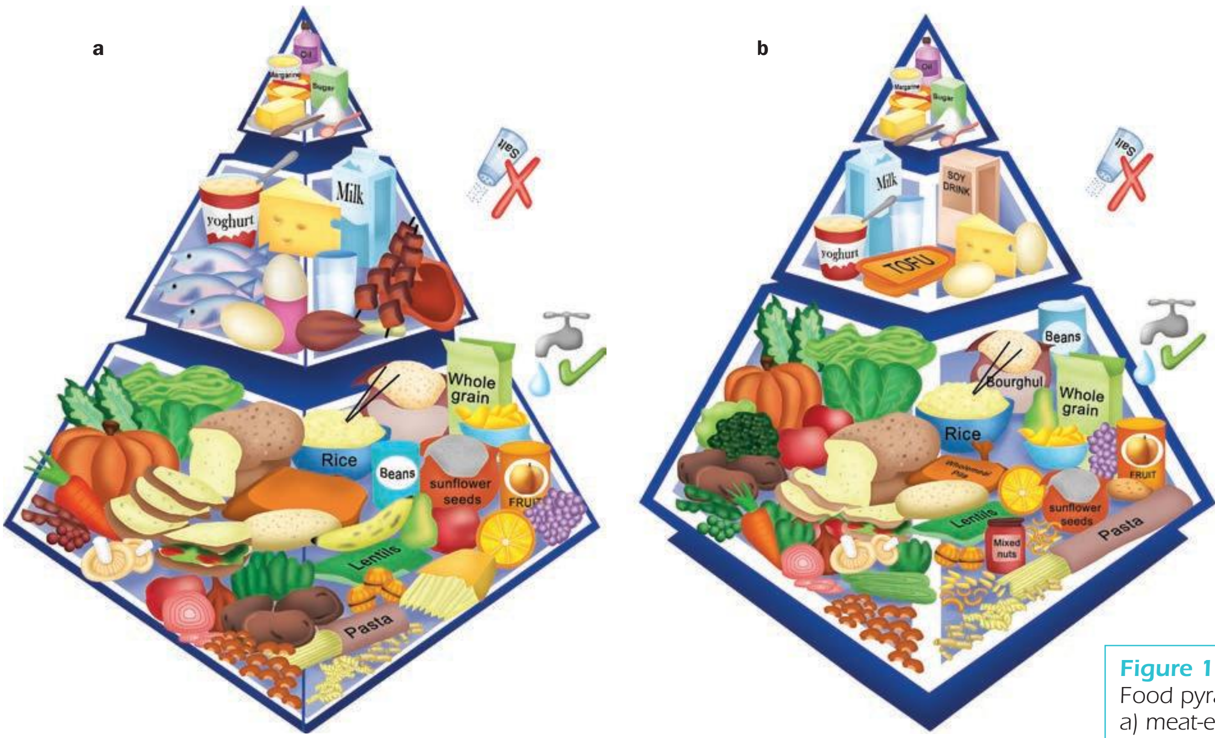

Figure 10.8 Food pyramids for a) meat-eaters and b) vegetarians

Nutritionists have divided foods into various food groups, which are generally arranged in this order:

1 Bread, cereal, rice and pasta
2 Fruit and vegetables
3 Meat, poultry, fish, dry beans, eggs, nuts
4 Milk, yoghurt and cheese
5 Fats, oils and sweets

In a balanced diet, people eat more of the foods in Group 1, with gradually decreasing amounts from Groups 2, 3, 4 and 5. The balance is obtained by supplying athletes with sufficient foods from each group to meet their training, competition and recovery requirements.

Recommended dietary intakes (RDIs)

NHMRC

In 2006, the National Health and Medical Research Council (NHMRC) released updated recommended dietary intakes for energy (kilojoules), fluids and more than 40 vitamins and minerals needed at all stages of life. For the first time, they also recommended dietary intakes of nutrients for preventing chronic disease.

By choosing foods from each of the major food groups daily, taking care to choose healthier options within each group and include some foods that contribute healthy fats to the diet, most people will be likely to get enough vitamins and minerals to meet their requirements.

The five food groups

Table 10.13 The five food groups and recommended daily intakes

	Food content is high in …	Typical foods	The *Australian Guide to Healthy Eating* recommendation	One serve equals:
Bread, cereals, rice, pasta	Carbohydrates, fibre, B vitamins and minerals, essential fatty acids	Wholegrain choices in particular, such as: wholemeal bread pasta brown rice oats corn tortillas	At least four serves daily, but you can eat less if you choose wholegrain varieties	2 slices of bread or 1 bread roll; 1 cup of cooked rice, pasta or noodles; $1\frac{1}{3}$ cups flaky breakfast cereal, $\frac{1}{2}$ cup muesli or 1 cup cooked porridge
Vegetables and legumes Fruit	Fibre, vitamin A, vitamin C and folate Fructose, fibre, vitamin C and folate	cabbage, spinach, broccoli, carrot, sweet potato, pumpkin, tomato , apples, oranges, bananas, peaches, grapes, fruit juice, dried fruit	Aim for at least five serves daily Aim for at least two serves daily	1 cup of salad $\frac{1}{2}$ cup of vegetables or legumes 1 potato 1 medium piece, such as an apple, orange or banana, or 2 small fruits such as apricot or kiwifruit 1 cup of diced or canned fruit 4 pieces of dried fruit or $1\frac{1}{2}$ tablespoons of sultanas $\frac{1}{2}$ a glass of juice (125 mL)
Meat, fish, poultry, eggs, nuts, legumes	Protein, vitamin B12, zinc and iron in varying amounts	lean red meat, fish, salmon or tuna, pork, chicken, legumes, eggs	At least 1 serve each day; for optimal nutrition, at least 2 serves from this group daily is ideal	85 g cooked lean beef, lamb, veal, pork or chicken; 100 g cooked fish; two eggs; $\frac{1}{2}$ cup cooked dried beans, lentils or chickpeas, or $\frac{1}{3}$ cup peanuts or almonds
Milk, yoghurt and cheese	Protein, calcium, riboflavin and vitamin B12, phosphorus, vitamin A, and vitamin D	yoghurt, skim milk, cheese, cream, dairy products usually made from cows' milk	At least two serves daily; choose low- and reduced-fat versions	1 glass of milk (250 mL) or calcium-fortified soy milk; 40 g cheese; 200 g carton of low fat, yoghurt or 1 cup of custard

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Fats and oils	Fats	Healthy fats come from foods such as: • vegetable oils • unsaturated margarines • avocado • nuts and seeds • peanut butter Unhealthy fats are found in: • butter • ice cream • sugars • chocolate • cream		2 teaspoons of oil 3 teaspoons of unsaturated margarine, 2 tablespoons of avocado

Australian Guide to Healthy Eating, 2008

Hydration considerations

hypohydration total body water or fluid below normal levels

Hypohydration impairs the body's ability to regulate heat, resulting in increased body temperature and an elevated heart rate. Perceived exertion is increased, causing the athlete to feel greater fatigue than usual at any given work rate. Mental function is reduced, which can have negative implications for motor control, decision-making and concentration. Gastric emptying is slowed, often resulting in stomach discomfort. All these effects lead to poorer performances. Most types of exercise are adversely affected by hypohydration, especially when they are undertaken in hot conditions.

By drinking regularly during exercise, athletes can prevent declines in their concentration and skill levels, improve their perceived exertion, prevent excessive elevations in heart rate and body temperature, and improve performance.

Rehydration rates

Fluid requirements vary remarkably between athletes and exercise situations. Fluid losses are affected by:

- genetics: some people sweat more than others
- body size: larger athletes tend to sweat more than smaller athletes
- training: 'fitter' people sweat earlier in exercise and in larger volumes
- environment: sweat losses are higher in hot, humid conditions
- exercise intensity: sweat losses increase as exercise intensity increases.

Athletes can easily estimate their own fluid requirements by weighing themselves before and after exercise sessions. Each kilogram of weight lost is equivalent to one litre of fluid. Adding on the weight of any fluid or food consumed during the exercise session will provide an estimate of total fluid loss for the session. For example, an athlete who finishes an exercise session one kilogram lighter and has consumed one litre of fluid during the session, has a total fluid loss of two litres.

It is better to begin drinking early when exercising and drink small volumes regularly rather than trying to tolerate larger volumes of fluid, which may cause gastric disturbances.

Catchy fact

Most athletes can tolerate 200 mL to 300 mL fluid every 15–20 minutes but tolerance will vary according to the exercise intensity and rate of dehydration.

How much do athletes actually drink?

Athletes typically replace 30 to 70 per cent of sweat losses during exercise. Fluid replacement is an issue for all sports, including sports such as swimming and water polo conducted in wet

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environments, and sports conducted in air-conditioned stadiums. There are many reasons for athletes failing to drink enough to replace fluid losses. Some athletes are so focused on training or competing that they forget to drink, while others fear stomach discomfort. Drinks need to be cool, pleasant to taste and easily accessed or they will not be consumed. The sensation of fluid in the mouth sends nerve signals to the brain that switch off the drive to drink. When low-sodium fluids such as water, juice and cordial are consumed, the desire to drink is often switched off before the athlete has consumed sufficient fluid to match sweat losses.

Is it possible to drink too much?

hyponatraemia
low blood sodium levels

Consuming fluid in excess of requirements may cause gastrointestinal discomfort. In extreme cases, a condition called hyponatraemia can occur. Hyponatraemia causes symptoms similar to dehydration, and is potentially life threatening. Consuming fluids containing sodium, such as sports drinks, and matching fluid intake to sweat loss lowers the risk of hyponatraemia.

What should athletes drink?

Research shows that fluid intake is enhanced when beverages are cool (around 15 °C), flavoured and contain sodium. This makes sports drinks an ideal choice during exercise. Sports drinks are not gimmicks. They are legitimate products that are well researched and proven to improve fluid intake and performance. A lot of science has gone into developing the flavour profile of sports drinks so that they encourage fluid intake during exercise. In addition, sports drinks contain carbohydrate at a four to eight per cent concentration, which allows refuelling to take place during exercise.

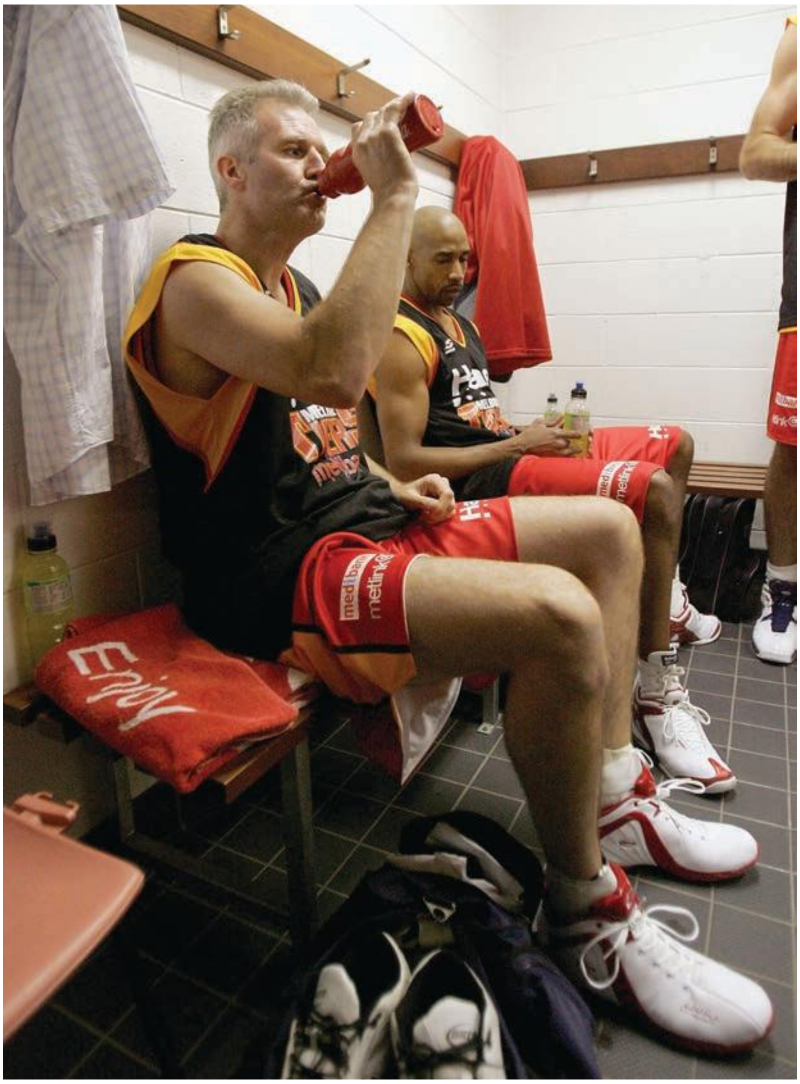

Figure 10.9 *Fluid intake needs to be matched to sweat losses*

Several studies demonstrate that use of sports drinks improves fluid intake. A study conducted in 1999 with AIS netball and basketball players demonstrated better fluid balance with a sports drink compared to water. This is consistently observed across all AIS sporting programs. Even athletes who prefer to drink water during exercise demonstrate better fluid intake when forced to drink sports drinks.

Water is still a suitable option during exercise. However, water drinkers need to be aware that water does not stimulate fluid intake to the same extent as sports drinks. Cordial, soft drinks and juice generally contain greater than ten per cent carbohydrate and are low in sodium. This slows down gastric emptying and makes these drinks a less suitable choice, especially for high-intensity activity. Some athletes exercising at low intensities may tolerate juice, soft drink and cordial, but sports drinks are the better option in most situations.

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Which sports drink is the best?

Sports drinks sold in Australia are very similar in composition due to food standards.

Table 10.14 The carbohydrate (CHO) and sodium content of popular sports drinks

Drink	CHO (%)	Sodium (mmol/L)
Gatorade	6	18
Powerade	8	4
Adam's Ale Sport	6	10
Staminade Sport	6.8	10
PB Fluid and Electrolyte Replacement	6.8	25

Summary of fluid guidelines

- Begin each exercise session in fluid balance, which requires drinking regularly throughout the day leading up to training or competition. Drink with all meals and snacks.
- Immediately before exercise commences, consume 200–600 mL of fluid.
- Develop a plan for fluid intake for all exercise sessions longer than 30 minutes. Aim to match previous fluid losses as closely as possible (within one per cent of body mass). Take all opportunities within the sport to replenish fluid, such as time outs, scheduled breaks, etc.
- Begin drinking early in the exercise session and continue to drink small amounts regularly.
- Replace any residual fluid deficit after exercise. You will need to drink 150 per cent of any fluid deficit in the four to six hours after exercise to account for ongoing sweat and urinary losses. When fluid losses are high or rapid rehydration is required, sodium replacement may be required. Sports drinks, oral rehydration solutions and salty foods can all contribute to sodium replacement.

Adapted from Michelle Minehan and the Department of Sports Nutrition, AIS © Australian Sports Commission 2004

TEST YOUR KNOWLEDGE

>> multiple-choice questions

1 Carbohydrates should be consumed along with proteins in an effort to:

A meet the recommended daily intake for each of these
B maximise the muscle-rebuilding process
C maximise the carbohydrative effect.
D None of the above.

2 When considering the glycaemic index of carbohydrates, high-GI foods:

A are those that are rapidly digested and absorbed and are often most useful as a dietary recovery strategy
B are those that are slowly digested and absorbed and are often most useful as a dietary strategy for endurance athletes
C are often associated with glycogen sparing
D should be combined with free fatty acids to promote delayed use of glycogen during endurance events.

>> short-answer questions

1 When comparing the dietary intakes of AFL players between 1988 and 1999, one of the most significant changes has been seen in the percentage of carbohydrates that make up their diet.

Table 10.15 Suggested pre-exercise foods

3–4 hours before exercise	1–2 hours before exercise	Less than an hour before exercise, or during an event
Crumpets with jam or honey + flavoured milk	Liquid meal supplement	Sports drink
Baked potato + cottage cheese filling + glass of milk	Milkshake or fruit smoothie	Carbohydrate gel
Baked beans on toast	Sports bars (check labels for carbohydrate and protein content)	Cordial
Breakfast cereal with milk	Breakfast cereal with milk	Sports bars
Bread roll with cheese/ meat filling + banana	Cereal bars	Jelly lollies
3–4 hours before exercise	**1–2 hours before exercise**	**Less than an hour before exercise, or during an event**
Fruit salad with fruit-flavoured yoghurt	Fruit-flavoured yoghurt	
Pasta or rice with a sauce based on low-fat ingredients (e.g. tomato, vegetables, lean meat)	Fruit	

a Discuss two reasons why this may have occurred.
b Comment on why you believe alcohol has been almost totally removed from the dietary intake of players.

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2 Research the use of 'power bars' or 'energy bars' by athletes.
   - a What do these bars typically contain?
   - b Are they more beneficial to some athletes than others?
   - c Discuss how you could use these food bars to improve your performance in school sports training or competitions.

>> essay questions

1 Sport drinks consist of many different combinations of dissolved substances. Clearly discuss what needs to be present in sports drinks in order to do the following.
   - a Allow hydration to occur at rapid rates, and prevent decreases in performance caused by dehydration or elevated body temperatures
   - b Provide performers with stores of usable fuels to prevent fatigue caused by fuel depletion
   - c Maximise recovery from training in readiness for the next session or competition. Include in your response an indication of the amount of fluid that needs to be taken.

2 Design a pre-training meal and post-training or recovery meal for the following two sportspeople. Ensure that you include foods from each of the five recommended food groups in the food pyramid.
   - a An endurance runner participating in a 60-minute fartlek session conducted on hilly terrain
   - b A football player participating in a 45-minute weight session focusing on the development of power, followed by 45 minutes of team training focusing on tackling drills.

Your response should take the format of Table 10.16.

Table 10.16

	Pre-training meal	Main focus	Recovery meal	Main focus
Endurance runner				
Football player				

11 Environmental conditions and performance

acclimatisation becoming accustomed to a set of circumstances

The term 'environmental conditions' has many applications in sporting and performance contexts. For the purpose of this chapter, we will consider the environment to include any outdoor or indoor conditions that can potentially impact on performance: warm weather and humidity, cold weather or conditions, high altitude, pollution, wind speed and time-zone changes. All of these can be 'trained for' by adopting an acclimatisation regime.

An athlete's ability to overcome environmental conditions via acclimatisation requires specific training targeting the conditions an athlete is likely to face in upcoming performances. Acclimatisation relies upon the ability of various body systems to adapt to specific training circumstances over a period of time.

The article below profiles the specialised training of Australia's cyclists before the 2008 Beijing Olympics.

KEEP IT REAL!

When Michael Rogers and Cadel Evans hit the track in Beijing, they will be more prepared than ever, with an edge over their cycling competitors. Thanks to the efforts of innovative AIS sports scientists, they have been preparing on a high-tech simulation of the Beijing Olympic course.

At the 'Good Luck Beijing' Test Event in 2007, Australia was the only country with the foresight to fit cyclists with instrumentation to collect footage and detailed data profiling the course prior to the race.

Back in the lab, the data was integrated with other technologies including SRM (measures time, power, speed, distance and cadence), GPS (used to display the course map, elevation and course profile), a heart-rate monitor, a Veletron cycling ergometer, Cycleway computer software and a heat tent to replicate Beijing weather conditions.

This technology provided Australia's cyclists with the opportunity to ride a simulated Beijing course, with true physical and visual sensations. They felt what it's like to power up the killer hills in 35 °C heat and 60 per cent humidity, all while in the controlled conditions of the laboratory, where scientists can monitor multiple-performance variables and provide real-time feedback for the athletes.

Figure 11.1 Training in an acclimatisation tent

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So when the road race and individual time trial races commence on Saturday, Australia's cyclists will be confident in the knowledge that they have the edge to perform their best.

Evans is now one of the favourites to win gold in the time trial and Rogers is favoured to be among the medals. It would be a medal for the athlete, for Australia and for the dedicated scientists working behind the scenes.

Australian Institue of Sport

Checkpoints

1 Write a short essay of 1000 to 1200 words clearly outlining how SRM, GPS, a heart-rate monitor, a Veletron cycling ergometer, Cycleway computer software and a heat tent used to replicate Beijing weather conditions would provide an advantage for cyclists participating in the endurance cycling event. Your response must show how cyclists would use each apparatus to prepare them for the race they were training for at the Beijing Olympic Games.

Catchy fact

Leading up to the 1984 Los Angeles Olympics, American marathon runner Alberto Salazar changed from running 160 km per week on tracks and road circuits to running the same distance on a treadmill in his garage, with his car's engine running to mimic the pollution he was likely to encounter during the actual marathon. He placed 15th and last in the event! The world record at the time was held by Robert De Castella, with a time of 2:08:18 set in 1981.

Heat and humidity performance considerations

Normal core body temperature ranges from 36.5 to 37.5 °C. Maintaining this range is important if performances are to continue unimpeded. Performers need to maintain a balance between heat production and heat loss; if heat production exceeds heat loss, then core temperatures will rise, and hyperthermia or heat stress may result.

During exercise, 80 to 90 per cent of body heat can be produced internally as energy is released by exercising muscles. Externally, heat is attained from the air temperature, as well as from thermal and solar radiation. This heat must be lost promptly to facilitate cooling. It can be lost through radiation, conduction, convection or, most importantly, evaporation of sweat. Evaporation of sweat is a mechanisim to provide body cooling. High air temperature combined with high humidity levels impedes heat loss from the body.

Warm weather is often linked with high humidity, but most of Australia experiences 'dry heat', and high temperatures without the accompanying humidity tend to cause fatigue. It is the most common adverse environmental condition faced by athletes, with most activities occurring on land rather than in (or on) water. The effects of heat and humidity are calculated via a 'heat index' or humidex that combines the variables of heat and humidity and reveals how hot it really is.

hyperthermia
unusually high body temperature

Table 11.1 Heat index

Relative humidity (%)

Temperature (°C)

RH (%) T (C°)	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20
21	29	29	28	27	27	26	26	24	24	23	23	22					
22	31	29	29	28	28	27	26	26	24	24	23	23					
23	33	32	32	31	30	29	28	27	27	26	25	24	23				
24	35	34	33	33	32	31	30	29	28	28	27	26	26	25			
25	37	36	35	34	33	33	32	31	30	29	28	27	27	26			
26	39	38	37	36	35	34	33	32	31	31	29	28	28	27			
27	41	40	39	38	37	36	35	34	33	32	31	30	29	28	28		
28	43	42	41	41	39	38	37	36	35	34	33	32	31	29	28		
29	46	45	44	43	42	41	39	38	37	36	34	33	32	31	30		
30	48	47	46	44	43	42	41	40	38	37	36	35	34	33	31	31	
31	50	49	48	46	45	44	43	41	40	39	38	36	35	34	33	31	
32	52	51	50	49	47	46	45	43	42	41	39	38	37	36	34	33	
33	55	54	52	51	50	48	47	46	44	43	42	40	38	37	36	34	
34	58	57	55	53	52	51	49	48	47	45	43	42	41	39	37	36	
35		58	57	56	54	52	51	49	48	47	45	43	42	41	38	37	
36			58	57	56	54	53	51	50	48	47	45	43	42	40	38	
37					58	57	55	53	51	50	49	47	45	43	42	40	
38							57	56	54	52	51	49	47	46	43	42	40
39									56	54	53	51	49	47	45	43	41
40										57	54	52	51	49	47	44	43
41											56	54	52	50	48	46	44
42												56	54	52	50	48	46
43													56	54	51	49	47

Environment Canada

Key:

Humidex	Degree of comfort
20 - 29	No discomfort
30 - 39	Some discomfort
40 - 45	Great discomfort; avoid exertion
46 and over	Dangerous; probable heat stroke

Warm weather and humidity are readily adapted to by gradually acclimatising the body to the unaccustomed heat through living and training in warmer conditions. Most heat-acclimatisation programs suggest training at approximately 50 per cent capacity for the first four to seven days of the program. Most athletes will achieve 75 per cent heat acclimatisation within 10 days of commencement, with 100 per cent tolerance within 21 days. All heat training requires careful attention to hydration. The average adult requires a minimum of one litre of fluid replacement per hour in temperatures exceeding 25 °C; heat increases the body's production of sweat as it redirects blood to the skin's surface in an effort to promote cooling.

KEEP IT REAL!

This article looks at efforts to keep Australian athletes hydrated at the 2008 Beijing Olympic Games.

Aussie athletes cool off with a slushie

Slushies could prove the recipe for success in helping Australian athletes cope with intense heat during competition at the Beijing Olympic Games.

Australian sports scientists have been trialling the secret formula for slushies designed to help elite athletes combat heat and high humidity during the Beijing Games. Logistics dictated that scientists needed to implement

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simple strategies, as access to water and freezer space would limit the availability of ice baths and jackets previously used at the Games.

Australian athletes will sip on slushies made from a mixture of carbohydrate, electrolytes and ice, with other secret ingredients added to the drink. The slushie acts as an agent to retain additional water taken into the athlete's body through fluid they have consumed. This means the athlete passes less fluid through their body, retaining the fluid, which helps with hydration and thermoregulation.

The slushies will be used as an integral part of the pre-event cooling strategy and recovery for Australian cyclists competing in events like the road race and time trial.

Speaking from the Beijing Olympic Games, head dietician at the Australian Institute of Sport (AIS) Dr Louise Burke says the slushie formula is providing athletes with a simple and effective way to lower their core body temperature.

'The ice slushies have proven to be very effective in helping Australia's top athletes to reduce their body heat by one degree Celsius.'

Preliminary tests of slushies used by Australia's elite athletes have shown positive results in helping to maintain a lower body core temperature for longer.

Figure 11.2 Slushies were used by Australian cyclists as part of a pre-event cooling strategy

Slushies will be used by Australian athletes in rowing, cycling, triathlon, hockey, track and field and canoeing teams during competition at Beijing Olympic Games. The AIS is renowned for conducting groundbreaking sports science and technological innovation.

Australian scientists are working hard behind the scenes to help our athletes find improvements, preserve performance in the face of the Beijing climate, and gain a leading edge across Olympic sports. The AIS has kept at the forefront of sports science and technological innovation, playing a big part in Australia's sporting success.

Australian Institue of Sport

Exercise at high intensity that extends beyond 30 minutes, even in cool weather, may place performers at risk of heat stress. However, this risk is greatly increased in hot and humid conditions for two key reasons: humidity may restrict the adequate evaporation of sweat; during high temperatures, performers may not hydrate adequately, and may not be able to produce enough sweat to cool themselves.

Heat illness

If athletes can't cool themselves, they may suffer from heat illness. Symptoms of heat illness include:

- light headedness, dizziness
- nausea
- reduced or little sweating
- loss of skill, coordination or balance
- confusion

- irrational behaviour
- altered consciousness
- pale skin.

Competitors who collapse from low blood pressure during or after an activity are likely to be suffering from heat exhaustion. If core temperatures continue to rise during performances, altered consciousness and mental function are both likely to occur; this signals the onset of heat stroke.

The treatment of anyone exhibiting heat-related illness involves:

- stopping the activity immediately
- resting affected person in the shade (if available)
- removing excess clothing
- raising the legs and pelvis to improve blood pressure and blood flow back to the heart
- immediate cooling via application of ice packs to the armpits, groin and back of neck, or spraying cool water over major body parts
- vigorous fanning with towels to enhance evaporative cooling
- rehydration: oral, if person is conscious, or IV hydration by medical professionals
- calling for medical assistance or transfer to appropriate medical facility.

Rapid cooling, without causing hypothermia, improves recovery rates and eases distressed state.

hypothermia
dangerously low body temperature caused by prolonged exposure to cold

Figure 11.3 *1984 Women's Olympic Marathon: Gabriela Andersen-Scheiss suffered from heat exhaustion. She took over five minutes to complete the last lap before collapsing*

Beating the heat

Athletes need to avoid rises in core temperatures, rather than trying to counteract problems when they occur. Acclimatisation is an important strategy that requires at least five days of training in hot or humid conditions, progressing from moderate intensity and short duration to higher intensity and longer duration. Performers will reach near maximal levels of acclimatisation in three weeks. Acclimatisation develops more quickly in summer as the weather becomes warmer and more humid. Here are some other practices that should also be considered to prevent 'heat stress'.

1. 'Heat tolerance' can be developed by regularly training in warm conditions (above 25 °C), especially training that is primarily aerobic. (Refer to Chapter 14 Training programs.)
2. Modify training and competition to suit the level of fitness and environmental conditions. As athletes decrease their training loads at the end of a season, then return to training during pre-season, they should keep loads at a moderate intensity. Training and competition should be adjusted as weather conditions heat up. This might mean providing performers with more-frequent breaks, and regular use of interchange or substitution possibilities. The breaks should be supplemented by:
    - reducing clothing and resting in shade provided by trees, buildings or portable structures

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- assisting evaporative cooling with fans wetting the skin
- applying ice packs to groin and armpits
- drinking cooled water or sports drinks

Warm ups should be shortened during hot conditions to reduce the risk of elevated body temperatures prior to competition.

3 The hottest part of the day occurs between 11 am and 3 pm; early-morning, late-afternoon or night training sessions and competitions reduce the risk of exercise-induced heat stress. Administrators should consider rescheduling sporting events during the hotter summer months.

4 Clothing should be light coloured, lightweight, loose fitting, and provide UV protection against the sun, while also allowing evaporation of sweat from the skin. COOLMAX® is an engineered sports-performance fabric that includes a fibre-based moisture-management system that can move perspiration away from the body and through the fabric, where it can evaporate quickly, allowing the wearer to feel cooler and more comfortable.

5 Drinking adequate fluid before, during and after exercise is important to minimise dehydration and promote optimal performance. The first symptom of dehydration is often thirst, but thirst is a very poor indicator of dehydration. By the time they begin to experience thirst sensations, performers are usually at least two per cent dehydrated. To prevent dehydration, performers must ensure they are adequately hydrated. Fluids need to be readily available at training and competition. Performers must match their sweat losses with fluid intake and professionals determine the amount sweated by comparing body weight pre and post-training. For each 100 grams of weight lost, replace this with 100 millilitres of fluid.

KEEP IT REAL!

A 62-kilogram Year 12 student takes part in a hockey training session. The temperature is 28 °Celsius, and shortly after starting training she begins to sweat. The student hydrates frequently during the session, which continues for one hour 15 minutes, and at its completion she has consumed two 750 mL bottles of sports drink. She has heard of elite hockey players weighing themselves before and after matches to determine how much they should drink during recovery, but she doesn't really understand how to apply this to her training session. She weighs herself after the session and the reading is 59.5 kg.

How much fluid intake should she be encouraged to drink after completing the training session, and what is her sweat rate?

Pre-exercise weight	62 kg
Post-exercise weight	59.5 kg
Volume of fluid consumed during exercise (1.5 litre = 2 × 750 mL)	1.5 kg

Fluid deficit (L)	=	62 kg – 59.5 kg	=	2.5 kg
Total sweat loss (L)	=	2.5 kg + 1.5 kg	=	4.0 kg
Sweat rate (L/h)	=	4.0 ÷ 1.25 h	=	3.2 L/h

The student has a sweat rate of 3.2 litres per hour (3.2 L/h) and she must consume an additional 1.7 L of fluid during recovery as a minimum.

General guidelines for fluid intake during sport are 500 mL during the 30 to 60 minutes prior to exercise, 200 mL every 15 minutes during exercise, and 500 to 1000 mL in the first 30 minutes following exercise. Sports drinks have an important role in enhancing hydration, delaying fatigue and refuelling glycogen stores. After consumption, they are quickly absorbed into the blood stream to bring about improved performance via glycogen sparing. Athletes prefer drinks that are flavoured, non-carbonated and served cool; this must be ensured to encourage consumption.

Water intake exceeding sweat loss in events lasting several hours can lead to the hyponatremia**,** which will significantly contribute to reduced performance levels.

Catchy fact
Dehydration can lead to heat stress and reduced performance. A loss of two per cent of body fluids, which is typically when performers feel thirsty, can reduce performance by 10 to 20 per cent. Instead of completing the 10 000 m in 35 minutes, imagine taking an extra four or five minutes to complete the race due to dehydration-related fatigue!

Checkpoints

1 A group of netball players are flying to Darwin in a month's time to compete in the schoolgirl championships. How can they develop heat tolerance?

2 To sustain blood glucose levels and not use glycogen unnecessarily, athletes are better off drinking sports drinks rather than eating carbohydrate-rich foods during performances. Discuss.

3 Why would it be unadvisable for a football player suffering heat stroke to be immersed in an ice bath at the end of the game?

4 **a** What is the general trend on 'real heat' if the temperature remains constant but the humidity rises?

b By referring to the heat index table on page 210, would it be 'hotter' playing tennis outdoors when the temperature is 30 °C with a humidity of 70 per cent, or when the temperature is 32 °C with a humidity of 50 per cent?

5 Tina was playing basketball. She drank two 500 mL sport drinks in each half of the game but lost 1.5 kg from her pre-game weight. Calculate Tina's sweat rate and how much she should drink during recovery.

Catchy fact
Reduced oxygen pressures experienced at altitude mean that performers are unable to maintain high-intensity training schedules, and consequently they experience a decrease in their aerobic capacity. This reduction in aerobic capacity can offset any positive physiological adaptations from high-altitude exposure.

High-altitude effects on sport performance

High altitude is defined as any altitude where the oxygen available to the body is less than that available at sea level; most researchers have quantified this as altitudes in excess of 2000 metres. These altitudes present significant challenges to normal athletic performance, as the body finds itself in serious oxygen deficit and is forced to produce a greater number of red blood cells to transport oxygen. However, it is not all bad! At altitude, there is reduced air resistance and air pressure, which is a huge advantage in sports involving speed, such as sprints. The force of gravity is reduced and this gives an advantage to sports where relative and maximum strength are critical to successful performance.

Our bodies have a built-in protective mechanism to counter the effects of low oxygen in altitudes above 2000 metres. The brain senses that we are not receiving normal levels of oxygen and it produces a greater number of red blood cells. This in turn increases the ability of blood to transport more oxygen to working muscles and tissues.

Some of the acute responses to higher altitudes include increased breathing rate, increased heart rate, reduced blood flow to the brain, headache, nausea, sleeplessness and decrease in the volume of oxygen we can take up, or VO_2 max. Collectively, these responses reduce the athlete's work capacity. It can take an athlete up to three weeks to acclimatise and familiarise themselves with these new environmental conditions.

VO_2 max
the maximum amount of oxygen that can be taken up, transported and utilised per minute

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It generally takes an athlete three months to achieve a greater oxygen capacity at altitude than could be attained at sea level. High-altitude training adaptations will be retained for one to three months even after moving back to sea level. The most significant adaptations are increased erythrocyte volume, increased haemoglobin volume and concentration, increased blood viscosity, increased capillarisation, continued lower VO_2max, decreased lactic-acid tolerance and reduced stroke volume. The decreased VO_2 max and inability to conduct extended aerobic training at altitude has seen the development of the 'live high, train low' model, where athletes sleep at an altitude of 2000 to 2500 metres but train at sea level. After acclimatisation, the resting and submaximal heart rate will decrease slightly, but will still remain higher than at sea level.

erythrocyte
a red blood cell

hypoxic
when inadequate amounts of oxygen reach the body's tissues

hypoxic tent
a tent that simulates high altitudes by pumping in hypoxic (or low-oxygen) air

The cost and inconvenience of moving to higher altitudes to live and then moving back to sea levels to train, has forced sports scientists to develop an altitude-simulation tent, or hypoxic tent. Sleeping in a simulated-altitude environment allows the body to achieve some of the same adaptations obtained at altitude while still permitting the athlete to train at an oxygen-rich lower altitude, where muscles can perform at their normal work level. A big advantage of the altitude tent is that it remains at normal pressure and athletes do not need to deal with the low-pressure experiences of high altitude.

High-altitude sports performances can bring direct advantages as a result of having lower air pressure and thinner air. The 1968 Olympic Games in Mexico City were the first games staged at high altitude: 2300 metres. The number of world records broken reflects the significant impact that thinner air has on performance.

Figure 11.4 A hypoxic tent

At the 1968 Olympic Games, Bob Beamon set a new long jump event record of 8.9 metres, which was over half a metre better than the previous record. This record remained for over 20 years. Lee Evans set a world record of 43.86 seconds in the 400 m track event, which also stood for over 20 years. The reduced wind resistance and drag upon competitors' bodies in the thin air allowed them to move with greater efficiency. Nearly every track record from 100 metres to 1500 metres was broken at altitude; however, the records at distances of 5000 metres and longer remained intact: the athletes were not accustomed to high-altitude training and competition, and knew very little about acclimatisation.

Figure 11.5 Long jumper Bob Beamon at the 1968 Mexico Olympic Games

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> **Catchy fact**
>
> The increased release of metabolites, predominantly lactate, during the acclimatisation phase of altitude training can increase urine production by up to 500 mL per day. It is critical to drink four to five litres per day when training at altitude or above sea level.

Table 11.2 All-time top male long jumpers

Distance (m)	Name	Country	Year	Location
8.35	Igor Ter-Ovanesyan	Russia	1967	Mexico City
8.90	Bob Beamon	USA	1968	Mexico City
8.95	Mike Powell	USA	1991	Tokyo

Table 11.3 All-time top male 400-metre runners

Time (seconds)	Name	Country	Year	Location
43.18	Michael Johnson	USA	1999	Seville
43.29	Harry Reynolds	USA	1988	Zurich
43.45	Jeremy Wariner	USA	2007	Osaka
43.50	Quincy Watts	USA	1992	Barcelona
43.75	LaShawn Merritt	USA	2008	Beijing
43.81	Danny Everett	USA	1992	New Orleans
43.86	Lee Evans	USA	1968	Mexico City

Checkpoints

1 a What type of athletes benefit the most from altitude training?
  b List three chronic adaptations that are likely to occur to athletes sleeping in hypoxic tents after a six-month period. Discuss the physiological benefits that would result for each adaptation.

2 Provide three reasons why it is better to 'train low and live high' at sea level using hypoxic tents or chambers than it is to 'live high' by moving to places situated 2500 metres or more above sea level and 'train high'.

The wind and its physiological effects

The true coldness of a day depends on temperature *and* wind speed. A cold but bearable 5 °C temperature will become uncomfortable and approach 1 °C if a 20 kilometre per hour (k/ph) wind develops. This is called wind chill. If the wind speed doubles to 40 k/ph, the 'coldness' will drop to about –1 °C. Muscles generate heat while performing in cold

Temperature (°C)

Wind speed (km/h)	5	0	−5	−10	−15	−20	−25	−30	−35	−40
Calm	5	0	−5	−10	−15	−20	−25	−30	−35	−40
10	3	−3	−9	−15	−21	−27	−33	−39	−45	−51
20	1	−5	−12	−18	−24	−31	−37	−43	−49	−56
30	0	−7	−13	−20	−26	−33	−39	−46	−52	−59
40	−1	−7	−14	−21	−27	−34	−41	−48	−54	−61
50	−2	−8	−15	−22	−29	−35	−42	−49	−56	−63
60	−2	−9	−16	−23	−30	−37	−43	−50	−57	−64
70	−2	−9	−16	−23	−30	−37	−44	−51	−59	−66
80	−3	−10	−17	−24	−31	−38	−45	−52	−60	−67
90	−3	−10	−17	−25	−32	−39	−46	−53	−61	−68
100	−3	−11	−18	−25	−32	−40	−47	−54	−61	−69

Wind chill (°C) = $13.12 + 0.62157 - 11.37\,(V^{0.16}) + 0.3965T\,(V^{0.16})$ T = air temperature (°C)

Frostbite times: 30 minutes; 10 minutes; 5 minutes V = wind speed (km/h)

Figure 11.6 Wind chill chart

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and windy environments, and this can negate the wind-chill effect. For example, running at 15 km/h into a 15 km/h wind provides the same chill factor as standing still in a strong 30 km/h wind. When training on windy winter days, it is important to complete as many runs into the wind (or headwind) as possible until fatigue sets in. When slowing down, an athlete generates less heat; as clothes are likely to be wet with sweat and this is when runs should be completed with the wind at your back (or tailwind). Running at 15 km/h with a 15 km/h wind behind you totally eliminates any wind-chill effect.

headwind
a wind blowing against the direction of travel

tailwind
a wind blowing in the direction of travel

Rain combined with wind will impact on the tactics and outcome of most outdoor sports. Rain will alter the playing surface of fields, requiring athletes to consider changes in footwear, particularly cleat, spike or stud length. Wet sporting equipment, such as footballs and soccer balls, has different physical characteristics than when it is dry. Short athletes, with a lower centre of gravity, may run better on rain-affected playing fields. Athletes must prepare for rain by using appropriate clothing and footwear if sporting performances are to continue with minimal detriment.

Figure 11.7 *Cyclists riding in heavy rain during the Tour de France*

Cold weather concerns

Training and competing in cold weather results in fewer risks to health and performance than working in hot and humid conditions. In air at 25–28 °C (or in water at 35 °C), a resting unclothed individual can maintain body temperature by varying the amount of heat delivered to the skin via the circulatory system. As temperature falls, the body attempts to reverse this fall by shivering. Water is 25 times more conductive than air, and heat is lost three to five times faster than with air at the same temperature.

Below a muscle temperature of 27 °C (which is ten degrees below 'normal' core temperatures), the muscles' contractile force and force application rate is reduced and fatigue occurs earlier. Consequently, movement speed, muscle strength and mechanical efficiency are all reduced with cooling.

Vasoconstriction of peripheral blood vessels during cold exposure can reduce skin temperature in the hands and feet to levels that can cause injuries. Early warning signs of cold injury include tingling, numbness or a burning sensation in the fingers, toes, ears or nose. If protective action is not taken at this point, tissue damage may occur, giving rise to a 'freezing' cold injury (FCI) such as frostbite.

vasoconstriction
when blood vessels reduce their diameter to allow less blood to flow though

Cold-air inhalation can aggravate asthma symptoms, and even cause exercise-induced asthma in otherwise healthy athletes. It is unusual for the respiratory tract and lungs to be

Catchy fact
Maximum power output falls by three per cent for every one degree fall in muscle temperature.

Figure 11.8
Snowboarders need to be aware of frostbite

in danger of damage when exercising in the cold. The air is warmed and moistened rapidly during inhalation to avoid potential damage. However, this moistening of the inspired air can dry out the airways, giving rise to such complaints as dry mouth, a burning sensation in the throat, and general irritation of the respiratory tract.

Cold-weather performances often lead to decreases in body temperatures. The danger does not arise from the frosty air but from the combination of frigid air and sweat. As mentioned, water is a terrible insulator: it conducts heat away from the body about 25 times faster than air. Clothes that become wet from rain can potentially lead to decreased body temperatures and earlier fatigue. To avoid this, performers wear waterproof jackets and pants; these stop water getting onto clothing, but increase sweating. Sweat-soaked clothes can rapidly cause body temperatures to drop, reducing the ability to sustain desired workloads. It is important to strike a balance between maintaining core and skin temperature, staying dry and warm and avoiding excessive insulation. Over-insulation leads to a rise in core temperature and sweat production, and consequently to wet clothing that may affect heat balance.

Performing in cold water results in core-temperature reductions at much quicker rates than competing in cold conditions compounded by rain. Prolonged exposure to cold can make the body temperature dangerously low, leading to hypothermia. When performing in cold water, wetsuits or dry suits should be worn when sporting bodies allow them. Wetsuits protect against hypothermia by trapping a thin layer of water next to your body and minimising heat loss. You warm this layer, so while the sea may be at 10 °C, you feel like you're swimming in a heated pool. Wetsuits also provide 100 per cent UV protection and protect against the wind when you are out of the water.

Wetsuits come in a variety of thicknesses and materials. Most suits are made of neoprene. The thicker the neoprene, the more ability the suit has to keep you warm. A snug-fitting suit keeps you warmer, as it allows only a thin later of water inside the suit: less water present means less needs to be insulated against. A dry suit differs from a wetsuit. A wetsuit insulates the water once it enters the suit; a dry suit doesn't allow any water in at all. The tight seals around the neck, wrists and ankles keep the water out. The air trapped inside a dry suit will help to keep you warm.

FINA
international ruling body for swimming

Sporting performances that occur in water can lead to accelerated drops in core body temperatures unless the water is heated. FINA regulation 2.1 states that the temperature of swimming pools at Olympic Games must be 25 °C to 28 °C; most pools are kept at 26 °C. In cold water, a fall in core body temperature intensifies shivering, which raises oxygen consumption during submaximal exercise by nine per cent in water at 25 °C and 26 per cent

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Figure 11.9 Cold environmental conditions make it hard to maintain core temperature

in water at at 18 °C. The energy cost of submaximal exercise is increased in water cooler than 26 °C, and this can rapidly deplete glycogen and fatty acid supplies, with earlier onset of fatigue.

The glycogen depletion is caused by two factors. First, shivering, which causes muscles to empty their glycogen stores at five to six times the normal rate. Second, increased blood levels of epinephrine, a hormone that stimulates glycogen breakdown. This high rate of glycogen breakdown empties out muscle glycogen stores quickly, forcing muscles to turn to fat as a source of energy. Epinephrine can also enhance fat metabolism.

epinephrine an adrenaline-based hormone

ectomorph slim, linear body type

Furthermore, oxygen uptake (VO_2 max) is greatly reduced when performing in cold water. There is a ten per cent reduction in VO_2 max with a 0.5 °C fall in core temperature, and a 30 per cent reduction with a 2 °C fall in core temperature. This results in the appearance of lactate in the blood at lower workloads than usual, and it also accumulates more rapidly, suggesting decreased oxygen supply to the muscle and greater reliance on anaerobic metabolism.

Beat the cold

1 Sweating rates are lower in the cold than in the heat, but cold-weather exercise can still be dehydrating so it's just as important to remain hydrated in such conditions. Feelings of thirst are lessened in cooler climates, and some performers automatically drink less fluid. This can result in dehydration, with associated decreased performance levels and difficulties in staying warm.

2 Exposure to cold temperatures increases the rate that muscles use up their carbohydrate stores, so glycogen depletion can become a problem. It makes sense during cold conditions to increase intake of sports drinks high in dissolved carbohydrates. Winter also increases fat oxidation, but extra dietary fat is unnecessary. Even ectomorphs usually have enough fat stored to support the increased fat required for fuel.

3 During extremely cold weather, find sheltered exercise locations that are at least partly out of the wind. This allows exercise to continue more efficiently and reduces the risk of core temperatures dropping.

4 Wear adaptable clothes during runs or performances. Clothes with zippers are great, because these can be opened up and removed if it gets too hot during a workout. Unzipping garments also allows the excess moisture you have built up to escape.

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Figure 11.10 An athlete training in cold conditions

A good recommendation is to wear sufficient layers of clothing to stay warm as you exercise or perform, but not so much that you begin to sweat heavily. The layers should be easy to remove as the core temperature begins to rise.

Checkpoints

1. Discuss two disadvantages, other than cost, associated with living and training at high altitude.
2. Discuss what is meant by 'wind chill', and apply this to an outdoor sporting situation of your choice where the temperature is 8 °C and the wind is blowing at 30 k/ph.
3. Why should athletes try to remain as dry as possible when training or competing in wet conditions during winter months?
4. A surfer attempting to stay in cold water without a wetsuit for 40–50 minutes might not be able to so. Discuss three mechanisms that will contribute to fatigue and force the surfer from the water

Time-zone changes

Time-zone changes and variations in daylight-saving can make competition difficult for national and international travel. International competition often involves travel through multiple time zones, and can have a marked effect on performances. For a football team based in Western Australia that will be competing in Melbourne, there is be a three-hour time difference. The West Coast Eagles and the Fremantle Dockers have uniformly high home winning percentages when playing against east-coast teams. The win:loss percentage increases for teams playing against other teams proportional to their travel time: the further a team needs to travel to compete without any acclimatisation, the more likely they are to lose. Teams have adopted anti-jet lag strategies by flying interstate the day or night before a game to eliminate the expected drop in performance.

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Figure 11.11 The West Coast Eagles fly out a day before an east-coast match to allow them to become acclimatised to the playing conditions

The body becomes accustomed to a daily rhythm, sometimes referred to as the body clock, which is connected to sunrise, sunset and usual sleeping patterns. Travel to a time zone that is several hours advanced or behind what the athlete is used to can cause disturbances in performance. The potential impact of a time zone change can be addressed by acclimatising: getting to the venue a number of days in advance of the competition.

TEST YOUR KNOWLEDGE

>> multiple-choice questions

1 Sprinters perform better at high altitude because they:

A have increased levels of red blood cells
B have less resistance to run against ‘thinner air’
C run high after training low.
D All of the above.

2 During exercise, most heat is produced by:

A inappropriate clothing that doesn’t allow heat to escape
B plasma that leaves the blood and becomes sweat
C energy liberated when muscles contract
D conduction from playing surfaces.

>> short-answer questions

3 Discuss why football players are likely to use more carbohydrate stores during cold playing conditions than in games played under warm conditions.

4 Some AFL teams play exhibition matches in Dubai, where temperature and humidity are both high. Teams playing in February can encounter 25 °C days with 80 per cent humidity.

a What do these conditions present players with in terms of a heat index or ambient temperature?
b Players stop playing in September when the AFL season ends. How could players participating in this exhibition match best prepare to avoid heat stress on match day?

>> essay questions

1 You have been selected to represent your school in the state cross-country finals. The course is marked out at a state forest, and consists of a five-kilometre course over undulating terrain. It has been raining for several days and the course is likely to be ‘heavy’; more importantly, the weather forecast for race day is rain with 40–60 km/h winds. Discuss three strategies you should consider from the following areas to perform at your best in these conditions.

- Clothing
- Diet (pre-race and during the race)
- Hydration
- Footwear
- Training

2 Most sports drinks claim to ‘replace lost electrolytes’. Research the role electrolytes play in achieving optimal performances and if any differences exist between two or three sports drinks produced by different companies.

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12 Legal and illegal performance-enhancement strategies

Training, competition and recovery

There is an ever-increasing quest to discover practices that might enhance an athlete's capacity to train, recover and perform. Before considering some of the most commonly used practices for performance enhancement, it is worth reviewing the path illegal ergogenic aids have taken – and some worldwide anti-doping initiatives.

ergogenic aid
practice, substance or method (legal or illegal) that improves performance

Prior to the implementation of drug testing programs in the late 1960s, athletes commonly used performance-enhancing substances. Along with their coaches and administrators, athletes turned a blind eye to the side-effects and ethical implications. Illegal drug use was reputedly widespread at the 1952 Helsinki Olympic Games, and to a lesser extent at the 1956 Melbourne Olympic Games. With increasing numbers of athletes suffering irreversible side-effects, people began to speak out against the harm drugs were causing the athletes and their sports.

The first significant international anti-doping development took place in 1960, when the Council of Europe tabled a resolution against the use of doping substances in sport. This signalled the beginning of a more positive international anti-doping stance. It wasn't until the death of British cyclist Tommy Simpson during the 1967 Tour de France that the International Olympic Committee (IOC) became actively involved in anti-doping initiatives.

The Medical Commission of the IOC was established in 1967, and the first drug tests were conducted at the 1968 Mexico Olympic Games. A list of banned substances was developed by the IOC; this list currently includes stimulants, beta-blockers, narcotic analgesics, diuretics, anabolic agents (protein-building substances), peptide hormones, glycoprotein hormones and analogues. Practices such as blood doping and pharmacological, chemical and physical manipulation are also prohibited.

Despite the efforts of governments, and international and national sporting organisations who implemented anti-doping initiatives throughout the 1960s and 1970s, athletes continued to take illegal performance enhancers. They quickly learned how to beat the drug-testing systems. In 1983, drug-testing strategies took an important step forward when analytical procedures were significantly refined, allowing accurate results to be consistently obtained from athletes' samples.

Figure 12.1 A technician analysing a sample in a drug-testing laboratory

Shortly after this, the IOC established a comprehensive set of operating procedures and standards for laboratories to ensure that uniform drug testing was conducted. The Australian Sports Drug Testing Laboratory in Sydney is world renowned, and one of only 24 laboratories worldwide carrying accreditation from the IOC to conduct sports drug testing.

Catchy fact
An ergogenic aid is 'anything that enhances or is thought to enhance physical or mental performance'. Most people mistakenly believe that drugs are the only ergogenic practices used by athletes to give them competitive and training advantages.

In 1999 the World Anti-Doping Agency (WADA) was established. It was a direct result of the 1998 Tour de France scandal, where widespread doping was discovered and covert attempts were made to hide the large number of athletes involved. The Tour de France scandal highlighted the need for an independent international agency that would set unified standards for anti-doping work and coordinate the efforts of sports organisations and public authorities. At a 2003 anti-doping conference in Copenhagen, all major sporting federations and 73 governments signed a resolution accepting the World Anti-Doping Code (or Code) as the basis for continuing the fight against the use of illegal ergogenic aids and doping. Countries and sporting groups must be signatories of WADA to be able to compete in the Olympic Games. The aim of WADA is to implement a standardised doping policy across all sports and all countries. All signatories uphold sanctions imposed by any WADA signatory, so a banned athlete cannot compete in any other sport for the duration of the ban.

signatories
people, governments, or organisations that have signed a contract or agreement and are bound by it

Illegal performance enhancing practices

Many factors can contribute to an athlete turning to illegal performance-enhancing drugs and practices, which also include optimising training and recovery. Essentially it comes down to the athlete themselves and their environment. An athlete might take illegal performance enhancers for a variety of reasons.

- Ongoing dissatisfaction with their own performance
- Lack of progress
- Psychological dependence
- Self-pressure and doubt, lack of confidence, nervousness, stress, anxiety or depression
- Relaxation or socialisation
- The belief that such practices will not cause long-term harm
- Wanting to keep up with other athletes using illegal practices
- Poor testing procedures; believing they can 'get away with it'
- Being easily influenced by peers
- A 'win-at-all-costs' mentality
- Personal pride and the need to retain a 'hero' or role-model status

Environment-related reasons for athletes taking illegal performance enhancers include:

- drug culture: friends or peers using illegal practices and achieving improved results
- pressure from the coach, parents, public and media to win
- unreasonable scheduling of events allowing insufficient recovery time
- product endorsements and the financial rewards offered as prize money by sponsors
- the prestige and fame associated with being 'the best'
- the influence of role models
- the demanding qualifying standards or performance expectations required to make national selection
- national honour and pride.

Ausport

WADA produces a 'Prohibited list' containing the substances and methods that are prohibited in sport. This list is reviewed annually and comes into effect on 1 January every year, with no amnesty period. The prohibited list ensures consistency across all World Anti-Doping Code–compliant sports and signatories. The latest information is on the Ausport website. You can link directly to the website via the weblinks on the student DVD. A substance or practice will be included on the prohibited list when it meets any two of the following three criteria.

- Medical or other scientific evidence, pharmacological effect or experience that the substance or practice, alone or in combination with other substances or practices, has the potential to enhance or enhances sport performance

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- Medical or other scientific evidence, pharmacological effect or experience that the use of the substance or practice represents an actual or potential health risk to the athlete
- WADA's determination that use of the substance or method violates the spirit of sport described in the Code

A substance or practice will also be included on the prohibited list if WADA determines there is medical or other scientific evidence, pharmacological effect or experience that the substance or method has the potential to mask the use of other prohibited substances or prohibited methods.

Catchy fact
A current list of prohibited performance enhancers can be viewed on the government Ausport website. If the medication an athlete is required to take to treat an illness or condition happens to fall under the prohibited list, a Therapeutic Use Exemption (TUE) may give that athlete the authorisation to take the required medicine.

therapeutic
used in the treatment of disease or disorders; used to maintain health

Substances and methods prohibited at all times (in- and out-of-competition)

Prohibited substances

S1. Anabolic agents

S2. Hormones and related substances

S3. Beta-2 agonists

S4. Hormone antagonists and modulators

S5. Diuretics and other masking agents

Prohibited methods

M1. Enhancement of oxygen transfer

M2. Chemical and physical manipulation

M3. Gene doping

Substances and methods prohibited (in-competition)

In addition to the categories S1 to S5 and M1 to M3 defined above, the following categories are prohibited in competition:

S6. Stimulants

S7. Narcotics

S8. Cannabinoids

S9. Glucocorticosteroids

Substances prohibited in particular sports (governing sporting body)

P1. Alcohol

- Aeronautic (FAI) • Archery (FITA, IPC) • Automobile (FIA) • Boules (IPC bowls) • Karate (WKF)
- Modern Pentathlon (UIPM) for disciplines involving shooting • Motorcycling (FIM) • Ninepin and Tenpin Bowling (FIQ)
- Powerboating (UIM)

P2. Beta-blockers

- Aeronautic (FAI) • Archery (FITA, IPC) (also prohibited *Out-of-Competition*) • Automobile (FIA)
- Billiards and Snooker (WCBS) • Bobsleigh (FIBT) • Boules (CMSB, IPC bowls) • Bridge (FMB) • Curling (WCF)
- Golf (IGF) • Gymnastics (FIG) • Motorcycling (FIM) • Modern Pentathlon (UIPM) for disciplines involving shooting
- Ninepin and Tenpin Bowling (FIQ) • Powerboating (UIM) • Sailing (ISAF) for match race helms only • Shooting (ISSF, IPC)
- Skiing/Snowboarding (FIS) in ski jumping, freestyle aerials/halfpipe and snowboard halfpipe/big air • Wrestling (FILA)

Adapted from World Anti-doping Association website

Figure 12.2 The 2009 Prohibited list: world anti-doping code (from 1 January 2009)

exogenous
a substance that is not produced naturally by the body

endogenous
a substance that is produced naturally by the body

Table 12.1 Illegal ergogenic practices: perceived benefits versus harmful side-effects

Illegal ergogenic aid or practice	Perceived benefit	Common sports	Harmful side-effects
Stimulants • amphetamines • cocaine • caffeine • ephedrine	Mask fatigue; increased alertness and aggression; improved muscle reaction; improved anaerobic performance	• athletics • swimming • weightlifting • cycling	Anxiety; restlessness, tremors, irritability, cardiac arrhythmia, stomach upset, dependence, hypothermia, heart attack
Narcotic analgesics • codeine • morphine • opiates	Mask pain; euphoria	Any sport where injury is common	Dependence, respiratory failure, risk of further damage and injury
Anabolic steroids exogenous or endogenous	Increased muscle bulk, power and strength; increased aggression and increased speed of recovery; can train harder and longer	Sports requiring strength/power	Dependence, depression, hypertension, cancer, sudden death, salt/water retention, testicular atrophy, male breast enlargement, alopecia, female breast atrophy, facial hair, infertility, increased masculinity, higher LDL cholesterol
Beta-blockers	Reduced heart rate; tension and tremors; increased relaxation and AV difference	• shooting • archery	Dangerous in cases of asthma; cardiac failure, hypotension; hypoglycaemia; impotence
Diuretics	Used to reduce weight quickly; mask use of anabolic steroids	• boxing • weightlifting	Dehydration; cramp; muscle strain; cardiac arrhythmia
Polypeptide hormones and analogues • human growth hormone • corticosteroids • insulin-like growth factors • mechano growth factors	Muscle and bone development; anti-inflammatory preparation; mask use of anabolic steroids; euphoria	Sports involving strength, power, muscle bulk	Sodium and water retention; skin changes; decreased immune function; diabetes; hypertension; heart failure; impotence
EPO (erythropoietin) or hormonal blood boosting • haemoglobin-based blood substitutes • microencapsulated haemoglobin products	Increased red blood cell and oxygen-carrying capacity, and also VO_2 max	Endurance events	Blood-clotting; stroke; hypertension; heart failure; death

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Blood-doping (red blood cell reinfusion)	Increased VO_2 max (possibly up to 25%); decreased fatigue	• tour/road cycling • endurance events	Transfer of blood-born diseases (hepatitis B, AIDS); blood-clotting; stroke; hypertension; heart failure; death
Alcohol	Relax; boost confidence	Many sports	May induce fatal changes in heart, liver, nerve and muscle tissue; decreased performance in most cases

Prohibited substances

Anabolic agents

Anabolic steroids are the most commonly used sporting drug. They are related in structure and function to the male sex hormone testosterone. Testosterone is responsible for growth of bone and muscle during puberty, as well as secondary sex characteristics. Synthetically produced chemicals attempt to maximise the anabolic properties of testosterone while minimising the androgenic side-effects.

Anabolic steroids are used by athletes to increase muscle bulk, power and strength. These effects are achieved by:

- increasing protein synthesis
- blocking the hormones that cause the breaking down of muscle tissue following very intensive exercise
- steroid enhancement of aggressive behaviour, which promotes a greater quantity and quality of weight training
- reducing recovery time in between 'heavy' training sessions using loads close to repetition maximums

There is also a belief that athletes using anabolic steroids recover more quickly from hard training sessions, and can train at a higher intensity and more frequently than athletes not using them. According to Fishman (1993), nearly one in 15 young men in the USA have used steroids, compared with one in 50 who have used cocaine. The majority of

anabolic
protein building

androgenic
natural or artificial male sex hormones responsible for the development of male sexual characteristics

Figure 12.3 Marion Jones masked her steroid use, but later admitted to extensive use

people using steroids are thought to be bodybuilders or athletes looking for an edge on their opponents. However, a growing number of young Americans are using steroids for cosmetic reasons; either to look muscular because of their vanity, or for the 'invincible' feelings they produce: the 'steroid rage'. The horrific side-effects (see Table 12.1) do not seem to deter them. Some athletes take sedatives and tranquilisers to counter the side-effects of anabolic steroids or to mask against their detection.

Hormones and related substances

Hormones and related substances includes various human growth hormones (HGH) and corticosteroids. These are used to increase muscle and bone development, to induce a state of euphoria, as an anti-inflammatory preparation, and to normalise the testosterone–epitestosterone ratio used in dope testing. Some athletes believe the use of these drugs can offset the side-effects of injecting anabolic steroids. The side-effects of this category include diabetes, hypotension, decreased immune function, sodium and water retention, skin changes, impotence and heart failure.

Insulin-like growth factors (IGFs)are being used increasingly to illegally enhance performance. IGF-1 is a naturally occurring growth hormone that stimulates many processes in the body, including protein synthesis. It is the hormone through which growth hormone exerts most of its growth-promoting effects. Some athletes use IGF-1 in an attempt to increase muscle bulk, reduce muscle cell breakdown and reduce body fat, but they are using very large doses to achieve these advantages. Large doses carry the risk of significant adverse effects, including hypoglycaemia, swelling of the brain, enlargement of the heart and 'diabetic' coma – all of which can be fatal.

tachycardia
an excessively rapid heartbeat, faster than 100 beats per minute in a resting adult

hypertension
unusually high blood pressure

beta-blockers
drugs used to slow the heart and prevent tremors

gynecomastia
the development of abnormally large mammary glands in males, resulting in breast enlargement

Beta-2 agonists and beta-blockers

Beta-2 agonists are commonly used to treat asthma; however, they can have anabolic effects if taken into the bloodstream. They don't have the same side-effects on the body as steroidal anabolic agents. Side-effects of beta-2 agonists include tremors, tachycardia, palpitations, hypertension, headaches, nausea, flushes, sweating, muscle cramps, twitching, restlessness, dizziness and sleep disturbances. All beta-2-agonists are prohibited, except those that are inhaled and are a group of bronchodilator medications. These are used in the treatment of asthma and are formulated to act on special receptors called beta-2 receptors, which are located on smooth muscle and mucous membrane in the lungs and smaller airways. Even young children competing in school cross-country events take asthma medications containing beta-2 agonists to improve their uptake of oxygen and endurance performance – despite not being asthmatic!

Beta-blockers prevent the effect of beta-receptors (nerve impulse receptors) found in the heart and blood vessels. They are used to control blood pressure, slow the heartbeat and reduce pre-competition tension. They have been used in sports that require relaxation, such as shooting and archery, to reduce tremor and to reduce the heartrate to permit shots or arrows to be fired between heartbeats. They are of little use in sports where vigorous physical activity is important. Their side-effects include hypotension, hypoglycaemia, increased severity of asthma, and cardiac failure.

Hormone antagonists and modulators

Hormone antagonists and modulators are also known as anti-oestrogenic substances; they act to either decrease the amount of oestrogen in the body or block oestrogen receptors. Anti-oestrogenic drugs are used by both male and female athletes. Males use them in conjunction with anabolic steroids in an attempt to prevent gynecomastia, but primarily to increase testosterone levels. Female power athletes, such as shotputters, discus throwers and weightlifters, have been known to use anti-oestrogenic drugs to block the oestrogen receptors; this leaves testosterone unopposed, leading to an increase in anabolic properties.

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Diuretics and other masking agents

Diuretics promote water and electrolyte loss from the body. They are used by athletes to reduce weight quickly in sports where weight restrictions apply. They are also used to dilute the concentration of banned substances in urine, such as anabolic steroids, in an attempt to evade detection. Their side-effects include dehydration, cramps, muscle strains and cardiac arrhythmia (irregular heartbeat).

Common masking agents include plasma-volume expanders, which are taken to prevent dehydration or to mask use of recombinant erythropoietin (EPO). When plasma volume expanders are taken with EPO, they can elevate the blood volume while maintaining a haematocrit and haemoglobin level that is within the legal range.

haematocrit
the percentage of red blood cells in the blood

Stimulants

Stimulants are substances that act on the brain, stimulating the body mentally and physically. Their chemical structure is similar to adrenaline and noradrenaline, which are both produced by the body. They increase alertness, competitiveness and aggression and help to combat fatigue, making athletes feel stronger, more energetic and decisive.

The most common stimulants used by athletes include pseudoephedrine, ephedrine, cocaine, amphetamines and caffeine. Misuse of stimulants can increase blood pressure and body temperature, create insomnia and an irregular heartbeat; more severe consequences include convulsions, heart attack and stroke. Long-term use of stimulants can result in an increased tolerance for the drugs, and the need to continually take more for the same effect. It is not uncommon for athletes to become drug-dependent and have difficulty withdrawing from them.

Stimulants can be contained in prescription and over-the-counter medications, as well as in herbal and nutritional supplements, and these must be 'cleared' by relevant sporting bodies or administrators.

Narcotics

Narcotic analgesics such as codeine, morphine and derivates of the Asian poppy (opiates) are used to reduce moderate to severe pain. They enable athletes to continue competing while injured and induce a euphoric state. Narcotics are highly addictive, and the 'high' associated with their use can impair judgement, balance and concentration. Athletes who continue to compete when injured, with pain that has been 'masked' by narcotics, run the risk of further acute and chronic damage. They have associated significant side-effects including dependence, addiction and respiratory depression or failure.

Catchy fact
A snowboarder who won gold at the 1998 Winter Olympics later tested positive for marijuana. He blamed it on passive inhalation at a pre-Olympic Games party. While he was given the benefit of the doubt and called a hero, one unimpressed journalist sent him a gasmask!

Cannabinoids

Cannabinoids are one of the most commonly used illicit drugs in Australia. They originate from the dried flowers, leaves or resin of the cannabis plant containing the agent THC. Marijuana is the most common name for the cannabinoid group, which have no real performance-enhancing value other than decreasing arousal and providing pain relief post-competition. Cannabinoids cause hallucinations, induce drowsiness, increase the heart rate and impair judgement, balance, coordination and memory.

Catchy fact
Most asthma medications contain glucocorticosteroids, which are the most effective anti-inflammatory drugs for treating this condition. If athletes are prone to asthma, they should consider getting a Therapeutic Use Exemption (TUE) authorising them to take this medicine.

Glucocorticosteroids

Glucocorticosteroids are powerful anti-inflammatory agents primarily (and legally) taken to treat chronic inflammatory conditions such as arthritis, asthma, inflamed joints and allergic reactions. It is illegal for athletes to take glucocorticosteroids, as they are abused to lessen pain and reduce sensations of tiredness. Possible acute side-effects include fluid retention, hyperglycaemia and mood alteration. Potential chronic side-effects include systemic infections (due to immunosuppression) and musculoskeletal problems, such as osteoporosis, softening of the connective tissue and weakening of muscles, bones and ligaments.

Prohibited methods

Enhancement of oxygen transfer

Erythropoietin (EPO) is a polypeptide hormone produced in the kidneys. It increases red cell production by the liver and bones, which in turn increases the amount of oxygen supplied to muscles. Recombinant (artificially produced) EPO has a legitimate use in the treatment of anaemia in patients with diseases such as kidney disease, HIV and some cancers. Some athletes use recombinant EPO to improve endurance performance or to improve recovery from anaerobic exercise. Its side-effects are similar to those of blood-doping (see page 231). A number of cycling teams in the 1998 Tour de France were disqualified for being in possession of EPO.

Figure 12.4 Andrew Wyper cooling down after a ride

KEEP IT REAL!

Two-year suspension for Australian cyclist for attempted use of HGH and EPO

The Australian Sports Anti-Doping Authority (ASADA) welcomed the Court of Arbitration for Sport (CAS) announcement to impose a two-year sanction on Australian cyclist Andrew Wyper.

Mr Wyper is a former national team member who competed in the World Road Championships in Canada and the World Junior Track Championships in Russia in 2003. He was charged by Australian Customs and convicted of importing the prohibited substances human growth hormone (HGH) and erythropoietin (EPO) via the Internet in October 2005.

The CAS stated in its judgment that, 'There is no reason to require as a prerequisite that Mr Wyper must have obtained possession of the substances before he could take a substantial step in a course of conduct planned to culminate in the commission of an anti-doping rule violation.'

The CAS further stated that, 'The conduct of Mr Wyper on or about 18 October 2005 of placing the order, arranging for it to be posted to him in Inverell and paying for the prohibited substances was itself a substantial step within the meaning of the Anti-Doping Policy.'

ASADA Chairman, Richard Ings, said, 'This case is significant for two reasons. Firstly, it demonstrates that the partnership between Australian Customs and ASADA is effective in detecting serious Anti-Doping Rule Violations.

'Secondly, this case highlights that athletes who purchase prohibited substances via the Internet may face serious consequences under anti-doping rules and Australian law.'

Mr Wyper is ineligible to compete in all sporting competition for a period of two years from 7 February 2008, and all competition results from 18 October 2005, any medals, points and prizes obtained, shall be invalidated. Mr Wyper will be eligible to return to sporting competition on 7 February 2010.

Australian Sports Anti-doping Authority

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Blood-doping is an ergogenic procedure in which an increased red blood cell count is achieved by reinfusion of the athlete's own blood, or by transfusion from another donor with the same blood type. Blood-doping boosts the oxygen-carrying capacity of the blood, enhancing delivery of oxygen to the working muscles and improving VO_2 max and endurance capacity. Besides being unethical, blood-doping carries the risk of transfusion of blood-born viruses such as hepatitis B and AIDS, and of hyperviscosity syndrome, which leads to blood clotting, heart failure and death. Blood doping is detected by athletes having a red blood cell count outside accepted limits set down by WADA, which are the same as those set to detect athletes using EPO.

hyperviscosity excessively thick blood

Chemical and physical manipulation

Tampering, or attempting to tamper, in order to alter the integrity and validity of samples collected during doping controls is prohibited. Athletes have attempted to use catheterisation, urine substitution and altering in an effort to prevent detection of practices they have used to enhance their performance. Various intravenous infusions have been used by athletes to avoid detection but these too are prohibited, except in the management of medical emergencies, clinical investigations or for surgical procedures.

Genetic manipulation (gene doping)

In 2005, WADA stated that 'the non-therapeutic use of cells, genes, genetic elements or the modification of gene expression, having the capacity to enhance athletic performance, is prohibited'.

The area of genetic technology is going to provide the greatest sporting ethical dilemmas in coming years. It seems inevitable that genetic manipulation will provide athletes with the greatest opportunities to improve their suitability for certain sports and events, as well as improving their training, recovery and actual performances. It is likely that by the 2012 Olympic Games some athletes will have had their abilities enhanced by genetic manipulation. This will be obvious when athletes become stronger, faster and have more endurance, and world records tumble. Performance-enhancing gene therapy might be even harder to detect than the range of WADA-declared illegal substances. An athlete might improve their performances by injecting designer genes into an organ (for example, the lungs or the liver) and the effects could be limited just to that organ, but provide huge benefits for the athlete. How is this going to be detected?

Genetic technology might be used to select the most promising athletes from an early age, in a similar manner to today's talent-identification processes. This might see people who are genetically suited to endurance or power events trained in this area. Susceptibility to injury and healing qualities also have a genetic makeup, and it may well be that an AFL club chooses players who show genetic potential in terms of performance qualities, but also those less likely to be sidelined by injuries. Gene therapies will provide medical specialists with the ability to inject areas to develop superior body parts. For example, football players who have damaged knee ligaments could have them genetically repaired to better-than-new or pre-injury levels.

How far can it go? Genetic engineering can potentially be used to choose genes for unborn children. Parents could enhance the performance capabilities of their children by using genetic variations taken from others in the population who have qualities that they themselves don't possess, even before their children are conceived.

Catchy fact

In 1964, the Finnish cross-country skier Eero Mantyranta won two Olympic gold medals, and was suspected of blood doping because he had too many red blood cells in his system. Three decades later, he was cleared when genetic researchers found that Mantyranta and his family members have a genetic mutation that increases their red blood-cell count by 20 per cent.

Genetic engineering would allow this variation to be selected and used to improve the aerobic-performance levels of anyone having this 'transplanted' on their genetic makeup. The only way to detect this would be to take samples from the parents and compare these to the genetic sequence of the athlete. This too may be masked because genetically modified characteristics are passed on from one generation to the next.

KEEP IT REAL!

A website has been created detailing information about the AFL's Illicit Drug Policy and the responses from players and experts in the drug prevention field.

AFL Players Association CEO, Brendon Gale, said today that AFL players should be supported for the stand they have taken. 'No other sports people in the country have volunteered for the out-of-competition testing and holiday testing,' Mr Gale said.

'Our players are showing great leadership by signing up to this policy, and it is clear that they want to make a difference to ensure that the minority of players who need help receive it.'

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AFL General Manager of Football Operations, Adrian Anderson, also released the results of the AFL illicit drug testing for the 12 months to February 2008, saying it demonstrated the AFL's commitment to transparency.

There were 1152 tests in the 12 months to February 2008, resulting in only 1.2 per cent failed tests: a drop of 35 per cent on 2006 and 70 per cent on the first year of testing in 2005. In 2007, there were 14 failed tests and three players who recorded a second failed test. The majority of failed tests occurred during a blitz of testing players returning to their clubs post-season.

'The AFL is the only sport to publicly release the results of our testing. The drop in the rate of failed tests despite the significant increase in the number of tests is very pleasing,' Mr Anderson said. 'Three years of results shows that taking immediate action in referring players to counselling and treatment is making a difference. After 2000 tests, we now have evidence that our approach is working to change behaviour.'

Mr Anderson said advice from the AFL Medical Commissioners that irresponsible use of alcohol was a precursor in almost all failed out-of-competition illicit drug tests, and that almost half of the failed tests had resulted from increased post-season testing, had accelerated moves to develop a responsible alcohol policy and led to the players agreeing to holiday hair-testing.

www.afl.com.au, 2008

Say no to drugs

Table 12.2 Illicit drug policy (IDP) testing breakdown 2005–2007—AFL

Year	Total detections	2nd positives	Test numbers	Detection %
2005	19	3	472	4.03
2006	9	0	486	1.85
2007	14	3	1152	1.2
TOTAL	42	6		

Table 12.3 Breakdown of detected substances 2005–2007 by type—AFL

Year	2005	2006	2007	TOTAL
Cannabinoids	6	0	4	10
Stimulants	12	8	10	30
Mixed	1	1	0	2
Total	19	9	14	42

Legal methods

Many legal strategies also provide athletes with advantages. These include dietary manipulation and psychological skills training.

Dietary manipulation

- Carbohydrate loading
- Creatine supplementation
- Fluid replacement
- Caffeine ingestion
- Other supplements

Psychological skills training

- Mental rehearsal or imagery; simulation
- Arousal reduction and promotion techniques
- 'SMARTER' goal setting
- Stress inoculation training
- Improved concentration and confidence

These will be investigated in greater detail in Chapters 15 and 16. Visit the Australian Institute of Sport website to discover more about research in sports psychology, or research by other AIS staff. The website provides current research findings and links to worldwide psychological research findings.

AIS sport psychology

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Other legal practices, such as coaching, warm-up, appropriate training methods, altitude training and fluid replacement have been covered elsewhere in this book. As with training, performance-enhancing practices must be tailored, and must be specific to training and competition demands. A practice may be helpful in improving the performance of endurance athletes but bring limited improvements in power-based performers. There is also a training misconception that 'more is better', but this can be counterproductive, especially when illegal practices result in irreversible physiological damage and even death.

Dietary performance-enhancing practices

Legal and illegal supplements

Before deciding to take any supplements, athletes and coaches need to consider likely performance gains, and balance these against the costs associated with participating in a supplementation program. Supplementation can be quite expensive and other costs, such as negative side-effects and positive doping results, need to be considered. Sport scientists and sport nutritionists should be consulted when considering supplements and sport foods as part of any performance-enhancing program.

In the AIS Sports Supplement Program supplements are classified into four groups according to their effectiveness and safety. Because the products on this list will change over time, look up the AIS website for the most up-to-date information.

AIS legal and illegal supplements

Group A

Group A sports foods and supplements are supported for use by athletes. They provide a useful and timely source of energy and nutrients in the athlete's diet, or have been shown in scientific trials to benefit performance when used according to a specific protocol in a specific situation in sport. They include:

- antioxidant vitamins C and E
- bicarbonate and citrate
- caffeine*
- calcium supplements
- creatine
- electrolyte replacement supplements
- glycerol
- iron supplements
- liquid meal supplements
- multivitamins and minerals
- sports bars
- sports drinks
- sports gels

* This supplement is no longer made available to athletes under the AIS Sports Supplement Program.

Group B

Considered for provision to AIS athletes only under a research protocol.

Group C

Little proof of beneficial effects exists; this category includes the majority of supplements and sports products promoted to athletes.

Group D

Should not be used by AIS athletes; they are at high risk of being contaminated with substances that could lead to a positive drug test.

Ausport

Table 12.4 Summary of dietary and nutritional performance-enhancing practices

Nutritional performance-enhancing Practice	Performance benefits
Antioxidant **(Vitamins C and E)**	Large increases in training loads lead to temporary increases in the production of free oxygen radicals. Antioxidant vitamins may help to reduce oxidative damage until the body's own antioxidant system can adapt to the new loads. A dose taken over two weeks is recommended for athletes likely to experience the following training stressors. • A new period of high-volume or high-intensity training • Acclimatisation training in hot or humid environments • Altitude (sea-level = house) training
Bicarbonate and citrate	Bicarbonate and citrate are both used as extracellular buffers to increase the body's ability to dispose of excess H+ ions produced through anaerobic glycolysis. A pre-event dose of 0.3 g sodium bicarbonate or citrate per kg body mass, 60 to 90 minutes pre-event; or a longer term (spread over 24 hours) of 0.5 g sodium bicarbonate per kg body mass, split into four doses spread over the day both achieve increases in blood-buffering capacity. This practice is recommended for athletes: • competing in high-intensity competition events lasting three to seven minutes • participating in prolonged intermittent high-intensity activities, e.g. team sports • engaged in interval training.
Caffeine	Caffeine is used as a central nervous system stimulant, diuretic (a substance that promotes fluid loss), circulatory and respiratory stimulant. Caffeine intensifies muscle contractions, masks the discomfort of physical exertion and even speeds up the use of the muscles' short-term fuel stores. Caffeine is thought to improve performance by increasing the utilisation of fat as an exercise fuel and 'sparing' the use of the limited muscle stores of glycogen (glycogen sparing) but only in the first 15–20 minutes of sub-maximal performance. A pre-exercise dose of 5 to 9 mg (tablet form) per kilogram of body mass would benefit: • medium- to high-intensity performance lasting 60–90 minutes • high-intensity training lasting up to 20 minutes.
Creatine	Creatine can be replenished either from food (or supplements) or through synthesis from precursor amino acids. Dietary sources: beef, tuna, cod, salmon, herring and pork. Most popular supplement source: creatine monohydrate. Rapid loading may be achieved by five days of repeated doses (e.g. 4 doses x 5 g). Similar loading will occur over a longer period (21–28 days) by taking a daily dose of 3 g (slow load). Once the muscle creatine content has been saturated, it takes about four weeks to return to resting levels. A daily dose (maintenance dose) of 3–5 g will allow elevated levels to be maintained. These protocols will increase creatine muscle stores by 20 to 50 per cent. Most beneficial for athletes: • involved in repeated short maximal efforts with brief recovery periods • engaged in short interval training • undertaking high-intensity resistance training seeking to increase protein synthesis. Caffeine nullifies the ergogenic benefits derived from creatine supplementation. Co-ingestion with a substantial amount of carbohydrate (50–100 g) may enhance creatine loading.

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Glycerol	Glycerol is a naturally occurring metabolite that is rapidly absorbed and distributed throughout the body to eventually be excreted over the following one to two days. It allows athletes to temporarily retain extra fluid, which may be more beneficial to performance than fluid ingested via water loading. It is suggested that 1–1.5 g glycerol per kilogram of body mass is consumed two hours pre-event, in conjunction with 25–35 mL fluid per kilogram of body weight. It is best used for athletes: • undertaking endurance training or competing in hot, humid conditions, where excessive fluid losses cannot be replaced sufficiently during the exercise • requiring enhanced rehydration after weigh-in where dehydration has been used to make weight (weight division sports).
Liquid meal supplements	Typical composition: high carbohydrate (60–70 %), moderate protein (20–30%), and low-fat (5–10%) powder for mixing with milk, water or liquid. Provides substantial source (RDI) of many vitamins, minerals and essential amino acids in 500–1000 mL serve. They are useful for athletes: • needing pre-event 'glycogen loading'; endurance performers • needing to increase energy-intake without preparing or eating additional food or meals • aiming to increase lean body mass • coping with heavy training loads • adolescents who are undergoing growth spurts • requiring post-exercise rapid glycogen restoration • travelling.
Sports bars and gels	Typical composition: high carbohydrate (70%), moderate protein (20–30%), and low-fat (5–10%) and fibre. Some are enhanced with micronutrients (typically containing 25–50% NRV of various vitamins and minerals per bar). Sports bars and gels are a more concentrated form of carbohydrate than sports drinks. Useful for athletes: • requiring post-exercise recovery supplement supplying carbohydrate and some protein • requiring rapid recovery between events or games in a multi-event competition • undertaking a heavy training load, growth or aiming to increase muscle mass • needing energy and carbohydrate as part of a pre-competition carbohydrate-loading regime.
Carbohydrate loading	Carbohydrate loading attempts to prolong carbohydrates as the main fuel and delay the body's reliance on fats. Breaking down fats (catabolism) decreases power output because fat mobilisation and aerobic breakdown are significantly slower than that fuelled by carbohydrates. See pages 185–187 in Chapter 10 for more detail.
Sports drinks	Typical composition: carbohydrate-rich fluid (6–8% carbohydrate), containing sodium (10–25 mmol/L) and potassium (3–5 mmol/L) which provides rapid delivery of fluid and fuel during and after exercise and ensure fluid retention. Sports drinks are an ideal fluid to consume during and after training and competition sessions, allowing the athlete to replace fluid and electrolyte losses, and simultaneously providing an additional source of carbohydrate fuel: carbohydration. In many situations, sports drinks are a better choice than water because they promote better fluid intake than water and increasing retention of fluid consumed post-exercise by reducing urine losses. Carbohydrate replacement during prolonged exercise enhances immune function by reducing immuno-suppression observed post-exercise.

	They are useful for athletes: • participating in endurance activities; ~ 10–20% improvement attributed 50:50 to fluid and carbohydrate replacement • involved in high-intensity intermittent exercise such as team games • before, during and after performances • seeking to counteract fatigue caused by elevated body temperature and dehydration **Hypotonic drinks** Hypotonic drinks have a low osmolality, containing the fewest carbohydrate and electrolyte particles. Due to the lower osmolality, the drink is more diluted and therefore absorbed at a faster rate than ordinary water. Hypotonic drinks generally contain less than four grams of carbohydrate per 100 mL. They quickly replace fluids lost by sweating and are most suitable for athletes who need fluid without the added boost of carbohydrate. **Isotonic drinks** Isotonic drinks have the same osmolality as the body's own fluids, containing comparable amounts of carbohydrate and electrolytes. *Of the three types of sports drinks, isotonics are usually preferred by athletes for their balance of refuelling and re-hydration.* Isotonic drinks usually contain between 4–8 g of carbohydrate per 100 mL. Glucose is the body's preferred source of energy, so an isotonic drink such as Lucozade Sport, where the carbohydrate source is glucose in a concentration of 4–8%, is an ideal choice for assisting in hydration. **Hypertonic drinks** Hypertonic drinks are more concentrated so they have a higher osmolality than the body's own fluids, which means the absorption of hypertonic drinks is slower than water. They contain approximately eight grams of carbohydrate per 100 mL. They are used to supplement daily carbohydrate intake and are normally taken after exercise to top up muscle glycogen stores. In ultra-distance events, high levels of energy are required and hypertonic drinks can be taken during exercise to meet the energy requirements. If consumed during exercise, hypertonic drinks need to be used in conjunction with isotonic drinks to replace fluids.
Colostrum	After over 20 years of research, scientists now believe that bovine (cow) colostrum is the only safe alternative for human consumption. The growth and immune factors found in bovine colostrum are virtually identical to those in human colostrum and are reportedly many times richer. Colostrum contains nutrients such as protein, carbohydrates, fat, vitamins and minerals, and also bioactive components such as growth factors and immunoglobulins. The concentration of immunoglobulins G1, G2, M and A in bovine colostrum is approximately 100 times greater than in normal milk. It is useful for athletes: • seeking good health during training and in-season competition by activating immunological defence systems against microbes • undertaking strenuous training to increasing protein synthesis via increased IGF-I concentration in blood and muscle • recovering from long interval sessions

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KEEP IT REAL!

Justine Henin-Hardenne won the US Open in 2003 after spending the previous night on an intravenous drip, which she needed to reverse dehydration suffered the night before during a gruelling and drawn-out semi-final match. This is not unusual in some sports, but raises the ethical issue of which medical interventions should be legal and allowed in sport.

In the NRL and AFL, intravenous fluid use is banned during a game and in the 24 hours before a game, whereas in the NFL (American gridiron), intravenous fluid use during the game is commonplace. The Brisbane Lions made headlines in 2003 with their use of half-time intravenous drips. The AFL deemed this practice illegal and banned it almost 18 months after the Lions started using it.

In tennis, many medical experts believe that if Pat Rafter had been able to use intravenous rehydration during his five-set matches he would have won more Grand Slam matches and maybe even a Davis Cup final. Pat Rafter suffered badly from the effects of dehydration during extended matches, and lost fluid at a greater rate than many other players on the circuit. This eventually caused fatigue and decreased performance levels.

Rafter's case is hypothetical, as there is not enough of a break during a tennis match to run a drip. But in football matches, half-time is an obvious opportunity where players could use intravenous drips, and the interchange bench could also be used.

Complicating the issue is the fact that there is no drug test available to prove whether a player has been intravenously rehydrated. Is water itself an illegal aid? Why is the practice allowed in some sports and some countries but not others? Who would be responsible in the unlikely event that an athlete died from dehydration that could have been avoided through the use of intravenous rehydration? The issue of using intravenous hydration therapies creates many ethical considerations.

1 How is intravenous hydration different from consuming sports drinks?
2 What are some of the risks associated with intravenous hydration that might affect player health and wellbeing?
3 Do you believe that sportspeople, where practical, should be allowed to use intravenous hydration practices?

Figure 12.5 Pat Rafter suffered badly from dehydration during extended tennis matches

Some of the most accessible legal dietary practices available to students include hydration and carbohydrate loading, including carbohydration and caffeine ingestion.

carbohydration fluid replacement using carbohydrate-filled fluids

Fluid replacement and carbohydration

A recent innovation in sports nutrition is carbohydration. As the word suggests, carbohydration is a form of fluid replacement involving recovery from events lasting longer than 50 to 60 minutes by using carbohydrate-filled fluids that replace vital body fluids and refuel muscles, replacing glycogen stores.

Water is vital as a lubricant in the musculatory, respiratory, and digestive and excretory systems. It forms an important part of blood volume in the circulatory system, and is significant in maintaining a desirable fluid balance between the interior of cells and the fluid surrounding the cells (called osmotic equilibrium). It is critical in regulating body temperature via sweating. Water is also stored in the process of storing carbohydrates, and is liberated as glycogen stores are used. It is a vital ingredient in athletic performance and in the overall health of the athlete.

Recent research indicates that muscles are most receptive to replacing glycogen stores within the first two hours after exercise, so the sooner you eat or drink carbohydrates after exercise, the faster your muscles recover. The harder you train, the more critical this carbohydration becomes.

Figure 12.6
A dehydrated triathlete being carried to an ambulance

Fluid loss and hydration

One way to tell when you're hydrated is if you have to urinate often and your urine is clear in colour. Dark-coloured urine is a sign of dehydration. Many nutritionists recommend a two-dose carbohydrate recovery routine to replace glycogen losses. Dose 1: As soon as tolerable post-exercise, preferably within 15 to 30 minutes, but at least within two hours. Dose 2: Within two to four hours post-exercise. One 'dose' is one gram of carbohydrate per kilogram of body weight.

Catchy fact
Two main factors affect the speed at which fluid from a drink gets into the body:
- the speed at which it is emptied from the stomach to the duodenum, which is called gastric emptying.
- the rate at which it is absorbed through the walls of the small intestine to the blood, which is called intestinal fluid absorption.

The higher the carbohydrate levels in a drink, the slower the rate of stomach emptying. Isotonic drinks with a carbohydrate level of between six and eight per cent are emptied from the stomach at a rate similar to water. Electrolytes in a drink, especially sodium and potassium, reduce urine output, enable fluid to empty quickly from the stomach, promote absorption from the intestine and encourage fluid retention.

Table 12.5 The effect of fluid loss on body mechanisms and functions

Percentage of body weight lost as sweat	Physiological effect
2 %	Impaired performance
4 %	Capacity for muscular work declines
5 %	Heat exhaustion
7 %	Hallucinations and impaired coordination
10 %	Circulatory collapse and heat stroke

Water alone does not compensate for the mineral salts lost during intense exercise. During strenuous aerobic exercise, the body can lose as much as two litres of fluid per hour in the form of sweat. Sweat contains mineral salts that need to be replaced in order to maintain an optimum osmolality within the body's fluids. (Osmolality is the number of particles in a solution.) It is the presence of mineral salts (called electrolytes) within body fluids that initiates thirst urges. Drinking plain water causes bloating, suppressing thirst and further drinking while stimulating urine output, so the water is inefficiently retained. Where a high fluid intake is required, water is a poor hydration choice as it contains no carbohydrates or electrolytes.

Most sportspeople consume sports drinks. They can be listed under three broad categories based on electrolyte composition: hypotonic, isotonic and hypertonic. The importance of electrolytes lies in the role of fluid regulation in and out of body structures. Movement of water across cell membranes is reliant on the electrolyte concentration either side of the membrane. For example, any increases in electrolyte concentration outside a cell membrane will cause water to move towards it from within the cell and vice versa; this is called osmosis.

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Checkpoints

Investigating sports drinks and hydration

Visit the Gatorade website.

Gatorade

This site has many interesting links. Of particular interest is the library of information on dietary supplements, hydration, sports nutrition and tackling the heat. It also has a fluid-loss calculator, which you can use to investigate likely losses during your sports activities along with recommended fluid-replenishment strategies.

1 Using the Gatorade fluid-loss calculator, enter information for a sport or activity you are involved or interested in. (This is an American site, so all figures are in imperial measurements. They will need to be converted.)

- **a** What recommendations are made for hydration before and during the activity?
- **b** What effect does increasing your body weight have on the recommendations made? Briefly explain why changes need to be made due to the varying weights of athletes.

2 Take a 'Tour of the labs – physiology'.

- **a** In which three key focus areas is research conducted at the physiology labs?
- **b** Briefly explain how the environmental chamber can be used to improve athletic performance(s).

3 Take a 'Tour of the labs – biochemistry'.

- **a** Which three key areas are analysed in the physiology laboratories and which aspects of performance do they relate to?
- **b** How do athletes use results and feedback obtained from the physiologists to improve their performance levels?

4 Launch the 'Tackling the heat interactive presentation' to discover ways to best perform during extreme conditions, as well as hydration tips for various parts of training and performance. Take summary notes in point form and compare these with a classmate's notes.

5 Under which performance conditions would you provide an athlete with:

- **a** a hypotonic drink?
- **b** an isotonic drink?
- **c** a hypertonic drink?

Carbohydrate loading

Carbohydrate loading is a strategy that involves altering training and nutrition to maximise muscle and liver glycogen (carbohydrate) stores prior to endurance competition. Carbohydrate loading needs to be considered in conjunction with the glycaemic index, both of which are discussed in greater detail in Chapter 10.

Carbohydrate loading:

- requires an exercise taper
- involves training lightly for three to four days before competition
- requires lots of rest
- involves eating seven to ten grams of carbohydrate per kilogram of body weight.

Carbohydrate loading usually causes body mass to increase by approximately two kilograms in an average 70-kg athlete. This extra weight is due to extra muscle glycogen and water: 2.7 grams of water is stored for each gram of muscle glycogen added. As well as feelings of being 'heavy', the extra weight directly adds to the energy cost of performing.

Checkpoints

1. Outline two ways that athletes might inadvertently test positive to a dietary-related substance.
2. Chapter 10 outlined the importance of athletes carefully considering the GI content of foods consumed before and after a game. Outline which GI foods are best consumed before and after a game by discussing the role each plays at these different stages of performance.
3. When some AFL players increase their training loads they actually lose weight, even though they are trying to 'bulk up' to be competitive during physical contests. On the other hand, some players actually decrease their percentage body fat when skinfold measurements are taken, yet find themselves increasing in weight. How do you account for these two very different outcomes?
4. Outline three reasons why liquid carbohydrate meals are preferable for sports athletes to meals containing solid forms of carbohydrate.
5. Nutrients and mineral levels are carefully monitored in players. What role does iron play in a player's performance and recovery?

Caffeine

Caffeine, found in products such as coffee, tea, cola drinks and chocolate, stimulates the central nervous system. In doing so it is believed to have a glycogen-sparing effect, enabling more fat to be used as a fuel with less usage of glycogen and reducing or postponing muscular fatigue. Caffeine also stimulates respiration, increases urine production and increases muscle cell membrane permeability to calcium ions, thereby improving muscle contractility.

The ergogenic effects of caffeine are widely disputed. While early research by Costill (1978) attributes caffeine with producing a significant improvement in endurance performance, other studies contradict these findings. Dr Cathy Laska from the University of Melbourne indicated in a 1992 study that there is no conclusive link between sports results and caffeine. A more recent study conducted at the University of Guelph, Canada, found that the ingestion of caffeine can enhance the quality of interval workouts, possibly by boosting adrenaline levels and increasing anaerobic energy production. Other recent studies suggest that the consumption of just two cups of coffee can increase 1500-metre running performances by four seconds and increase kicking speed at the ends of 1500-metre races by three per cent; that caffeine can boost 100-metre swimming velocity and enhance sprinting ability on a bicycle; and that caffeine ingested during exercise does not increase an athlete's risk of dehydration. (Adapted from pponline.co.uk.)

Until recently, the use of caffeine as an ergogenic aid has been almost exclusively associated with prolonged endurance events. Current thinking is that it is actually sprint and events of less than five minutes' duration that benefit most from the ingestion of caffeine. It is also argued that 'flat' cola drinks, diluted with plain water at a rate of one part water to two parts cola, would make a good sports drink, and could actually provide an endurance athlete with more power at the end of a race.

Critics of caffeine as an aid for endurance events argue that when ingested prior to an event, the diuretic effect can result in the expulsion of sufficient quantities of fluid (increasing urine production by up to 31 per cent) to raise body temperature and heartrate during exercise and increase the risk of dehydration. Other side-effects include anxiety, headache, irritability, restlessness, palpitations, tremor, gastrointestinal symptoms and dependence. The World Anti-Doping Agency (WADA) removed caffeine from its list of prohibited substances in 2004.

Catchy fact

Australian sports physician Dr Peter Larkins, a Melbourne-based former chairman of the National Drugs in Sport Committee and former Olympic athlete, says there has been an increased use of caffeine by Australian athletes since it was taken off the WADA list.

ISBN 9780170227124

A large range of performance and recovery-enhancing strategies also exist and are worth considering. Whilst these are legal and ethically acceptable, they tend to be expensive and mainly used by athletes at the elite level.

Table 12.6 Performance and recovery-enhancing strategies

Acclimatisation	Allows performers to adapt to prevailing environmental conditions prior to competition.
Altitude training, altitude tents, altitude houses	Trains the body to adjust to lower oxygen levels and associated increased red blood cell and oxygen-carrying capacity that translates into higher VO_2 maximums over time
Contrasting	Alternate hot and cold showers or baths lead to vasodilation and vasoconstriction of blood vessels, leading to increased blood flow and removal of metabolic by-products
Hydrotherapy	Passive use of jets and warm water to relax soft-tissue injuries and provide less stress on joints via increased buoyancy. Additionally beneficial by the way it offers constant resistance through range of movements (isokinetic)
Hyperbaric chambers	Greatly increases amounts of available oxygen, which is critical in healing soft-tissue injuries in reduced periods of time
Ice jackets	Counteracts elevated body temperatures and either delays or avoids fatigue, dehydration and blood flow away from working muscles
Massage	Massage 48–72 hours following injury or post-exercise without any injuries is effective in promoting blood flow, improving joint mobility, decreasing accumulated by-product build-up and inflammation
Physiotherapist treatments	Ultrasound, infra-red, diathermy, interferential, intermittent pressure pumps, passive motion machines, electrical muscle stimulation, exercise therapy, strapping and taping are some of practices used to facilitate recovery and improve future performances
Video analysis: biomechanics, movement patterns, etc.	Used to provide athlete feedback on key movement and playing patterns; used to compare to most efficient movements and previous performances

TEST YOUR KNOWLEDGE

>> multiple-choice questions

1 Hormonal blood boosting leads to hypertension because it:

A results in hardening of arterial walls
B increases stroke volumes
C leads to increased amounts of red blood cells
D All of the above.

2 The most recommended practice for carbohydrate loading is to:

A 'drain' carbohydrate levels via an intense training session, then increase carbohydrate intake leading up to competition
B only eat high-GI foods leading up to competition
C increase fibre and water intake while consuming increased levels of carbohydrates
D increase carbohydrate intake while decreasing training volumes up to a week before competition.

>> short-answer questions

1 An increasing number of elite sporting clubs are using video analysis and GPS in an effort to bring about improvements in performances.

a Discuss how video-analysis programs such as Dartfish and Swinger are being used to bring about improvements.
b If your school uses video analysis of performances, discuss how it is used to bring about future improvements.
c Discuss why GPS used in conjunction with video analysis of performers leads to even more powerful potential improvements.
d GPS is being used by AFL players, NRL players, and national hockey and soccer players. What sort of data can it provide, and how can it be used by the coach during the game as well as the fitness advisors after the game?

2 Many dietary 'myths' exist. A myth is an entertaining story or piece of information that is circulated as though it is true, but has no real scientific support. For example: 'Eating chocolate before an endurance event will provide you with extra energy and improve your performance', or 'Salt tablets should be taken to replace salts lost through sweating and thus prevent cramps'.

a For each 'myth' above, state the effect of following the unsupported advice.
b Make up a list of three other dietary myths and the truths behind their claims.
c Is it possible for excess amounts of vitamins and minerals to have negative effects on performance? Discuss briefly.

>> essay questions

AIS nutrition

1 Visit the AIS website and compare and contrast the dietary recommendations for optimum performance between athletes from any two of the following sports: basketball, cricket, gymnastics, netball, soccer, swimming, tennis, triathlon, volleyball, distance running and cycling. Use a table headed 'Similarities' and 'Differences' to summarise your findings.

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2 **a** What is an ergogenic aid?

b Copy Table 12.7 into your notebook and complete it.

Table 12.7 Ergogenic aids

Ergogenic aid	Performance enhancement sought	Likely users	Side-effects
Beta-blockers			
Amphetamines			
Recombinant EPO			
Anabolic steroids			
Diuretics			

c List and discuss four reasons why athletes use drugs.

d Outline the side-effects of insulin-like growth factors (IGFs) and glucocorticosteroids

13 Fatigue and recovery

During exercise, skeletal muscles cannot maintain constant levels of contraction. With repeated contractions, there is a loss of force as fatigue sets in: muscles are no longer able to respond to stimuli from the brain and activity levels decrease. The exercise-induced reduction in the power-generating capacity of a muscle and an inability to continue the activity is defined as 'fatigue'.

The onset and rate of development of fatigue depends on:

- the type of activity being undertaken: intermittent or continuous
- the muscle-fibre type being used: slow-twitch fibre types are more fatigue-resistant
- the type of muscular contractions occurring: isotonic, isometric or isokinetic; isometric contractions cause fatigue the quickest
- the intensity and duration of the activity undertaken: fatigue is more rapid with high-intensity or anaerobic work
- the level of fitness or training adaptations possessed by the performer.

Fatigue mechanisms

neuromuscular
the voluntary control of muscles by nerves

psychomotor
the function of muscles under the control of the mind

Fatigue can be caused by many factors, but this chapter focuses on the neuromuscular rather than the psychomotor mechanisms that might be responsible.

When we consider that fatigue is the inability to sustain a required exercise intensity, it can also be thought of as the point when exercise performance begins to deteriorate or falter. Fatigue sees a reduction in muscle force and shortening velocity; combined, these bring about reduced muscular power as well. Accompanying this, performers will most likely also experience slower muscle relaxation rates and increased perception of effort (RPE), which is very much a subjective measure. You will recall from biomechanics studies in Chapter 8 that power = force × velocity.

Many books discuss fatigue from differing perspectives, so it is important that we understand that it can manifest itself in various forms.

Central fatigue

Central fatigue occurs when muscular function is decreased as a result of central nervous system impairment.

Peripheral fatigue

Peripheral fatigue occurs when muscle function is disrupted at the muscle site or sites, as a result of impaired internal muscle processes.

It is possible for central and peripheral fatigue mechanisms to occur simultaneously. Many texts describe three other levels of fatigue, as outlined in Table 13.1.

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Table 13.1 Levels of fatigue

Level of fatigue	Causes, signs and symptoms	Fatigue indicator
Local	Fatigue is experienced in a muscle or group of muscles localised in one part of the body. This tends to occur if the same muscle group is called upon repeatedly during training or performance without sufficient recovery. Muscles often experience a heaviness, tingling pain or cramp-like feelings.	Commonly felt after completing a weight station, e.g. 8 x bench presses at 80% RM; or biceps or triceps after a game of squash or badminton **Fatigue indicator = 2/10–4/10**
General	This tends to occur after completing a full training session or competitive game of football, netball, etc. Performers feel all of their muscles are 'weak', and sometimes experience psychological fatigue as well.	Commonly experienced after completing a circuit session or full-on game of hockey **Fatigue indicator = 6/10–8/10**
Chronic	Performers experience an unhealthy breakdown of their immune system. This is usually caused by overtraining as a result of poor training-program design, inappropriate recovery strategies or excessive competition demands and schedules. Chronic fatigue is dangerous; it is accompanied by increased susceptibility to illness or infections, persistent muscle soreness and reduced motivation levels.	Commonly diagnosed as chronic fatigue syndrome (CFS) or sometimes glandular fever **Fatigue indicator = 10/10**

Catchy fact
Exhaustion is the total inability to keep exercising, even though muscles may still have the ability to generate muscular force.

Researchers have discovered that fatigue mechanisms are multifactorial. Recent findings suggest that fatigue is task-dependent and can vary for different tasks. Factors such as exercise duration and intensity, types of muscular contractions, physical fitness or conditioning, age, diet and environmental conditions all play a significant role in determining when performances will start to deteriorate. We covered the effect various environmental conditions can have on performers in Chapter 11.

multifactorial
more than one factor is involved

Current understanding of fatigue mechanisms suggests that the following key factors contribute to fatigue, either by themselves or in combination.

Fuel depletion

- Intramuscular ATP
- Phosphocreatine
- Muscle glycogen
- Blood glucose

Metabolic by-products

- H^+ ions in plasma and muscle
- Inorganic phosphate (Pi)
- Adenosine diphosphate (ADP)
- Ca^{2+}

Neuromuscular events

- Decreased CNS 'firing'
- Impaired sodium (Na^+) and potassium (K^+) gradients

Elevated body temperature

- Very high core temperatures
- Increased rates of dehydration
- Redistribution of blood to assist cooling

Lactic acid: Good guy or bad guy?

lactate threshold
the point where lactate begins to accumulate in the bloodstream

glycolysis
the breakdown of glycogen aerobically (with oxygen) or anerobically (without oxygen)

NAD+
nicotinamide adenine dinucleotide

acidosis
an abnormal increase in acidity

Lactic acid has long been thought of as a fatiguing waste product responsible for causing major fatigue in performers. It was often pointed to as the cause of DOMS, fatigue and even exhaustion. Today, lactic acid is thought of as being a very important and useful energy source used to enhance performance. It's worth linking energy systems to performances and associated production of lactic acid to get a better idea of the role of lactic acid in fatigue.

Lactic acid is continuously being produced and removed, even at rest. Ultra-endurance athletes, such as marathon runners and triathletes, can have near-resting lactic acid levels following training and competitions—despite feeling exhausted. During exercise, production of lactic acid increases but this is matched by its removal, showing no significant increase. Lactate production increases in proportion to our exercise rates and at some point, a rate or workload will be reached which sees lactate accumulate. This is known as the lactate threshold and is usually triggered above 85 per cent of maximum heart rate, depending on conditions and training. It is at this point that the rate of lactate production exceeds the rate of lactate removal.

Glycogen is our preferred energy source for exercise. Via glycolysis, each glucose molecule is split into two pyruvic acid molecules, and energy is released to form adenosine triphosphate (ATP), which then allows more muscle contractions to occur. Under aerobic conditions with sufficient oxygen, the pyruvic acid enters the mitochondria and undergoes aerobic glycolysis to produce more ATP. When there is insufficient oxygen supplied during anaerobic conditions, the pyruvic acid transforms into lactic acid via anaerobic glycolysis.

Glycolysis results in the formation of pyruvic acid and hydrogen ions (H^+). A build up of H^+ will make the muscle cells acidic and interfere with their operation, so carrier molecules (NAD^+) remove the H^+. The NAD^+ is broken down to NADH that deposits the H^+ ion at the electron transport gate (ETC) in the mitrochondria to be combined with oxygen to form water (H_2O). If there is insufficient oxygen, the NADH cannot release the H^+ and it builds up in the cell. To reduce the rise in acidity, pyruvic acid combines with H^+, forming lactic acid which then breaks down to lactate and H^+. Some of the lactate diffuses into the blood stream and takes some H^+ with it, as a way of reducing the H^+ concentration in the muscle cell.

Catchy fact
The 'burn' of lactic acid results from the build up of hydrogen, causing pH to be reduced; muscle contractions become impaired and the low pH stimulates the free nerve endings in the muscle, resulting in the burning sensation.

The increase in hydrogen ions and subsequent acidity of the internal environment is called acidosis, but it is clear that acidosis is caused by reactions other than lactate production. Increased lactate concentration coincides with acidosis and remains a good indirect marker for the onset of fatigue. Lactate production, especially if accompanied by a high capacity for lactate removal that occurs as an adaptation to training, may be more likely to delay the onset of acidosis. This occurs because lactate serves to combine with hydrogen ions and moves them from the cell to the blood. Training accelerates lactate clearance, reduces lactate accumulation at any given workload and results in a greater level of lactate accumulation during maximal effort. However, high concentrations of blood plasma acidosis may impair performance by causing a reduced central nervous system drive to the muscle (see page 256 in this chapter for more detail).

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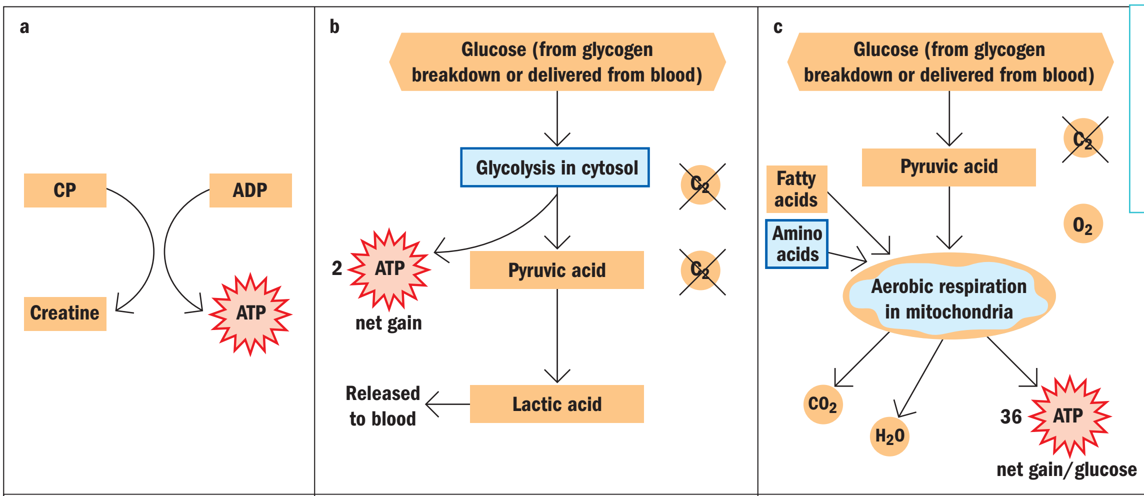

Direct phosphorylation (coupled reaction of creatine phosphate [CP] and ADP)	Anaerobic mechanism (glycolysis and lactic acid formation)	Aerobic mechanism (aerobic cellular respiration)
Energy source: CP	Energy source: glucose	Energy source: glucose; pyruvic acid; fatty free acids from adipose tissue; amino acids from protein catabolism
Oxygen use: None Products: 1 ATP per CP, creatine Duration of energy provision: 15 sec.	Oxygen use: None Products: 2 ATP per glucose, lactic acid Duration of energy provision: 30–60 sec.	Oxygen use: Required Products: 36 ATP per glucose, CO_2, H_2O Duration of energy provision: Hours

Figure 13.1 Methods of generating ATP during muscle activity: the fastest mechanism is direct phosphorylation (a); the slowest is the aerobic mechanism (c).

Let us summarise this process and make it a bit simpler, using what is known as the lactate shuttle model:

- As we exercise, glycogen is broken down and pyruvate is formed.
- When insufficient oxygen is available to break down the pyruvate, lactate and hydrogen (H^+) are produced.
- Lactate and H^+ enter the surrounding muscle cells and tissues, and are then transported to the blood.
- The muscle cells and tissues receiving the lactate break down the lactate and more ATP is produced for immediate use, or used in the creation of glycogen.
- The glycogen remains in the muscle cells until more energy or ATP is required.

Lactate is a critical element in producing energy as activities continue and may help to prolong sub-maximal activity. Evidence suggests that many aspects of lactate production are beneficial to athletic performance.

Catchy fact

Sixty-five per cent of lactic acid is converted to carbon dioxide and water, 20 per cent into glycogen, 10 per cent into protein and 5 per cent into blood glucose.

Catchy fact

Lactic acid and lactate are two different substances. Lactic acid is produced during glycolysis, but quickly breaks down and releases hydrogen ions (H^+). The remaining compound combines with either sodium ions (Na^+) or potassium ions (K^+) to form a salt known as 'lactate'. It is blood lactate that is measured by doing 'pin-prick' tests during training, not lactic acid,.

Figure 13.2 Swimmer Grant Hackett being lactate tested during training

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contractile the ability of muscle fibres to contract

When lactate accumulates and severe blood acidosis occurs, fatigue tends to follow quickly; when the cell or blood acidity increases, important contractile and metabolic functions are compromised. As you will learn, an active recovery clears lactate at faster rates than a passive recovery, but it may also further deplete the glycogen stores that need replenishing. Many athletes use a combined strategy, utilising active and passive recoveries together to decrease lactate levels while allowing glycogen resynthesis.

KEEP IT REAL!

Tired muscles? Don't blame lactate

by Anna Salleh

Lactic acid, produced in the muscles from intense exercise, enhances performance rather than reduces it as commonly believed, according to a new study.

A team of Australian and Danish researchers publish their findings in today's issue of the journal *Science*.

Lactic acid has long been associated with muscle fatigue, the loss of force and power with repeated muscle contractions.

'Everybody thinks lactic acid is a bad thing and that it's deleterious to performance but what we're showing is that it's a help,' said researcher Professor Graham Lamb of Melbourne's La Trobe University. 'It actually reduces fatigue.'

Lactic acid is produced when a muscle works so hard it is forced to convert glucose to energy without enough oxygen. Less energy is produced per molecule of glucose but it's a way of the body squeezing the last ounces of energy out of glucose despite there being enough oxygen.

Lamb said that sports commentators and trainers often said athletes needed to 'warm down' after intense exercise to wash out lactic acid.

'The reason people thought lactic acid caused fatigue is that when muscles fatigue they see lactic acid increase,' Lamb, a muscle physiologist, told *ABC Science Online*. 'It turns out it's a correlation but not the cause.'

Not only does lactic acid not cause fatigue, said Lamb, it improves the conditions for muscle contractions.

Contractions, contractions

Muscle contraction relies on a brief change in electrical potential across a muscle cell or fibre membrane. This occurs by the selective flow of positively and negatively charged ions.

Under strenuous exercise, potassium ions build up outside the cell, causing the cell to lose its normal potential and thus the ability to contract. Muscles also have a natural 'brake' on them, in the form of chloride ions, which prevent muscles contracting on their own.

Lamb's team has shown that lactic acid seems to remove this chloride ion brake on muscle contraction.

'You are taking away the inhibition of chloride and this lets the electrical impulses keep going when it would have failed.'

Lamb and his team looked at what happened under different levels of acidity in 'skinned' rat muscle fibres bathed in a solution that simulated a hard-working muscle.

'When it's normal acidity, it stops working. When it's more acid it keeps going.'

Lamb was unsure whether the practice of warming down to wash out lactic acid should change as a result of the findings.

'I'm not saying it isn't useful but the reason that it's useful is not that they're getting rid of lactic acid,' he said.

How about the brain?

Dr David Bishop, president of the Australian Association for Exercise and Sport Science, said the research was provocative and would stimulate a lot of debate.

'It is important to remember though, that all the cited studies are on a single muscle fibre,' he told *ABC Science Online*. 'There is something very important missing here: the brain.'

Bishop, who is based at the University of Western Australia, said many researchers believed the brain interacted with lactic acid to cause fatigue.

He also cited other research that supported the role of lactic acid in fatigue, including his own research, which has shown improvements in athletic performance following a drink of sodium bicarbonate to neutralise lactic acid.

Exercise physiologist and former triathlete, Dr Paul Laursen of Edith Cowan University in Perth, told *ABC*

Science Online that physiologists were starting to appreciate that muscle fatigue was a complex phenomenon and the idea that it was all down to lactic acid was false.

But he described the new research as 'very interesting'. 'It was news to me. I think it's going to be news to most,' said Laursen, who researches exercise fatigue. He was also unsure whether it would change athletic practice.

ABC Science Online, 2004

It is worth quickly revisiting the oxygen uptake during exercise and recovery to better link energy systems to fatigue and recovery mechanisms.

Checkpoints

1 List the metabolic consequences of supplying ATP via the lactic acid system.

2 How is it possible for triathletes to have near-resting levels of lactic acid despite performing for over a couple of hours?

3 Explain how the accumulation of H^+ is implicated in muscle fatigue.

4 Why do physiologists, fitness advisors and coaches test for lactate regularly during training sessions?

5 Explain how training reduces lactate accumulation at any given workload and yet results in a greater level of lactate accumulation during maximal efforts.

oxygen deficit
when oxygen demands are greater than the body's ability to supply the necessary oxygen levels

Oxygen deficit

As we start to exercise and move from a state of rest, there is a period where the body's oxygen demand exceeds the supply of oxygen from its systems. The body's respiratory, circulatory and cardiovascular systems cannot act quickly enough to satisfy the demand for oxygen, resulting in an oxygen deficit. The amount that the oxygen supply fails to meet the body's oxygen demand represents the oxygen deficit; this is the amount of extra oxygen required to perform the activity if all the energy could have been supplied aerobically. While oxygen deficit continues, the body must obtain adenosine triphosphate (ATP) from its anaerobic energy systems, which do not rely on oxygen.

For short-duration and high-intensity activities, the body is unable to deliver sufficient oxygen fast enough to meet the activity demands. This causes the body to rely on phosphocreatine (PC) splitting, utilising the adenosine triphosphate–phosphocreatine system (ATP–PC system) or anaerobic glycolysis, utilising the lactic acid system to supply ATP anaerobically.

Figure 13.3 shows the oxygen uptake and oxygen deficit for an elite 800-metre runner during an event lasting approximately two minutes.

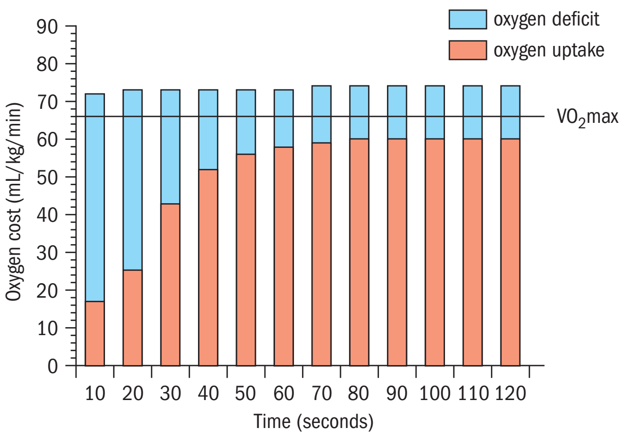

Figure 13.3 Exponential increase in oxygen uptake and eventual steady state for an 800-metre runner

Catchy fact
It is possible to work above 100 per cent VO_2 max by calling upon the anaerobic energy systems, essentially the lactic acid system, due to limited phosphocreatine (PC) stores. The lactic acid system increases its contribution to ATP supply during surges in activity (or increased workloads) that cause people to move out of steady state and create the exponential curve seen in Figure 13.3, creating increased oxygen demands on the body, which might not initially be met and contribute to oxygen deficit.

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Steady state

It is very difficult to sustain high-intensity workloads for periods beyond 30 seconds due to limitations of the two anaerobic energy systems, primarily depletion of PC and accumulation of lactic acid, hydrogen ions (H^+) and other metabolic by-products. At the commencement of exercise, all three energy systems contribute to ATP production, but the aerobic energy system calls upon many more chemical reactions to liberate ATP. This means that it 'lags' in its ability to contribute large amounts of energy in the first 20 to 30 seconds of exercise.

steady state
situation where the body is able to supply sufficient oxygen to meet the oxygen demands

plateau
period of unchanging oxygen demand

Aerobic training will greatly speed up a person's ability to supply oxygen to working muscles, as well as extract it in larger amounts once it is transported there. Oxygen consumption rises exponentially during the first minute of exercise, until sufficient oxygen is taken up, transported and utilised to meet exercise demands. Once the performance becomes predominantly aerobic in nature and the aerobic energy system becomes the major supplier of ATP, a steady state is reached. When the body is in steady state, oxygen supply equals oxygen demand and this contributes to lactate breakdown, removal and conversion back into useful forms. On any oxygen consumption graph, steady state will be represented by plateaus, and periods of oxygen deficit will be represented by sharp or exponentially increasing lines.

Table 13.2 The oxidation of lactate and conversion into useful fuels

Oxidation into carbon dioxide and water	65%
Conversion into glycogen	20%
Conversion into protein	10%
Conversion into glucose	5%

Lines on the graph that look like a series of increasingly steep hills can also mirror increased intensities during surges or increased workloads during activities.

This pattern can be repeated many times until maximum levels of oxygen uptake are attained, which is called VO_2 maximum (or VO_2 max). Every time oxygen demands increase below VO_2 max, the exponential oxygen consumption curve is repeated until another steady state is reached. VO_2 max is the maximum amount of oxygen a person can take up, transport and utilise per minute and is measured in millilitres per minute per kilogram of body weight (mL/kg/min). Table 13.3 shows VO_2 max figures for males and females who have had various levels of training to match the demands of their daily physical demands.

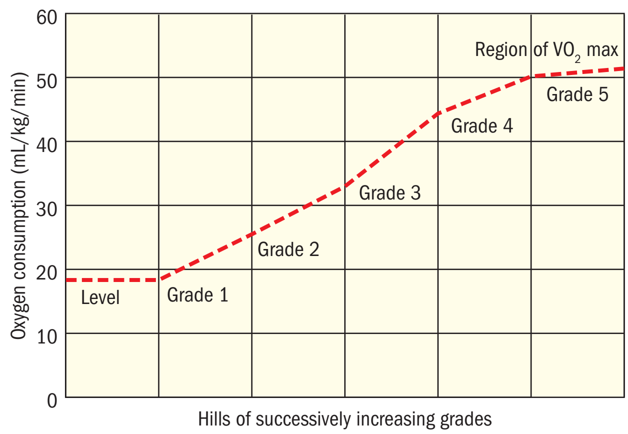

Figure 13.4 Oxygen consumption with increasing loads until VO_2 maximum is reached

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Table 13.3 VO_2 max comparisons for men and women in different activities

Men	VO_2 max (mL/kg/min)	Women	VO_2 max (mL/kg/min)
Active	51	Active	46
National level field hockey player	60	National level field hockey player	52
National level squash player	60	National level squash player	52
AFL rover (15–16 on beep test)	65–70	Netball centre (10–12 on beep test)	48–55
National 400-metre swimmer	70	National 400-metre swimmer	60
International-level long-distance runner	74	International-level long-distance runner	63
Cross-country skiier	83	Cross-country skiier	68

Oxygen debt

At the completion of exercise, the demand for ATP decreases dramatically. However, the amount of oxygen consumed still remains above the amount required at resting levels. This is known as an oxygen debt. Another term for oxygen debt is excess post-exercise oxygen consumption (or EPOC). EPOC describes the amount of oxygen consumed during recovery that is above resting levels. Oxygen debt is defined as the volume of oxygen used during recovery from exercise in excess of resting oxygen consumption. An oxygen debt can only occur *after* the body has undertaken anaerobic exercise. Exhausting, high-intensity anaerobic exercise results in a larger oxygen debt than exercise at lower workloads or intensities.

oxygen debt (or EPOC)
when oxygen consumption stays above resting levels after exercise has finished

Oxygen debt can be divided into two 'parts'; the first is fast, the second is slow. The fast replenishment is restoring phosphocreatine (PC). This takes approximately two to three minutes, in which time two to three litres of oxygen can be consumed to provide energy for this resynthesis. The slow replenishment is removal of lactic acid through buffering, which is the absorption of H^+ ions in the presence of hydrogen carbonate produced by the kidneys. The slow part of the oxygen debt is also concerned with various regulatory functions listed below and recovery time depends upon usage and metabolic disturbances during activity. The greater the accumulation of lactic acid, the larger the EPOC will be. This is also because an active recovery will most likely be undertaken, which extends EPOC when compared to a passive recovery.

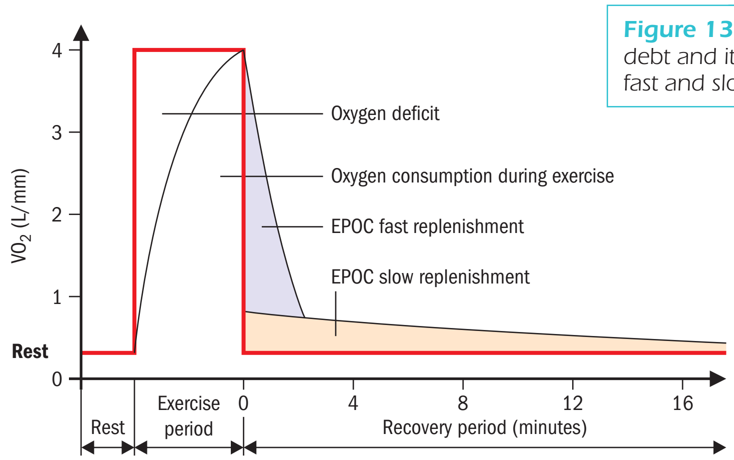

Figure 13.5 Oxygen debt and its two parts: fast and slow

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Table 13.4 Recovery processes during EPOC or oxygen debt

Fast Replenishment (0–3 minutes)	Slow Replenishment (0 minutes–several hours)
• ATP resynthesis	• Return core temperature to pre-exercise levels
• PC resynthesis	• LA converted to CO_2 and H_2O
	• Absorption of H^+ ions (buffering)
• Restore oxygen to myoglobin	• LA converted to glycogen, protein and glucose
	• Restoring heart rate, ventilation and other body systems to pre-exercise levels

It is important to understand the relationship between exercise intensity and the related factors of oxygen deficit, steady state and oxygen debt. An activity that calls rapidly upon the anaerobic energy systems will have a large oxygen deficit, possibly no steady state and a large oxygen debt. An activity performed at a lower intensity will have a smaller oxygen deficit, a longer steady state and a smaller oxygen debt. During activities where steady state has been established and the lactic acid system is increasingly called upon to supply ATP, such as surges or short sprints, these contribute to oxygen deficit and add to the oxygen debt during recovery, extending the slow replenishment. A person who has undertaken aerobic training will be able to consume a greater amount of oxygen during steady state, so the anaerobic energy system contribution becomes proportionately smaller at an earlier stage of the activity or performance.

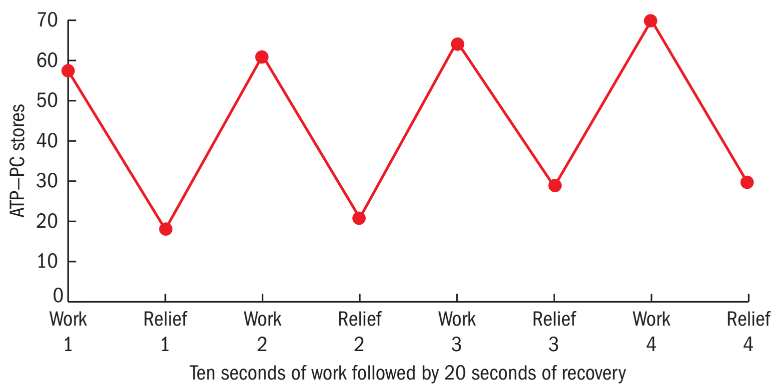
Checkpoints

1. Explain the circumstances under which an oxygen deficit occurs during activities, other than at the beginning of performance.
2. Why is it advantageous to prolong oxygen debt?
3. What is the trade-off for conducting an active recovery to facilitate metabolic by-product removal and fuel restoration?
4. If we compared the oxygen deficit for the 800-metre and 1500-metre running events, they would be very similar. Discuss how this can be possible.

Fuel depletion

When calling upon the anaerobic energy systems, the most common causes of fatigue are depletion of adenosine triphosphate (ATP) and phosphocreatine (PC). There are minute amounts of both stored at muscles: one to two seconds of ATP; around ten seconds of PC, but more in larger muscles. ATP is 'split' to release immediate energy for muscular contractions and then PC is 'split' to resynthesise ATP, but this is quickly depleted. As a result, efforts calling upon maximal effort or contraction forces can only last for relatively short periods of time.

Figure 13.6 Phosphocreatine (PC) depletion and restoration during interval training with a work to rest ratio of 1:2



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Muscles obtain glucose directly from foods, or from amino acids and lactate via gluconeogenesis. Glucose obtained from these two primary sources either remains soluble in the body fluids or is stored as glycogen. Glycogen is a stored form of glucose and is found mainly in the liver and muscles, with total glycogen stored at muscles being about three to four times that stored at the liver. Glycogen stored in the liver is considered to be the main buffer and reserve of blood-glucose levels.

gluconeogenesis
the production of glucose, mostly in the liver, from amino acids, fats, and other non-carbohydrate substances

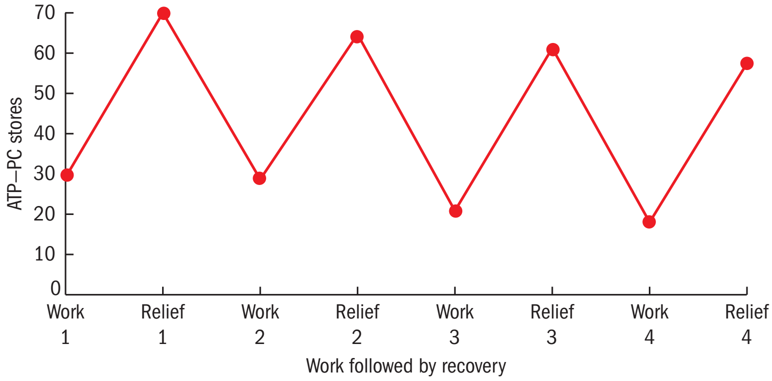

Figure 13.7 ATP–PC depletion and PC restoration during periods of work and rest

Glycogen depletion is a significant factor in events lasting over one hour. Carbohydrate is the only source of energy during maximal intensity exercise but fats are used increasingly during prolonged sub-maximal or endurance activities. Muscle glycogen provides the first fuel source during aerobic activities; as these are depleted, the muscles use glycogen stored in the liver. Once this runs low, muscles look to blood-borne fats as fuel sources, then stored fats. The rate at which glucose is broken down to resynthesise ATP decreases as the body switches over to fats as the major ATP producer at the two- to three-hour mark in extended endurance events.

The rate of energy production from aerobic use of carbohydrate is 50 to 100 per cent faster than the rate of energy production from the aerobic use of fat, due to more complex chemical reactions and greater amounts of oxygen required for fats.

This means that using fats when glycogen becomes depleted leads to 'slowing down', or fatigue. Also, the body needs to have some glycogen left in order to break down fats.

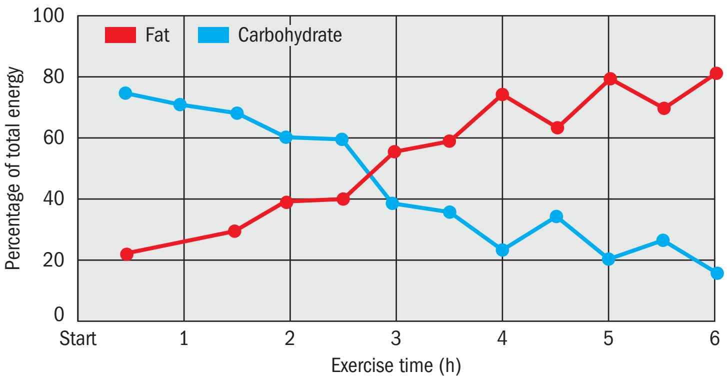

Figure 13.8 During sustained exercise, the percentage of energy from carbohydrate decreases over time, and the percentage of energy from fat increases (McCardle, Katch and Katch, 2006)

Protein can be used as a fuel source, but only in extreme performance conditions lasting more than five hours. Amino acids from protein breakdown can be used to fuel muscle movements. Although not primary energy substrates, amino acids are used as 'tertiary' fuels during muscular work. Exercise duration, muscle and liver glycogen levels and fat stores affect protein used to fuel contractions. Oxidation of branched-chain amino acids for fuel within skeletal muscles is increased during prolonged exercise and when muscle glycogen stores are very low and fat stores also running low. Protein can contribute up to ten per cent of the energy needs in extended endurance events such as long-distance triathlons. Proteins take longer to break down than fats and carbohydrates, and they also require more oxygen to break down. Table 13.5 shows energy availability and oxygen cost associated with the three major

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food groups. Carbohydrates and fats are both capable of releasing the same amount of energy, but proteins require more than twice as much oxygen to be broken down to resynthesise ATP.

Table 13.5 Energy availability and oxygen cost associated with three major food groups

Food fuel	Maximum energy (ATP per molecule)	Gross energy value (kilocalories per gram)	Oxygen required (litres per mole of ATP produced)
Carbohydrates	36	4	3.5
Fats	$147 \times 3 = 441$ Each triglyceride molecule contains three fatty acid molecules.	9	5.5
Proteins	After nitrogen is removed, amino acids serve as a source for glucose and fatty acid synthesis. Some enter the citric cycle and add to energy production.	4	8.0+

To identify which fuels are being depleted and likely to cause poor performance, it is vital to consider the duration of the activity and its intensity, then link this to the primary energy systems being called upon. This is also useful when considering how to reverse these effects and bring about recovery.

Table 13.6 Fuel depletion and recovery

Predominant energy system	Likely causes of fatigue	Types of recovery
ATP–PC	**Fuel depletion:** • ATP and PC	Rest recovery
Lactic acid	**Accumulation of metabolic by-products:** • H+ (hydrogen ions) • Pi (inorganic phosphates) • Lactic acid is no longer thought to contribute to fatigue; it is regarded as a positive performance enhancer rather than a negative.	**Non-dietary:** • active recovery • massage • hydro/water-based therapies e.g. contrasting hot/cold baths
Aerobic	**Fuel depletion:** • glycogen stores, then fats • elevated body temperature, leading to dehydration and blood flow away from muscles	**Dietary:** • high-GI foods • rehydration via sports drinks—hypertonic to replace glycogen; hypotonic to replace lost fluids **Non-dietary:** • active recovery • massage • hydro- and water-based therapies

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Metabolic by-products

Hydrogen (H^+) ions in plasma and muscle

Most exercise physiologists agree that any negative effect on performance associated with blood lactate accumulation is due to an increase in hydrogen ions. The breakdown of glucose or glycogen produces lactate and hydrogen ions; for each lactate molecule, one hydrogen ion is formed. The presence of hydrogen ions, not lactate, makes the muscle acidic, which will contribute to decreased muscle function. As hydrogen ion concentrations increase, the blood and muscles become increasingly acidic. This acidic environment will slow down enzyme activity and ultimately the breakdown of glucose itself.

Inorganic phosphate (Pi) and adenosine diphosphate (ADP)

During muscle contractions, adenosine triphosphate (ATP) is broken down to adenosine diphosphate (ADP) and inorganic phosphate (Pi), which are both released during the crossbridge cycle of the sliding-filament theory explaining muscle contractions (see Chapter 6). Pi release is linked to the powerstroke of the crossbridge cycle. Pi accumulation that occurs rapidly during high-intensity exercise or performance bouts would lead to a reversal of its release step, resulting in decreased contractile force production. Interestingly, inorganic phosphates are released into the cytoplasm where they reduce the amount of $Ca2^+$ that can be then released via the sodium–potassium pump, and the associated slowing of muscle contractions. Recently, physiologists have hypothesised that due to the release of Pi with both the ATP–PC energy system and the break down of stored ATP, Pi accumulation is probably the largest contributor to the fatigue process in exercise of any duration.

ADP is released near the end of the crossbridge cycle after ATP has been split to release energy. ADP controls the speed of crossbridge detachment and its accumulation causes a decrease in the maximal velocity of shortening in the crossbridge cycle and an associated reduction in power output. The combined effects of these accumulated by-products are significant in contributing to the fatigue process in exercise of varied intensity and duration.

Neuromuscular events

Decreased CNS ‘firing’

Decreased CNS ‘firing’ contributes to fatigue when the brain detects fatigue and sends weaker signals to working muscles in an effort to reduce intensity and slow down the work rate of muscles. Less electrical stimulation created by sending fewer signals will result in less forceful and less frequent muscle contractions occurring. This is the body’s self-protection mechanism.

As you have read in Chapter 6, nerve fibres don’t connect directly to muscles. Instead, there is a gap called a synaptic cleft or neuromuscular junction that a neurotransmitter substance (Ach) travels across. As the intensity of exercise increases, a point is reached where Ach release slows down; this means there is less electrical stimulation crossing the gap and less muscle stimulation, too. The muscles will contract less forcefully, and in some cases not at all if the Ach is not given sufficient time to rebuild.

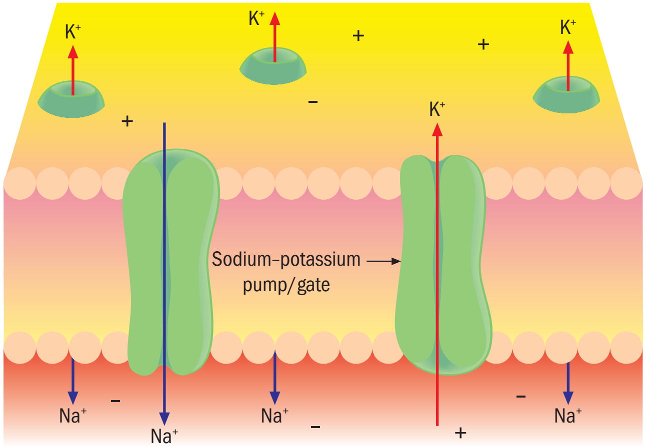
The sodium–potassium pump

The sodium–potassium pump occurs in the cell membrane and has the following key functions.

- Facilitating the transport of glucose, amino acids and other nutrients into the cell
- Creating an osmotic gradient to allow the absorption of water into the cell
- Allowing electrolyte movement
- Transmitting nerve impulses
- Calcium release, which plays a key role in all muscle contractions

The sodium–potassium pump in the cell wall actively transports potassium into the cell and sodium out of the cell by using ATP, and acts like a gate. When changes occurring in the membranes of the dendrites and the body of the cell reach the axon, the sodium gates respond: some of them open and let sodium ions in, so that the inside starts to become less negative. If this reaches a certain level, called a threshold, more sodium gates open and let more ions in. This action potential results in a moving exchange of ions that runs along the length of the axon. So many sodium ions get in that, for a very short time, the difference between the outside and inside of the cell is actually reversed: the inside is positive and the outside negative.

Figure 13.9 Movement of sodium (Na^+) and potassium (K^+) ions in opposite directions as the neural impulse travels along the length of the axon



All of this happens at one little segment of the axon at a time: sodium goes in at section one; that triggers the potassium to start going out at section one and the sodium to start coming in at section two; that triggers the potassium to go out at section two and the sodium to come in at section three; etc. It's almost like athletes passing the baton to each other along a length of track. This explains how electrical impulses move along the length of axons and are transmitted from the brain to muscles via motor neurons and back again via sensory neurons.

When the action potential reaches the axon ending, it causes another ion calcium ($Ca2^+$) to enter the cell. This causes the vesicles to release Ach into the synaptic gap and the electrical message continues to the next axon. $Ca2^+$ inhibits the action of troponin (a protein complex that separates actin and myosin filaments) and the actin and myosin then join up. This joining causes the myosin ATPase to split ATP, and energy is released to drive myosin crossbridge activity – and muscular contractions occur. (See pages 125–126 in Chapter 7 for more about crossbridges.)

The myosin crossbridge uncouples from actin when the ATP binds to it. As long as calcium ($Ca2^+$) concentrations remain high, the coupling and uncoupling continue. When neural stimulation stops, the $Ca2^+$ moves back into the lateral sacs and muscles relax. Interference to the sodium–potassium pump sees $Ca2^+$ release reduced dramatically for high-intensity activities. Impaired excitability (disrupted action-potential generation) is the main contributor to severe fatigue in all muscle types. Changes to $Ca2^+$ release, distribution and uptake alter the activity of the myosin filaments which, in turn, impedes muscle contractions – even though hundreds of nerve impulses might still be being sent to the muscles!

Catchy fact

In nerve cells, 70 per cent of the adenosine triphosphate (ATP) is used to fuel the sodium–potassium pump.

Acidosis dramatically disrupts the intracellular environment and causes increased movements of potassium out of muscle cells. Accumulation of potassium is thought to interfere with the sodium–potassium pump mechanism, and has an associated reduction in neural drive (nerve impulses from the brain) due to reflex inhibition at the central nervous system level. Nerve messages from the brain, which usually make their way along axon chains, are interrupted or inhibited, resulting in greatly reduced muscle tension.

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Figure 13.10
Exhausted triathletes crossing the finish line, severely fatigued

Checkpoints

1 What role does calcium (Ca2^{+}) play in muscular contractions? What happens when it has reduced or impaired function?

2 Copy and complete the following table, clearly outlining one major fuel that contributes to fatigue.

Event or training conditions	Major fuel depleted to cause fatigue
100-metre sprint (track event <10 seconds)	
100-metre swim (approximately 50 seconds)	
AFL football match (rover covering 18 km)	
Short interval training with this ratio: work = 60 seconds : rest = 120 seconds	
Triathlon (approximately 4½ hours)	
English Channel swim (18 hours)	

3 Discuss two advantages associated with switching from carbohydrates to fats as the main fuel source in any performance.

4 How does the accumulation of inorganic phosphate (Pi) resulting from plyometrics training contribute to decreased muscle force?

5 Summarise in point form how the sodium–potassium pump allows the movement of electrolytes to enable nerve impulses to travel along axons.

Elevated body temperature

Body temperature will often rise during prolonged training or competition while performing in heat and high humidity, or during the acclimatisation phase for competing in heat and high humidity. Normal core-body temperature ranges from 36.5–37.5 °C. It is important to maintain a balance between heat production and heat loss to stay within this range and sustain normal physiological functions. If heat production exceeds heat loss, then body core temperature will rise, and hyperthermia may result.

Heat production

Body heat is produced both internally and externally. During maximal exercise and prolonged exercise (more than 90 minutes) up to 90 per cent of body heat can be generated by exercising muscles, with the remaining heat coming from ambient air conditions (temperature and humidity), normal metabolic processes and through thermal or solar radiation.

Heat loss

Our bodies lose heat by radiation, conduction or convection, and during exercise via evaporation. Sweat is produced during evaporation to provide body cooling. In warm environments, evaporation is the main mechanism for heat loss, and when temperatures rise above 36 °C, evaporation is the only effective mechanism. High air temperatures combined with high humidity levels greatly reduce heat loss from the body; together they produce extremely dangerous performance conditions.

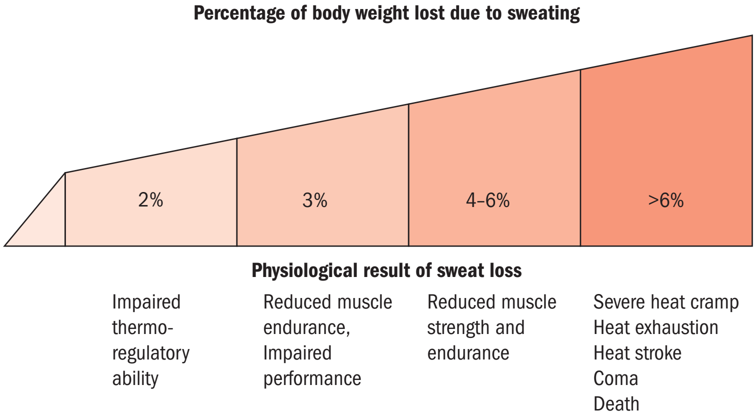

Figure 13.11 The relationship between fluid loss and physiological functions

Figure 13.11 reveals that two to three per cent weight loss through sweating will result in impaired thermoregulation, muscle endurance and neuromuscular coordination. Left unchecked, more sweating will result in greater decreased muscle function. If more than six per cent of body weight is lost via sweating to cool the body, it can result in unconsciousness, as the body tries to protect itself from overheating. Overheating can see core temperatures rise close to 40°C.

As core temperatures rise, sweat rates increase and blood is redistributed away from working

Figure 13.12 Water-spray systems are used to maintain core temperatures within acceptable ranges and allow training sessions to continue at match intensity

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muscles to the skin's surface in an effort to maximise evaporative cooling caused by sweat. This leads to less blood, oxygen and fuels flowing to working muscles, which may cause aerobic exercise to become increasingly anaerobic. This starts a spiral: decreased sweating rates reduce the body's ability to cool via evaporation; this leads to increased risk of core temperatures increasing. You can see how one factor causes others to spiral towards increased core temperatures.

Where does sweat come from? Increased sweat rates cause decreases in blood plasma volumes; to counteract this, the heart rate and cardiac output must increase to continue supplying working muscles with the amounts of blood they were receiving before sweating became a factor. Decreased plasma volumes reduce the amount of blood that flows to both the muscles and the skin. Both of these result in diminished performance.

Catchy fact
Males have five litres of blood in their cardiovascular system on average, and females have four and a half litres. More than half the blood (55 per cent) is made up of plasma, which is the fluid part of the blood. Plasma is 90 per cent water, and is freely exchangeable with the fluids in the body cells and other extracellular fluids. Plasma is available to maintain the normal state of hydration of all tissues.

Recovery strategies

Recovery aims to return the body to pre-exercise conditions and reverse the effects of fatigue. Efficient recovery strategies will enhance adaptations to exercise loads, as well as prepare the performer for subsequent training or competition bouts. Insufficient recovery will delay the removal of fatiguing factors and possible adaptations, as well as taking performers into the dangerous area of overtraining and associated overuse injuries and immunodeficiency-related illnesses. We will now consider the key fatiguing factors and suggest the most appropriate recovery strategies. In the same way that fatigue is multifactorial, recovery involves considering the most likely causes and bringing about specific strategies.

Most coaches stress the importance of an active warm down or cool down following training and competition in aiding recovery processes, but this can actually delay the recovery process. This is another example of needing to match the recovery strategy to the most likely cause or causes of fatigue.

Fuel depletion

Intramuscular ATP stores

Intramuscular adenosine triphosphate (ATP) stores are activated for less than two seconds before they deplete totally. They are reynthesised quickly by breaking down other fuels in order of ease and availability: for high-intensity actions, this would be the breakdown of phosphocreatine and muscle glycogen. For endurance events, this would rely on muscle or liver glycogen; when carbohydrates are depleted in ultra-endurance events, it leads to the breakdown of fats. See Figure 13.1 on page 247.

Catchy fact
The body has difficulty absorbing phosphocreatine; for this reason, the common creatine supplement is in the form of creatine monohydrate. The body can readily produce the necessary phosphocreatine once the creatine has been ingested, and it is manufactured in the liver, pancreas and kidneys. Studies reveal that when creatine supplements are combined with a high-carbohydrate diet, the body retains much more phosphocreatine.

Phosphocreatine

Phosphocreatine (PC) is restored as soon as rest or recovery starts, and is facilitated by a passive recovery. Recovery needs to be either total rest or low enough not to call upon PC to be utilised, as this will hinder recovery rates. Most PC is restored during the rapid part of the oxygen debt, with an incredible 70 per cent being restored in the first 30 seconds of recovery. It can take up to 10 minutes to restore PC to pre-exercise levels. The body replenishes phosphocreatine from two sources:

- The liver produces PC from amino acids
- Dietary creatine is obtained from creatine monohydrate supplements or diets high in red meat

passive recovery
a recovery that utilises complete rest, or exercise at a slow walking pace

Low pH caused by accumulation of lactate will slow restoration of phosphocreatine, as will low oxygen supply during recovery. This is why having a high aerobic capacity can actually benefit anaerobic performances as well, and why

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many teams focus on building this up during pre-season training. Restoration rates assume total muscle depletion; if a muscle contracts forcefully for a few seconds, not all of the stored PC will be drained, so less resynthesis time would be required. This fact is critical when calculating the rest times needed during short and intermediate interval training.

Figure 13.13 Phosphocreatine restoration (PCR) and lactate removal following a 200-metre sprint

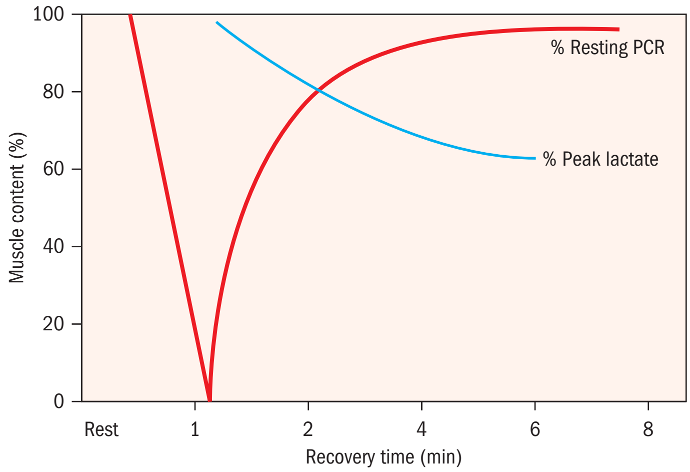

Table 13.7 Restoration rates

Recovery time (seconds)	Muscle PC restored
30	70%
60	75%
90	93%
120	95%
150	97%
180	98%
10 minutes	100%

Muscle glycogen and blood glucose

The body uses glucose at a rate of one gram per minute during moderate exercise, and slightly higher during high-intensity exercise. Carbohydrates should be consumed during exercise lasting longer than one hour, after which approximately 60 grams of carbohydrate will have been metabolised and converted to energy.

The effects of glycogen depletion can be minimised by ensuring adequate stores are achieved prior to training or competition, and possibly carbohydrate loading four to five days prior to competition. During training and competition lasting more than 60 minutes, hypertonic sports drinks should be consumed to reduce the amount of glycogen drained from the liver. Hypertonic sports drinks have two main advantages: they keep performers hydrated and well-fuelled. Whole foods high in carbohydrates may be impractical or cause gastric upset, so alternatives to sports drinks would be gels and sports bars. Recent research suggests that when multiple carbohydrates are ingested together (for example, glucose and fructose, or maltodextrins and glucose), it increases carbohydrate availability and oxidation, which could lead to improved endurance performance.

hypertonic sports drinks drinks containing a lesser proportion of water and a greater proportion of sugar than fluids in the human body

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Table 13.8 Suggested carbohydrate intake for athletes undertaking various training loads

Training situation	Carbohydrate intake (per day)
Daily refueling needs for training programs less than 60–90 minutes per day, or of low intensity	5–7 grams per kg of bodyweight
Daily refueling for training programs greater than 90–120 minutes per day	7–10 grams per kg of bodyweight
Daily refueling for athletes undertaking extreme programs of 6–8 hours per day	10–12 grams per kg of bodyweight, or more
Carbohydrate loading for ultra-endurance events, such as triathlons	7–10 grams per kg of bodyweight

Australian Institute of Sport

Aside from maintaining high blood glucose levels during performance, it is critical to replenish used glycogen as quickly as possible during recovery because muscles are able to store greater amounts of carbohydrates in the first few hours following exercise.

Table 13.9 Glycogen restoration rates with different 'wait times' before ingestion takes place

Post-event glycogen intake (High GI)	Glycogen returns to pre-exercise levels
Within 1 hour	55% restored in next 5 hours 100% restored within 24-hour period (1 day)
1–2 hours	100% restored 24–48 hours (2 days)
5+ hours	Up to 5 days

High-GI foods should be consumed as soon as is practical after an event to ensure rapid restoration of muscle glycogen and liver glycogen; delayed intake will potentially lengthen the time required to return glycogen to pre-exercise levels. The AIS recommends that performers consume one to one and a half grams of high-GI foods per kilogram of bodyweight in the first 30–60 minutes following exercise. There is no significant difference between solids or liquids, although most athletes prefer liquids, as they cause fewer gastric disturbances than solids when taken during recovery.

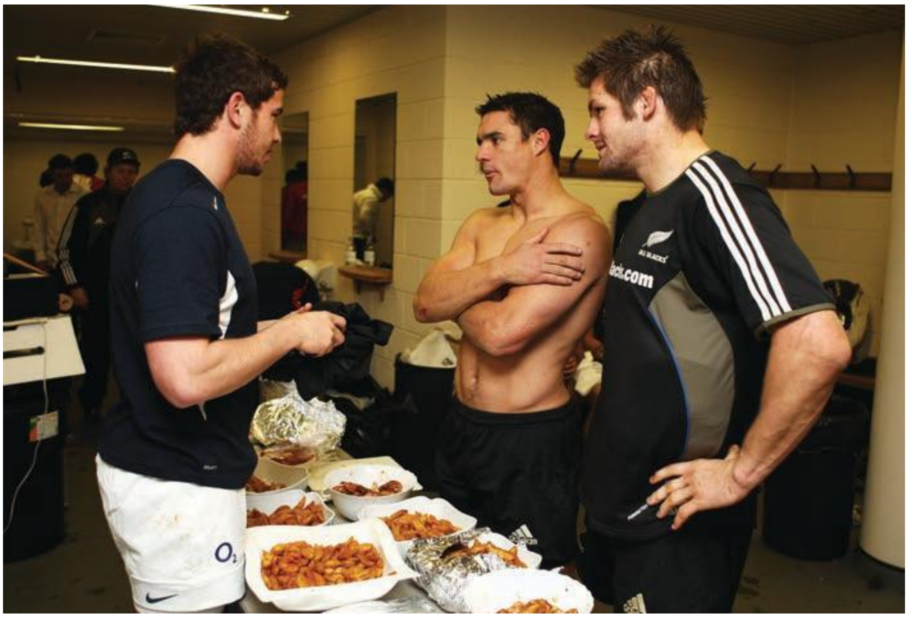

Figure 13.14 Elite players consume high-GI foods as soon as possible after a game finishes to speed up the rate of glycogen restoration

Even though fats are used as fuel sources, they have a high oxygen cost. Performers would not deliberately increase fat intake in their diets if it had been drained during training or competition. Excess carbohydrates that are not converted to glycogen are stored as fats. With decreased activity levels during the off-season, carbohydrate intake should be monitored and reduced, compared to levels taken 'in-season'. If this doesn't occur, it is likely that percentage body fat will increase. Elite performers are constantly being subjected to skinfold tests to ensure that this doesn't happen.

KEEP IT REAL!

Swim star Michael Phelps fuelled by 12 000 calorie a day diet

by Sarah Wotherspoon

A breakfast of champions is more than just a bowl of Weet-Bix for US swimming superstar Michael Phelps. The 23-year-old is swimming his way into the record books fuelled by 12 000 calories a day.

That's six times the average calorie intake for a 23-year-old man. NBC America revealed Phelps starts the day at 5 am with three fried-egg sandwiches topped with cheese, lettuce, tomatoes, fried onions and mayonnaise. That's followed by a five-egg omelette, a bowl of grits (porridge), three slices of French toast with powdered sugar, and three chocolate-chip pancakes, all washed down with two cups of coffee.

Figure 13.15 Michael Phelps

By lunchtime though, Phelps, who is contesting eight events in Beijing, needs refuelling. That comes in the form of half a kilo of enriched pasta, two large ham and cheese sandwiches on white bread with mayonnaise, and nearly 1000 calories worth of energy drinks. Phelps told NBC his competition regime was all about getting 'some calories into my system and try to recover the best I can'.

After a hard day's slog at the pool Phelps ends his day with another round calorie and carbohydrate loading. Dinner consists of another half a kilo of pasta followed by an entire pizza and another 1000 calories of energy drinks. The massive menu is needed every day to fuel Phelps' five-hour long pool sessions six days a week.

'Eat, sleep and swim. That's all I do,' Phelps told NBC. Phelps won a record eight gold medals at the Beijing Olympics in 2008.

***The Herald-Sun*, 14 August 2008**

The article above shows the importance of refuelling in order to maintain optimal training conditions and offset the fatigue caused by fuel depletion.

Catchy fact

Lactic acid is no longer thought to be the cause of fatigue, but is tested as an indirect measure of hydrogen (H^+) ion levels, as H^+ ion levels cannot be measured.

Metabolic by-products

Hydrogen (H^+) ions in plasma and muscle

We have seen that hydrogen (H^+) ions accumulate in large amounts when the lactate threshold is exceeded. In most cases, this corresponds to exercise intensities around 85 per cent of maximum heart rate, but aerobic conditioning can cause this to shift up to 90 per cent of maximum heart rate: another great reason to develop the aerobic energy system and aerobic capacity during off-season and pre-season training.

The quicker that H^+ ions can be removed from muscles, the quicker performers will recover and be able to return to muscle contractions closer to their potential. An active recovery is recommended because it:

- maintains oxygen levels higher than if the person were to simply sit or lie down; high oxygen levels speed up removal of lactate, which impedes recovery

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- creates a 'muscle pump', which increases the rate of oxygen supply and waste removal via the circulatory system, by muscles pressing on blood vessels surrounding the active or working area
- prevents venous pooling.

Massage is a passive recovery strategy with the benefit of having a 'muscle pump' created as muscles are squeezed or massaged, although this doesn't give the muscles any higher oxygen presence than rest. Contrast bathing (alternate hot/cold showers or baths) leads to increased removal due to vasodilation then vasoconstriction being repeated many times, so it is more a 'venous pump' than a 'muscle pump', and should be considered in conjunction with an active recovery.

venous pooling
when large amounts of blood remain or 'pool' around working muscles following high-intensity activity

vasodilation
enlarging of blood vessels to allow increased amounts of blood to flow through them

vasoconstriction
when blood vessels reduce their diameter to allow less blood to flow though

Table 13.10 Passive vs active recovery in removal of hydrogen ions

	Passive recovery (rest)	Active recovery (same activity, less intensity)
Minimal removal time	1 hour	30 minutes
Maximal removal time	2 hours	1 hour

Inorganic phosphate (Pi) and adenosine diphosphate (ADP)

Immediate or explosive energy comes from the chemical process of breaking down adenosine triphosphate (ATP) into two simpler chemicals: adenosine diphosphate (ADP) and inorganic phosphate (Pi). Creatine binds with the phosphorus in your body to form phosphocreatine (PC). When PC splits and energy is liberated, this bonds ADP and Pi to form more ATP, which means more energy. Recovery tends to occur quicker when phosphorous and oxygen are both available to ensure rapid PC resynthesis.

You'll recall that ADP combines with Pi when energy is released from either PC or any of the other food groups, such as carbohydrates, fats or proteins. Of these, carbohydrates are the quickest to break down and have the lowest oxygen cost, so it is important to replace these during and after the activity, especially in endurance performances or training sessions likely to extend beyond 60 minutes.

Neuromuscular events

Decreased central nervous system 'firing' is the body's safety mechanism or 'shut-down valve', and it is in place to protect us from overworking. As such, the only real recovery strategy from this is rest, or passive recovery, which stops acetlycholine (Ach) from being broken down. In trained endurance athletes, plasma choline concentrations can be halved during training or competition. These reductions in blood choline could lead to a reduction in acetylcholine synthesis. However, dietary meals high in cholines can increase the resynthesis of Ach.

An impaired sodium–potassium pump function can restrict muscular contractions. Remember, potassium is a mineral that works with sodium to balance the fluids and electrolyte levels in our body. Most of the sodium in your body is stored outside your cells, while most of the potassium is stored inside. Yet because of their different concentration levels, potassium constantly wants to get out and sodium wants to get in. When the movement of potassium is blocked, or when potassium is deficient in the diet, activity of the muscles and nerves can become compromised.

The transfer of these two crucial minerals in and out of the cells, called the sodium–potassium pump, comprises 20 to 40 percent of an adult's resting ATP expenditure. It is important that we replace lost sodium and potassium, as well as other key electrolytes such as calcium and chloride. It is also important to keep rebuilding ATP! Larger amounts of electrolytes are consumed during moderate to vigorous physical activity, such as sporting activities or working out at the gym, compared to walking from class to class. (See page 125 in Chapter 7 for more about ATP.)

Catchy fact
Acetlycholine (Ach)is broken down to acetic acid and choline within four to five milliseconds of its release from the synaptic vesicles. Axons recombine these two back into ACH so the process can occur again and quickly. Choline (especially in lecithin form) is a basic dietary component, and is present in many foods containing fats and proteins, such as eggs, meats, soybeans, peanuts and almonds.

Catchy fact
Have you ever wondered why tennis players eat bananas close to the end of their matches in the third, fourth and fifth sets?

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Sports Dieticians Australia

Sports drinks are an excellent electrolyte replacement. With many electrolyte drinks and sports drinks on the market, it is important to read the contents labels carefully. Choose an electrolyte drink that is not too high in sugar, as this can cause gastrointestinal discomfort and dehydration. Many sports drinks contain levels of sugars equal to soft drinks. Unless you are taking part in regular high-intensity exercise, drinking sugary sports drinks will promote weight gain.

Many websites allow you to compare the contents of some readily available electrolyte drinks sports drinks. Because of the sodium in most sports beverages, additional flavoring is often used to cover up the salty taste.

Checkpoints

Using the direct link from your CD, go to the *Sports Dieticians Australia* website and download their fact sheet on hydration.

Read the fact sheet and answer these questions.

1 Outline how an active recovery facilitates the removal of H^+ ions.

2 What dietary recommendation can you suggest to ensure recovery of Ach is complete and rapid during high-intensity training sessions?

3 Why would elite swimmers undertaking six to eight hours of training per day require almost twice as much daily carbohydrate intake than someone who was carbohydrate-loading for a marathon?

4 Discuss the best way for a long jumper to recover PC between each jump.

Elevated body temperature

Increased rates of dehydration and redistribution of blood away from working muscles to the skin's surface occur simultaneously to assist cooling. Together, they will lead to very high core temperatures; that's why it is imperative to hydrate regularly and make every effort to remain cool.

Cooling can be achieved by having adequate levels of hydration throughout training and competition (refer to Chapter 10). Post-exercise hydration can also be taken intravenously using a drip, although this must be conducted by fully qualified medical staff; it must also be permitted by the sport's organising body.

See the Sports Dietitans Fact Sheet 1 on the CD in the back of your book.

Apart from hydration before, during and after a performance, cooling can also be achieved by adopting some of these strategies:

- Ice baths or cool pools when off the field or court, or at end of activity; body temperature can cool down 25 times faster when immersed in cold water
- Cool or cold showers when off the field or court, or at end of activity
- Ice vests (during breaks in play, interchange situations)
- Refrigerated cool rooms during long breaks in play when players taken from the field
- Ventilation or fans on the side of the playing venue
- Protective shade, either natural (trees, surrounding buildings), or via shadesails and umbrellas
- Reduced or modified clothing

Clothing can play a vital role in preventing overheating. We lose heat in three key ways: convection, radiation and evaporation.

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Convection

Convection is heat loss to air. Air movement via ventilation or wind enhances convection of heat away from the body. To avoid overheating, it's recommended that loose-fitting, lightweight, light-coloured clothing is worn.

Radiation

Radiation is heat loss to surrounding objects. Heat is radiated from the body continuously through the skin. However, if the ambient temperature exceeds 37°C, the radiation mechanism doesn't work any more, as the body is actually *gaining* heat from the surroundings.

Evaporation of sweat

Evaporation is the most important heat-loss mechanism. As the water in sweat evaporates, the skin is cooled. In very hot conditions, evaporation of sweat allows the body to maintain its temperature within the narrow range necessary for healthy functioning. Whilst great for cooling, the large amounts of fluid that can be lost by this mechanism must be replaced to prevent dehydration.

KEEP IT REAL!

Coolmax® and Sorbtek fibres have been designed to form a transport system that pulls sweat away from the skin to the outer layer of the fabric or garment. This causes the sweat to dry or evaporate more quickly than if it had simply collected in the garment and stayed in contact with the skin's surface, as it would in cotton or woollen clothing. This leads to improved thermoregulation of the body by evaporative cooling.

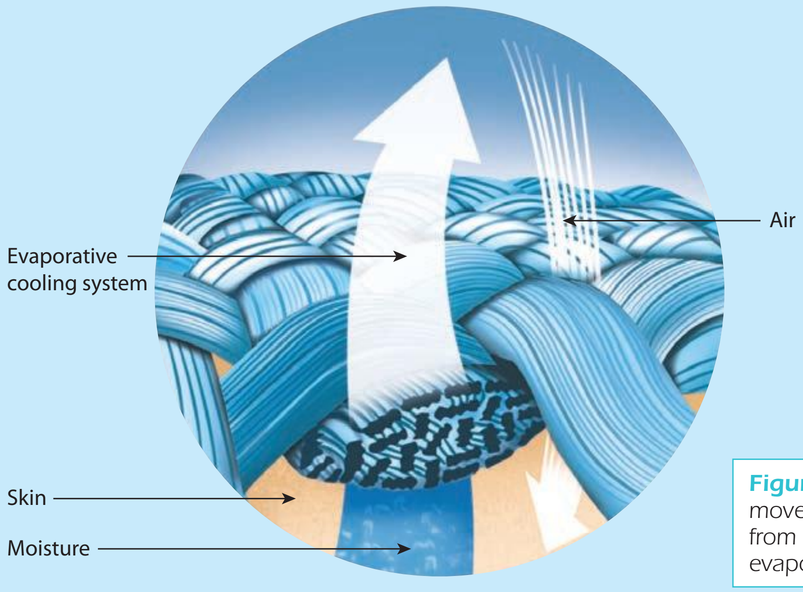

Figure 13.16 Sorbtek moves moisture away from the skin so it can evaporate.

The aim of all these methods is to maintain core temperatures around 37 °C and avoid core temperature from rising too much above this level during performances.

Checkpoint

1. Use the Internet to research the science behind fibres developed by Coolmax® or Sorbtek.
2. Investigate how Coolmax® or Sorbtek are designed to facilitate the sweating response, and how this impacts on the performers who wear them.
3. Discuss why these fibres would also be important to athletes competing in cold climates, such as downhill skiers.

KEEP IT REAL!

Muscle meltdown almost cost Aussie enduro cyclist his life

by Fred Dreier

rhabdomyolysis the breakdown of skeletal muscle tissue when muscles overheat, releasing the products of damaged muscle cells into the bloodstream, including myoglobin, which can stop the kidneys from working

Rhabdomyolysis is the technical name for 'muscle meltdown', resulting from high core temperatures that damage the integrity of the sarcolemma of skeletal muscle, leading to the release of potentially toxic muscle cell components into the circulation. This may result in potential life-threatening complications, including acute renal failure, hyperkalaemia and cardiac arrest.

Figure 13.17 More than a slight cramp: Gordon did some real damage

homeostatic any self-regulating process by which a body system maintains stability while adjusting to changing conditions

Craig Gordon is an Australian cyclist who pushed his body to the extreme limits of physical exhaustion to capture the '24 Hours of Adrenaline' solo world championships in Georgia, USA, in 2006, and suffered rhabdomyolysis. The endurance race lasts for 24 hours and the course takes riders through desert terrain around a 13-kilometre track. Gordon's cardiovascular system was so full of components given off from his overheated muscles that he was close to poisoning his kidneys.

Gordon said, while recovering in his hospital bed: 'The muscle breakdown combined with my dehydration sent a really toxic level of proteins into my blood stream. In a normal person, the range of protein is in the 20–250 parts per whatever range. My count was 5800.'

After having set up an unbeatable one-hour buffer between himself and the next competitor (six-time world champion Chris Eatough), Gordon embarked on one final lap around the course. These two competitors spent the first half of the race going blow for blow, and lapped the rest of the field by the eighth lap. After pushing hard, Gordon rode another 22 laps but midway through the final lap, Gordon's muscles seized up, then his body temperature dropped dramatically. He rode nearly 400 kilometres on a dirt track in the middle of the desert! His homeostatic mechanisms were also faltering. He got off his bike and began walking, but had to sit down in the dirt because his right calf had become, as he says, 'stiff as a piece of ice.'

Eatough finished the race and required medical intervention to assist his recovery, in the form of a trip to the medical tent for an intravenous drip. Gordon was raced by ambulance to nearby Rockdale Medical Center with very serious fatigue and life-threatening complications. He was placed on an intravenous drip in the ambulance and connected to a dialysis machine on arrival at the hospital to remove the toxins from his blood. Luckily for him, these toxins were removed over the next two days and he suffered no long-term physiological damage, having been lucky not to have suffered kidney failure or a heart attack in the process of pushing his body so hard and 'overheating'.

Adapted from *VeloNews*, 2006

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TEST YOUR KNOWLEDGE

>> multiple-choice questions

1 An elevated body temperature will contribute to fatigue by:

A decreasing oxygen supply to working muscles
B increasing the heart rate and thus increasing likelihood of anaerobic work
C increasing plasma depletion.
D All of the above.

2 An active recovery is often used following training or competition because it:

A delays DOMS
B keeps oxygen levels above resting levels and creates a muscle pump
C facilitates the electrolyte balance between active and passive transportation
D prevents cramps during recovery.

>> short-answer questions

1 A netball player is showing clear signs of 'slowing down' during the last quarter of a match. In table format similar to that shown below, complete the following tasks.

a Select three factors likely to be contributing to fatigue and outline their effects on her performance.
b Summarise strategies that could be used to minimise the effect of these fatiguing factors.
c Outline three recovery strategies that could be used at the completion of the game to maximise the player's return to pre-game conditions and be in condition to train effectively in two days' time.

Fatiguing factor	Effect of performance	Counteracting strategy
1		
2		
3		
Recovery strategies × 3		

>> essay questions

1 **a** Outline how lactic acid can be beneficial to performance.
b Hydrogen (H^+) ions need to be removed as quickly as they can be; briefly discuss two ways this can be sped up.

2 Discuss reasons you would send a runner with a hypertonic drink to a football rover, but send a hypotonic drink to a teammate playing in the full-back position. Your answer must consider the likely fatigue mechanisms each would face and why the different hydration strategies are being used by the coach.

3 Brett Lee is a fast bowler in the Australian Cricket Team. He is a regular visitor to the Gatorade Sports Science Institute in Chicago to look at ways of improving his performance. During testing, Brett's sweat rate was measured at 1.65 litres per hour.

a Briefly discuss how a sweat rate as high as this can lead to decreased performance for a fast bowler.

b If Brett were to become dehydrated, identify the symptoms he might experience.

c Outline a strategy that Brett could use to assist his fluid requirements during matches.

d What steps would you advise Brett to take to enable him to have complete hydration at the end of each day's play, and achieve optimal recovery prior to the next day's play?

4 For a sport of your choice, discuss factors that might contribute to fatigue during competition or training. Investigate how the fatigue might have been avoided or delayed, and the recovery strategies you would recommend to return the athlete to pre-competition or pre-training conditions.

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14 Training programs

When you are writing a training program, it is best to start with the end in mind and ask yourself:

- how many weeks are there until the competition or event?
- how long is the season?

The answers to these questions will determine the length and structure of the program.

Figure 14.1 Australian cyclist Anna Meares at the 2008 Beijing Olympic Games

An aspiring Olympic athlete may start training four years before their ultimate competition. Everything they do in their program will be designed around performing at their peak at the Olympic Games. There are always unforeseen circumstances, so every program needs to be flexible. Some of things that may eventuate include:

- injury and illness that require layoff periods and extended recovery
- rule changes that require training adjustments; for example, swimming finals were moved to the morning at the 2008 Beijing Olympic Games
- new methods being developed elsewhere
- personal issues

- weather
- results below expectations.

Core training principles

Any training program can be planned using these five core principles:

- Specificity
- Intensity
- Duration
- Frequency
- Progressive overload

1 Specificity

For an athlete to obtain optimal fitness benefits from a training program, they must train the specific:

- energy systems
- fitness components
- muscle groups and actions
- skills.

For more information on coaching and skill development, refer to Chapters 3, 4 and 5.

Understanding the specific requirements of sports and individual positions requires in-depth analysis. At an elite or professional level, this is achieved through data analysis, fitness testing and expert coaching. At a lower level, it is generally left to the coach. (For further information on performance analysis, refer to Chapter 5.)

Table 14.1 provides three examples of specificity, as it applies to a marathon runner, a netball centre and a shot putter.

Table 14.1 Examples of specifity

Marathon runner	Lots of continuous training to replicate demands of the activity. Training is conducted at the same intensities required during competition. Runner is also required to improve her leg strength, as weakness was revealed during pre-testing and hamstring injuries occur commonly, so resistance training focusing on leg muscles was undertaken pre-season and continued through the in-season phase to maintain gains.
Netball centre	Pre-season continuous training to improve cardiovascular fitness base, followed by in-season short-interval training to improve speed and speed endurance. Distances chosen replicate those seen in the game but work-to-rest ratio changed to improve the endurance aspect of sprints. Weights and plyometrics chosen to develop leg power, which rated poorly during pre-testing and showed up as significant during games analysis. Activities such as leg press and single-leg bounds replicate those seen in the games analysis.
Shot putter	Inclined bench press used during weight training replicates muscle action undertaken during the event. Repetitions are conducted explosively to train the fast-twitch fibres and the ATP–PC energy system. Lower back and hamstring flexibility observed to be only average after fitness testing; these are very important to speed and agility in the circle, so they were 'trained' during the warm-down part of each session.

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Simply competing in an activity is not meeting the principles of specificity. Too many variables are out of your control and you are reacting to situations, such as the skills performed, muscles used, distances run, recovery periods and energy-system contributions. To ensure specificity is applied effectively, training must mimic or replicate what occurs in the game or competition in terms of fitness components, energy systems, muscle groups, actions and skills.

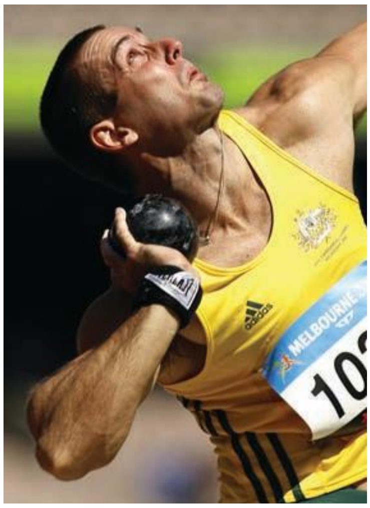

Figure 14.2 Training needs to be specific to the activity and the energy system required

2 Intensity

Intensity is the single largest determinant of how much adaptation will result from a training program. Intensity refers to how hard a training session is. Intensity can be measured in various ways, and will depend on which energy system the session is trying to tax. One of the simplest methods of assessing intensity is to work at a percentage of maximum heart rate (HR max). Table 14.2 shows a number of methods that are used to test the intensity an athlete is training at. The HR max has a direct relationship with maximum oxygen uptake (VO_2 max); the relationship is shown in Table 14.3.

Table 14.2 Methods used to test an athlete's training intensity

System	Training-intensity tests
ATP–PC system	Electronic timing, weights lifted, PRE, heartrate (HR)
Lactic acid system	Blood lactate, electronic timing, PRE, HR
Aerobic system	HR, GPS, PRE

Table 14.3 HR max and VO_2 uptake

Training zone	Energy systems trained	Percentage of maximum heart rate	Percentage of VO_2 maximum
Recovery	Negligible adaptations	< 70%	< 50%
Aerobic/continuous	Aerobic	70–85%	55–75%
Lactate threshold (inflection point)	Anaerobic	85–90%	75–80%
Anaerobic	LA	85–95%	75–85%
	PC	95%+	100–200%

AIS training-zone terminology

The AIS has recently examined all sports and their use of training-zone terminology. From this they developed a new system to provide a common approach across sports. Table 14.4 shows the different names various sports previously used to describe their training zones. Table 14.5 shows the new system, where training zones are named from T1 (recovery) through to T6 (maximal effort). The 'LT' is the lactate threshold, or the point at which lactate starts to build up. 'AT' is anaerobic threshold, the point at which lactate is being produced at a higher rate than the body can resynthesise it. The LT and AT points will be different for individual athletes and differing fitness levels.

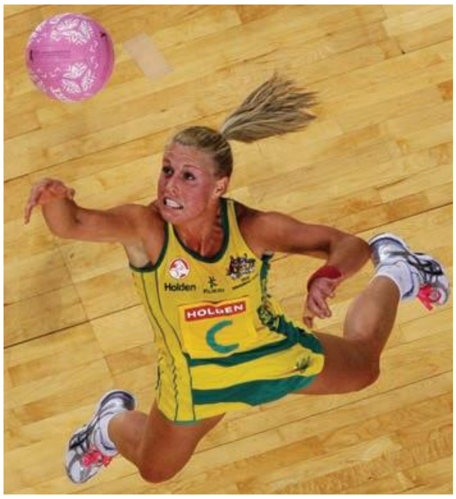

Figure 14.3 Madison Browne during an intense netball training session

Table 14.4 Sample endurance training zone classifications for elite athletes

Sport	Endurance training zones
Cycling	Endurance, E1, E2, E3, E4
Kayaking	Aerobic, A1, A2, A3, A4, A5, A6
Rowing	Utilisation, U3, U2, U1, AT, Transport
Triathlon	T1, T2, T3, T4, T5, T6 *

* Note different definition for zone determination applied

anaerobic
oxygen is not present during performance

Athletes can perform well above their VO_2 maximum. This occurs when energy is obtained anaerobically, and in most cases from the lactic acid system. Table 14.6 shows the intensity reached by various athletes. Note that as the competition distance lengthens, the performance intensity drops markedly.

Table 14.5 Relationship between training zones, lactate thresholds, HR max, lactate and perceived exertion

Description of training zone	Blood lactate threshold relationship	Percentage HR max (%)	Blood lactate (mmol/L)	Perceived exertion (PRE)
T1 Recovery	< LT	< 75	< 2.0	Easy
T2 Extensive aerobic	LT to LT+((AT-LT)/2)	75–84	1.0–3.0	Comfortable
T3 Intensive aerobic	AT to AT–((AT-LT)/2)	84–89	1.5–4.0	Uncomfortable
T4 Threshold	AT	89–93	2.5–5.5	Stressful
T5 VO_2max	> AT	> 92	> 5.0	Very stressful
T6 Anaerobic	Maximal	n/a	> 7.0	Maximal

Table 14.6 highlights the various intensities and relative energy systems used by athletes competing at distances from 100 metres to a marathon (42.6 kilometres). Remember: to keep a program specific, you need to mirror the requirements of that specific sport. A VO_2 max above 100 per cent is possible. A 100-metre runner performs at 200 per cent of their VO_2 max speed. We would expect a 100-metre runner to reach a speed of around 18 km/h at the end of the VO_2 max test. In a 100-metre sprint, they will travel at about 36 km/h, so they are performing at 200 per cent of their VO_2 max. A marathon runner, on the other hand, will complete a VO_2 max test running at 25 km/h, yet run the marathon race at just over 20 km/h, performing at 80 per cent of VO_2 max speed.

The speed reached at the end of the VO_2 max test is known as Maximal Aerobic Speed, and the fastest speed an athlete can reach is known as Absolute Maximum Speed.

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Table 14.6 Performance intensities for various track athletes vs food fuels

Event	Energy system contribution (%)		% VO_2 maximum
Marathon	Aerobic: 95–97	Anaerobic: 3–5	75–80 %
10 000 m	Aerobic: 90–95	Anaerobic: 5–10	80–85 %
5000 m	Aerobic: 90	Anaerobic: 10	80–90 %
1500 m	Aerobic: 80	Anaerobic: 20	110 %
800 m	Aerobic: 70	Anaerobic: 30	130%
400 m	Aerobic: 45	Anaerobic: 55	150%
200 m	Aerobic: 20	Anaerobic: 80	150%
100 m	Aerobic: 5	Anaerobic: 95	200%
Food fuel contribution			
Intensity % HR maximum	**% Carbohydrate**		**% Fat**
65 to 70	40		60
70 to 75	50		50
75 to 80	65		35
80 to 85	80		20
85 to 90	90		10
90 to 95	95		5
100	100		0

3 Duration

Duration refers to both how long a single session will last, and how long a training phase will last. The phases of training programs are discussed later in this chapter. Exercise intensity is a significant limiting factor on duration, as high-intensity exercise cannot be sustained for long before fatigue occurs. This is why it is critical that athletes wishing to improve the anaerobic energy systems have appropriate work : rest ratios in their program. Some anaerobic training sessions, such as plyometrics and short intervals, can be completed in 10–15 minutes, whereas the minimum duration of any aerobic training session needs to be at least 30 minutes.

plyometrics
a form of exercise that uses rapid movements to develop muscular power

Different fitness gains occur as training continues, with aerobic-related gains taking longer than anaerobic-related gains. Gains occur more quickly in the anaerobic energy systems and fast-twitch muscle fibres than in the aerobic energy system and slow-twitch muscle fibres. The aerobic-based areas take longer because changes to body systems occur over a longer period of time before they have a combined effect and improve performance.

Table 14.7 Duration of activity and results

Fitness area	Duration required to see noticeable improvements
Flexibility	1 week
Strength	5+ weeks
Speed, muscular power, agility, anaerobic power	10+ weeks
Local muscular endurance	12 weeks
Aerobic capacity	15+ weeks

Polglaze, AIS

Related to duration is the 'law of diminishing returns', which states that as a person gets closer to their personal best (PB), the rate of improvement will diminish. It then holds that the further into a training program an athlete progresses, the slower their rate of improvement will be.

4 Frequency

principle of maintenance
the ability to maintain a desired fitness level

overtraining
fatigue brought on by excessive frequency, volume or intensity of training

Frequency refers to the number of training sessions in a week. If improvements are being sought, three sessions per week should be undertaken. When performers have reached levels they wish to maintain, the frequency can be reduced to twice per week, which is called the principle of maintenance. Elite performers seeking gains train more than three times per week; for aerobic-based improvements they will train five to six times per week; for anaerobic-based improvements they will train three to five times per week. Anaerobic sessions place greater stresses on the body and its systems and require longer recovery periods. Rest sessions or days should be strategically interspersed throughout a training week and are critical for avoiding overtraining.

Periodisation

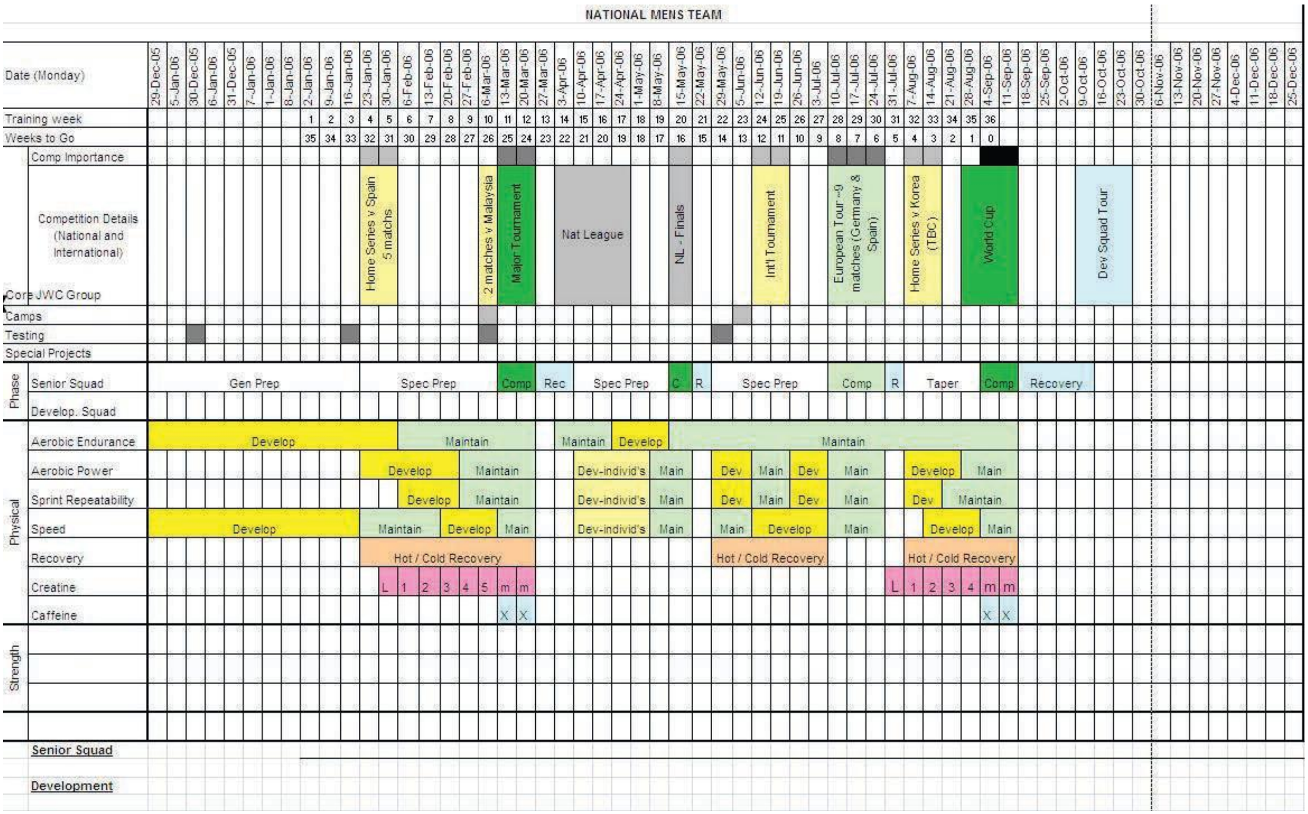
Sample plan

The goal of training is to maximise the body's adaptation, and periodisation is critical in the adaptation process. Periodisation is breaking up a training program into blocks of time.

The following definitions are often referred to in research journals; however, *mesocycle* is rarely used. A macrocycle is the large block of training, which can be a number of months or a year. Most sports work on a yearly macrocycle. A mesocycle is a block of four to 12 weeks in a training cycle. A microcycle is a training unit that repeats itself. In most sports this usually lasts a week; however, it can be from four to 10 days.

Figure 14.4 shows a sample annual training plan. The full-size sample annual plan is on the DVD.

Figure 14.4 An annual trainning plan



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General preparation

General preparation is often referred to as the 'pre-season'. The main goal is to improve an athlete's aerobic base and avoid injury. Some athletes will spend a considerable amount of time in this phase. A young cyclist who has just signed with a professional team is often considered an 'apprentice', and spends the first year or two building their base fitness.

It is also important to do some speed work in this phase, as the speed adaptations are quickly reversed when they are not overloaded. During this phase there is a large progressive-overload component.

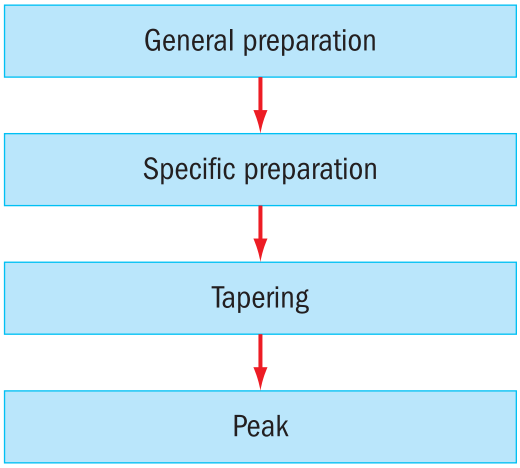

Figure 14.5 Parts of a training program

Specific preparation

Each athlete and sport will require a different specific-preparation phase. Some sports split this phase into two parts. First, they work on the specific fitness requirements of the sport; then they move to a maintenance phase once the season is underway. During the maintenance phase, the goal is to hold previous adaptations.

It is hard to improve physical capacity in collision sports that have a large amount of eccentric work, such as rugby and Australian Rules football. Hockey also has a maintenance phase because of the large amount of eccentric work involved in the game. Examples of demanding eccentric work include running, stopping suddenly, landing after a jump and running in a bent-over position. There also needs to be a balance in this time between fitness work and skill work. Good coaches design training drills that work on both fitness and skill.

Progressive overload

Improvements in performance occur as a result of adaptation to physical stress. An increase in the training workload will bring about physiological changes that make the body better able to cope with the stresses placed on it. Consequently, a workload that is initially stressful will cease to be so. Continuation at that workload will fail to produce further change. This is known as underload.

To gain maximum benefit from training, workloads must be gradually adjusted upwards as adaptation to stress takes place. This is known as progressive overload. To increase the workload to a higher level before the body has adjusted or adapted to the previous level can lead to excessive stress and possibly illness or injury. 'No pain, no gain' is a popular misconception. In fact, there is no need for the body to experience pain when adapting physiologically to training. Pain is an indicator that something is wrong; that the athlete is 'overtraining' and that training should be modified.

Applying progressive overload

Overload can be achieved by increasing the quantity or quality of training, or a combination of these. Quantity can be achieved by increasing the duration or frequency of training, or by increasing the resistance (load). An increase in quality is achieved by increasing the speed or intensity, provided specificity is not compromised. Increasing more than one factor could produce excessive overload and lead to injury. The key terms in overloading are 'gradual' and 'progressive'. Only one factor is adjusted upwards; for example, increasing resistance, distance or duration by 10 per cent, or intensity by two per cent, each week. Table 14.8 shows an example for a recreational jogger.

Table 14.8 Progressive overload—recreational jogger

Week	1	2	3	4	5	6
km	25	27.5	30.25	33	36.3	40

In the example in Table 14.8, the distance has been increased by 10 per cent each week. Training must be planned with sufficient rigour and flexibility to prepare for the event and for whatever lies beyond it. For this reason, the training season is planned in periods of time called training blocks (or cycles).

Tapering

A taper is a reduction in training load to eliminate residual fatigue, maximise energy stores and decrease psychological stress in a bid to optimise performance. During the taper phase, no adaptations will be made.

The more residual fatigue, the longer the taper required. An endurance sport will need more time in a taper phase than a power sport. This is due to the nature of power training: power-sport athletes have less residual fatigue because of the increased amount of rest in the specific preparation phase.

residual fatigue
accumulation of fatigue from one training session to the next

There are no specific guidelines available for taper length; however, four to seven days should be enough time to remove residual fatigue and replenish all energy stores. The length of the taper will vary with the individual, and will be primarily determined by the nature of the sport. An athlete preparing for an ironman triathlon may have a taper lasting two weeks, whereas a weightlifter may only taper for four days.

Catchy fact
Athletes participating in power sports, such as weightlifting, need to be careful when tapering so as not to diminish the neuro-muscular adaptations. This is one of the main reasons to hold intensity during a taper.

General taper guidelines

Intensity

Intensity of training needs to be maintained, as intensity is the single most significant factor in gaining adaptations; any reduction in intensity may lead to detraining.

Volume

Volume of training is the area that should be reduced by the greatest percentage: 50 per cent or more. The greater the previous workload or volume, the larger the taper in volume

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reduction should be. This may increase the time of the taper to a number of weeks for an ultra-endurance athlete.

For example, a training session during a taper phase for a 100-metre athlete may only include two 150-metre sprints at a very high intensity in the work section. To help with the taper there would also be a long recovery of around 30 minutes between the repetitions. Similar training loads would take place the whole week before a major event.

Team sports taper towards the end of the season, especially during the finals. The week before a Grand Final might see only two 30-minute high-intensity sessions for the week. There will also be some tactical sessions, but there will be a marked drop in training volume.

Frequency

Frequency of training should remain relatively high, at around 80 per cent of the previous workload.

Peaking

Peaking is the result of a quality program and an appropriate taper. Players in team sports that play 20 weeks in a row would not be able to taper and peak for each game. There is just not enough time. During the maintenance phase, teams will try to freshen athletes up for each game; however, this is not a true taper.

Sports such as rugby and football have specific weekly phases (considered a microcycle), where the training sessions later in the week are of considerably less duration. Table 14.9 shows a general week for a team sport. As many professional sports play on various days of the week, they will make necessary adjustments each week. When planning the week, it is best to work back from the game or competition day.

peaking
when an athlete reaches their optimal level of performance at the required time

Table 14.9 A team-sport weekly cycle

Saturday	Game day: high intensity
Sunday	Recovery and rehabilitation
Monday	Further recovery and rehabilitation Performance and game analysis Medium intensity Medium volume Afternoon weights
Tuesday	Skill work Continuous training Looking at opposition for coming week
Wednesday	Major training session High-intensity and volume training Weights in the afternoon
Thursday	Rest or study day
Friday	Light training Skill-based session Flexibility work Working on team strategies and tactics

Overtraining

Many athletes suffer the effects of overtraining (or overreaching), and the number may be as high as 20 per cent. Overtraining results in an inability to perform or train at their previous level. Overtraining is a complex interaction between the psychological and physiological systems in the body as it tries to cope with the increased stress. To force the body to adapt, we need to put it under stress, but too much stress can result in overtraining. Overtraining is generally a short-term problem if the training load is backed off. Overtraining also brings increased incidence of illness, high levels of residual fatigue and loss of motivation.

Finding the right balance between maximising the body's adaptation and avoiding injury and overtraining requires great skill. The body needs adequate rest for it to be able to adapt to an increased training load. This is an area where sports scientists can be of great benefit to coaches and athletes, and it is one of the reasons to have testing throughout a training program.

There have been many teams and athletes who have performed poorly because they were overtrained. Their coach has thought they were not fit enough and has gone on a mission to get them fitter. This only causes the athletes to become even more overtrained and make their performances suffer further. It may be that they need a rest so that they are able to make the required adaptations and freshen up for the weekend. Generally, the more you train, the greater the adaptations of the body will be; however, there is a point at which the body will not be able to cope with the increased demands placed on it.

There are also some chronic long-term effects of overtraining. They include:

- persistent poor results or form
- prolonged recovery from normal training sessions
- general fatigue, irritability and loss of motivation
- increased resting heart rate
- overuse injuries
- trouble sleeping
- weight loss from loss of appetite
- increased rate of infection.

adapted from McCardle, Katch and Katch 2001, page 502

chronic fatigue syndrome (CFS)
extreme fatigue that lasts six months or longer and does not improve with rest

All of the above symptoms are the result of stress. Illnesses such as chronic fatigue syndrome (CFS) have a similar effect on the body, and overtraining can lead to CFS.

Athletes involved in aerobic or continuous sports are more likely to suffer from overtraining than athletes in anaerobic sports. This is particularly true in sports such as triathlon, where the culture of the sport and the obsessive nature of athletes within the sport leads to overtraining.

Eccentric activities in anaerobic sports often cause the musculo-skeletal system to shut down before the adaptation process fails. A sprinter will need to rest their muscles and spend time removing the soreness before being able to train at high intensity again, whereas an aerobic athlete can overreach more easily because of the lower intensity of training.

Injured athletes

The information below has been provided courtesy of Sports Medicine Australia (WA Branch). Sport and recreational injuries are a known barrier to participation in and enjoyment of physical education. It is estimated that about one million Australians injure themselves while playing sports each year.

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Injury prevention

Sports-related injuries aren't inevitable; more than 50 per cent are preventable. Many common injuries can be averted with adequate attention to safety and a common sense approach. The Western Australian Sports Injury Study by Sports Medicine Australia (WA Branch, 2001) identified a number of risk and protective factors for sports injury.

To reduce the risk of injury it is recommended that:

- warm up and cool down be an important component of playing and training
- pre-season training programs be developed by an accredited or professionally trained person
- skill development and training preparation before participation be made a priority for sports-injury prevention
- preventive strategies be a priority for all players, as prior injury predisposes further injury
- all players with a prior or current injury should seek professional advice from a sports-medicine professional and be fully rehabilitated before returning to sport
- greater emphasis be placed on back care in order to reduce the risk of injury
- players ensure they have strong hamstrings to protect against knee injury.

Soft tissue injury

The most common injury in sport is the soft-tissue injury. Other sports injuries are summarised in Table 14.10. Figure 14.6 shows the brochure 'Soft Tissue Injuries' from Sports Medicine Australia. Further brochures on all types of sporting subjects are available as downloads from the Sports Medicine Australia website or as sets of multiple copies from the Sports Medicine Australia state branch. You can link directly to the *Sports Medicine Australia* website via the weblinks on the student DVD.

Sports Medicine Australia

Table 14.10 Sports injury facts

Sport	Common injuries	Causes	Facts	Other information
Hockey	• finger or thumb, knee, ankle, thigh, head or face • bruises, muscle strains	• Being struck by the ball or stick, contact with the playing surface, contact with other players	• In 2002–2003, 3944 people were admitted to hospitals across Australia for Australian Rules football-related injuries.	• In 2006, 157 600 Australians over 15 played outdoor hockey
Australian Rules football	• thigh, knee, lower leg and ankle • bruises, muscle strains	• Being tackled, hit or struck by another player, hit by the ball, falls	• 108 injuries per 100 000 players • Goalkeepers have the highest injury rate	• In 2007, there were 638 000 registered participants in Australian Rules football across the country • 96% of all injury cases are male • 48% of hospital-treated injuries occur to players aged 15–24
Netball	• ankle, wrist, hand, finger and knee • sprains, bruising, fractures and dislocations	• Awkward landings, slips and falls, player contact or collision, overexertion, overuse, being hit by the ball	• In 2002–2003, 1129 people were admitted to hospitals across Australia for netball-related injuries. • Rate of injury: 14 injuries per 1000 hours	• One of the most popular team sports in the country • In 2006, 593 900 Australians over 15 played netball • A recent study found that not warming up increases the risk of injury by 48%

Table 14.10 Sports injury facts (continued)

Soccer	• bruising, strains, sprains, fractures and dislocations	• Player contact, falls and tackles	• Up to 35% of injuries are caused by foul play	• One of the most popular team sports in Australia • In 2006, 697 400 Australians over 15 played outdoor soccer in the 12 months prior to the survey
Tennis	• lower limb (ankle, knee, thigh) injuries are most common • overuse injuries can occur in the upper limbs (elbow, shoulder, wrist) due to the repetitive activity	• Sprinting, stopping, pivoting and pounding	• Five injuries per 1000 hours of participation	• Statistics from the Australian Sports Commissions 2006 survey showed an estimated 1 130 700 Australians aged over 15 played tennis in the 12 months prior to the survey
Basketball	• ankle sprains • injuries to the fingers, hand, head, face and teeth are also common	• Falls, player contact, awkward landings, abrupt changes in direction, being hit by the ball	• Fourteen injuries per 1000 hours of participation • Knee injuries account for the most time lost in training and games	• Statistics from the Australian Sports Commissions 2006 survey showed 541 600 people over 15 played basketball in the 12 months prior to the survey
Squash	• ankle and knee	• Acute or traumatic events, e.g. fall on court or hit by racquet or ball	• Rate of injury is 18 injuries per 1000 hours of participation • During 2002–2003, the hospitalisation rate was higher among males and those aged between 45–54	• Squash is an international sport played in over 150 countries by 20 million people.
Cricket	• upper body, namely the hand and finger, the lower body and the head or face • sprains, strains, fractures, bruising and open wounds	• Injuries to the face, finger or hand from a cricket ball are the most common types of hospital-treated injuries, followed by falls • Overuse injuries; back and shoulder injuries among bowlers	• Although cricket is a non-contact sport, injuries do occur	• Cricket is a popular summer sport in Australia that has seen the pace, hazards and player expectations of the game increase over the years. • Statistics from the Australian Sports Commission 2006 survey showed 673 600 Australians aged over 15 played indoor or outdoor cricket in the 12 months prior to the survey

Sports Medicine Australia, 2008

ISBN 9780170227124

Injury management and return to play

If any injury occurs, the golden rule in management is 'do no further damage'. Inadequate or inappropriate first aid may aggravate the injury and cause an increase in the time required before returning to the sport.

Sports Medicine Australia (WA Branch) promotes safer sport messages through the development and delivery of education on injury prevention and management.

Table 14.11 Sports Medicine Australia workshops

Workshop	Sports medicine awareness course (SMAC)	Elastoplast sports taping	Return to play: rehabilitation of the injured athlete
Overview	Practical and interactive, this workshop highlights the latest findings in injury prevention and provides the skills for immediate injury management of sporting injuries.	You will learn when and how sports taping can assist in rehabilitation of an injury, prevent against minor sporting injuries and return to play safely.	A rehabilitation program is important for athletes to return to their sport safely after an injury. In this workshop you will work through the exercise prescription of a case study in an interactive set up.
Content	• PowerPoint presentation including pictures and videos • Warm-up and cool-down games and skills • Practical immediate injury management scenarios	• PowerPoint presentation including pictures and videos • Practical taping of the ankle joint, thumb and fingers	• Covers three phases the body goes through following an injury • Practical demonstration of the components of a rehabilitation program • Case study included
Comments	If any injury occurs, the golden rule in management is 'do no further damage'. Inadequate or inappropriate first aid may aggravate the injury and increase the time necessary before returning to the sport.	• 90% of sporting injuries involve the ankle • 95% of ankle injuries are an inversion sprain • 73% of people who sustain ligament damage (ankle, knee, shoulder) have recurrent sprains within six weeks of returning to training and competition	All players with a prior or current injury should seek professional advice from a sports-medicine professional and be fully rehabilitated before returning to sport.
Costs	• Two-hour workshop • $10 per student (minimum 15) • Includes SMA certificate of participation	• Two-hour workshop • $17 per student (minimum 15) • Includes SMA certificate of participation	• Two-hour workshop • $10 per student (minimum 15) • Includes SMA certificate of participation

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Figure 14.6 Sports Medicine Australia brochure 'Soft Tissue Injuries'

Checkpoints

1 When planning a training program, it is essential to manage the potential risks to your athletes. In a sport of your choice, outline the potential risks and describe how you would manage them.

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Recovery

The high levels of stress placed on the body's systems during exercise cause minor damage and depletion of fuel. Recovery strategies are designed to reverse the impacts of exercise and fatigue. The more quickly recovery is achieved, the more the body is able to cope with the next bout of exercise. If the recovery process is too long, the body will not be able to cope with exercise that is at a high enough level to cause positive adaptations. It is possible for the body to undergo detraining during the recovery process. Exercising at a high level, when the body is still trying to recover, may lead to overtraining.

The recovery process has three main goals:

- Replacement of energy and fluids
- Reducing muscle damage and starting immediate repair
- Reducing psychological fatigue

Recovery strategies

There are numerous recovery strategies that have a positive impact on the body. Most elite sportspeople will use a combination of strategies. The strategies chosen will depend on:

- the facilities available
- the time available
- the nature of exercise completed
- the time until the next competition
- any injury concerns.

Most strategies attempt to promote blood flow. Improved blood flow assists in the removal of toxins and provides an increased level of oxygen and nutrients to the cells so that they start to recover.

recovery strategies
strategies to improve blood flow after exercise; injuries must be attended to first, as some recovery strategies can make injuries worse

Catchy fact
Some recovery and training strategies have yet to be proven scientifically; however, it might be that we do not yet have the scientific understanding of exactly what is taking place. They still may be quite valuable, especially in helping psychological recovery.

Hydrotherapy

Hydrotherapy is the use of water to treat injury and illnesses. There are many cases in history where hydrotherapy was used, including ancient Greek and Roman civilisations.

Hot and cold water immersion

Hot and cold water immersion is a popular recovery strategy used by many professional athletes. The cold immersion cools the body and causes vasoconstriction; then, by warming body quickly, vasodilation occurs. This results in a pumping action in the periphery and an increase in circulation.

Scientific evidence is inconclusive whether the physiological benefits of this strategy are any greater than others, such as light walking. There is evidence to suggest that athletes enjoy this recovery strategy, and therefore receive some psychological benefit.

periphery
the outer layer; close to the skin

Ice baths

Ice baths cause considerable vasoconstriction, which results in blood being 'sqeezed' away from the muscles and taking the built-up toxins with it. Cooling the body also helps to reduce inflammation, which is the result of microscopic muscle tears.

The bath temperature should be around 13 °C. If the bath is too cold, blood flow will slow and toxins will not be removed. To get a bath to that temperature, you only need to add a small amount of ice to cold water. Some people will sit in an ice bath wearing a jumper, as they find the cold difficult to handle.

Ice-bath immersion is often used as a part of hot–cold water immersion. Remember, this is only when there are no injuries that will become worse with hot water. Special ice baths are available for around $6000 each. However, many sporting teams, including the Australian hockey team, use a blow-up wading pool or a wheelie bin. Check out the *Cold Spa* website for more ideas.

www Cold spa

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Figure 14.7 *Athletes using ice baths*

Ice vests

Ice vests are commonly used during matches, where they are effective in helping to reduce core temperature quickly. Ice vests are normally stored in a large bucket of icy water and worn when the athlete comes off the ground. They are most appropriate for hot and humid environments, where the body struggles to cool down because of the high humidity. More information about exercising in the heat can be found in Chapter 11.

Ocean recovery

After most AFL, rugby and A-League soccer games, the teams head to the beach as a part of their recovery. Generally this is the day after a game. Popular beaches include City Beach in Perth, St Kilda Beach in Melbourne and Bondi Beach in Sydney. Being in the ocean has many positive effects on the body:

- The movement of the water past the muscles has a massaging effect.
- There is some research to suggest that being in cold water causes the body to release the same hormones that fight colds and flus.
- Salt water has positive physiological and psychological health effects on the body.
- The increased density of salt water aids in resistance around the muscles, causing blood flow to increase.

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Figure 14.8 Footballers at a beach recovery session

Spa

Spa pools provide a number of physiological and psychological benefits to athletes. The swirling warm water helps to massage the body and promote blood flow. Spending time in a spa also helps to reduce arousal levels, which helps with the athlete's psychological recovery. Caution needs to be taken that the water temperature is not too high, as it is easy to become dehydrated in a spa. As spas recycle water, they must have the correct proportion of chemicals to stop bacteria from developing.

Catchy fact
In 2000, the Collingwood Football Club had ventilation problems in their recovery spa room. Legionella bacteria were found, and several players contracted legionnaire's disease.

Deep-water running

Running in deep water, with the use of a buoyancy vest, provides the same positive impact as a spa. It is also a good exercise when athletes need some time away from the high impact of running on hard surfaces. Athletes recovering from leg injuries use deep-water running to improve fitness before their injury is 100 per cent healed.

Figure 14.9 Deep-water running

Massage

Massage has two primary goals as a recovery strategy:

- To increase local circulation
- To provide a psychological soothing effect

There have been many studies on the effects of massage on athletes' recovery, with most studies finding little physiological advantage over other means of recovery. There was no significant lactate change because of massage, which suggests that there is also no extra removal of toxins. Most studies note that an active recovery is a better strategy. There is some suggestion that massage helps to relax muscles, which speeds up repair.

Massage does have a significant psychological impact on athletes. It helps with arousal regulation by lifting arousal when an athlete feels flat, and by calming athletes who are over-aroused. Athletes' perception of their recovery is also increased.

Massage may be of most benefit prior to strenuous exercise, where it has a warming and relaxing effect on the muscles. This may be of benefit in preventing soft-tissue injuries.

Ice massage

Ice massage is used to treat localised pain and limit swelling. It has been successfully used to treat symptoms associated with shin splints.

KEEP IT REAL!

'Shin splints' refers to pain in the lower leg. The most common cause is inflammation of the periostium of the tibia (which is the sheath surrounding the bone). The cause of pain is the muscle or tendon pulling away from this area due to poor running technique, incorrect foot placement or overuse.

Ice massage is a successful immediate treatment to reduce pain and swelling. However, it does not correct the underlying biomechanical problems. Most problems with shin splints can be corrected over time by wearing orthotics. Athletes suffering from shin splints will need to rest and see a podiatrist.

Light exercise

Light exercise such as walking is often underrated as a recovery strategy. The benefits of walking include the following.

- The promotion of blood flow
- It can be social and helps with psychological recovery
- It lowers arousal
- Not taxing to any energy system
- Requires minimal facilities and equipment

Stretching

Stretching is important in recovery to help return a muscle to its original state. Stretching combined with light exercise helps to keep the muscle fibres in the correct alignment. Keeping the fibres in correct alignment and stopping them from knotting is very important when the muscle is rebuilding.

Stretching also limits the mechanical jamming of the actin and myosin. Mechanical jamming results from damage to the muscle fibres, usually from sport. Cramping in the muscle is different from mechanical jamming, and is usually caused by biochemical imbalances, particularly because of low levels of sodium, calcium and potassium.

Hyperbaric chamber

hyperbaric chamber a large chamber in which the oxygen pressure is above normal for the atmosphere

There is some suggestion that increased levels of oxygen help recovery. As oxygen is critical in tissue formation, the theory is plausible. Some scientists believe the body has more than enough extra oxygen to help with healing. Other scientists propose that increasing blood-oxygen concentrations by being in a hyperbaric chamber increases the oxygen differential between the blood and the cells, causing more oxygen to go into the cells and accelerating healing.

In a hyperbaric chamber, the air pressure is two to three times above normal air pressure. This will have some positive impact on constricting the muscles, decreasing swelling and increasing bloodflow. Hyperbaric chambers may be better suited for injury rehabilitation than recovery from exercise.

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Intravenous therapy

Intravenous therapy (or IV therapy) is where fluid is supplied directly into the blood. It is commonly referred to as being 'on an IV drip'. It is a very successful way of treating dehydration and has been used by a number of athletes in a variety of sports. In 2007, the World Anti Doping Agency (WADA) added IV therapy to its banned list. However, IV therapy can still be used for medical reasons, such as treating dehydration after an event, but not during an event. The Australian Men's Hockey Team used IV therapy in the 2004 Athens Olympic Games, but was unable to use it during the 2008 Bejing Olympic Games.

How it works

Normal ingestion of fluid is limited by the rate that fluid can be absorbed through the gut and into the bloodstream. The average rate of fluid absorption is 200–250 mL every 15 minutes. This will be higher for an athlete who has caused their body to adapt by training and competing in hot environments. An IV drip can put 500 mL of fluid into the body in about 15 minutes. The rate-limiting factor for the IV drip is the size of the needle. The larger veins of elite athletes can take larger needles, so more fluid can flow into veins in a given period of time. The athlete can continue to ingest fluid through the gut as well.

The use of IV drips during athletic performance came to prominence in 2001 when the Brisbane Lions were using the technique at half-time in AFL matches. Many triathletes use IV drips to replace fluid after competing in events such as the Hawaii Ironman. Having fluid supplied via a drip has a double positive: it quickly returns the body's fluid levels to normal and helps the body to recover quickly; it also makes it simple to control the amount of fluid an athlete receives, as many athletes fail to ingest adequate fluid in the 24 hours after a performance when left to their own devices. Another advantage of using an IV drip is that glucose and other nutrients can be added to the drip, bypassing the ingestion phase.

Compression garments

The use of compression garments, when combined with light exercise, has shown to be the optimal recovery strategy for rugby players when compared to no exercise without compression garments, no exercise and wearing compression garments and light exercise without compression garments. The use of compression garments will have the greatest impact in the first 24 hours after exercise.

Figure 14.10 *An athlete training in compression garments*

deep vein thrombosis (DVT)
blood clot that develops inside the veins of the leg muscles

ankle oedema
swelling in the ankles caused by blood pooling because of loss of circulation

When athletes need to travel immediately after a competition, compression garments reduce the possibility of deep vein thrombosis (DVT). Most notably, they reduce the likelihood of in-flight ankle oedema.

DVT is a potentially fatal condition where blood clots develop in the leg. The clots form because of reduced blood flow, which is often due to long periods of immobility. Complications occur if the clot dislodges and travel to the lungs, which could cause a pulmonary embolism, which is the blocking of the pulmonary artery. This is potentially fatal.

Clotting is also more likely to occur after injury, especially if it is an area that has had previous injuries. Smokers also have a much greater chance of developing DVT. After surgery, patients wear special compression stockings to help prevent DVT.

Cool down

pyruvate
converted form of glucose used for producing ATP with oxygen

The cool down after competition is an effective way to limit venous pooling. By performing low-intensity exercise, blood continues to flow from the muscles through the organs of the body. This removes toxins and converts lactic acid in the liver back to pyruvate, making it available to become ATP.

Delayed onset muscle soreness

Delayed onset muscle soreness (DOMS) is the soreness found in muscles and joints after participating in unaccustomed exercise. It usually stays for three to four days. You may have experienced this after the first training session or the first game of a new season. Many students experience DOMS after a school athletics carnival, as they are putting muscles and joints under stress that they may not have had for 12 months. It is more likely to occur if the activity contained eccentric work.

There is still considerable debate over the cause of DOMS. It may be caused by:

- inflammation of the muscles and joints
- microscopic tears in the muscles, ligaments and tendons
- overstretching.

Catchy fact
Eccentric actions, such as running down hill, are more likely to cause DOMS.

DOMS will decrease markedly over the next couple of exercise sessions. By game three or four of the session, most players will not feel much effect, if any, from DOMS.

A gradual build up in a training program, plus an appropriate warm up and cool down will help to elevate the affect of DOMS. Recovery strategies designed to return the body back to pre-competition levels also have a positive impact against DOMS.

When people are starting a new fitness program, it is important that they understand the impact of DOMS. The effects of DOMS can debilitate sedentary people who suddenly start a fitness regime; they may think that life was easier when they did not exercise. Avoiding lots of eccentric contractions early in a fitness program will limit the impact of DOMS. Programs with walking, cycling and swimming are better to begin with than programs featuring stair running, jumping and squats.

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Checkpoints

1 What are the differences in recovery strategies for a 100-metre runner and 400-metre runner? Assume they have both just completed their semi-finals and have their final in three hours' time.

2 Imagine you are a personal trainer. A new group of middle-aged people have joined your class. None of them have done much exercise in the past 12 months. Describe the major considerations you would keep in mind when designing a program for this group. (Note: it is not to be a day-by-day program.)

Maintenance

It is not possible to overload the body continuously: there will come a point where the body has made all adaptations it is able to make. This normally happens with elite athletes, and any further gains in performance can only be made by refining technique.

It is difficult to make further adaptations during the season, as the body requires recovery time from the weekly performances. This is when athletes participate in a maintenance program; they are trying to hold their strength, speed and endurance adptations.

People who have participated in a fitness program to improve their general health and fitness often move into a maintenance phase once they have achieved their weight or fitness goal. Some people only have enough time to participate in a maintenance program. A minimum of two sessions per week is required for a maintenance program to be successful.

TEST YOUR KNOWLEDGE

>> multiple-choice questions

1 The progressive overload principle states that an increase in workload from one week to the next should not exceed:

- **A** 2 per cent
- **B** 10 per cent
- **C** 5 per cent
- **D** 20 per cent.

2 Specificity of training refers to:

- **A** maintaining a true target heart range
- **B** varying intensity to suit energy systems requirements
- **C** tailoring training activities to mirror the requirements of the sport
- **D** ensuring that peaking, tapering and recovery are well planned.

3 Venous pooling refers to:

- **A** blood remaining in the periphery due to a poor cool down
- **B** blood remaining in the core due to heat stress
- **C** veins becoming distended due to hypertension
- **D** veins becoming engorged with blood due to exercise overload.

4 A cool down after activity is an effective method of reducing:

- **A** venous pooling
- **B** muscle tears
- **C** ligament damage
- **D** bruising.

>> short-answer questions

1 Discuss the benefits of cross training for elite athletes.

2 Traditionally, training programs have been broken into three distinct phases. Identify these phases and describe the outcomes expected in each.

3 What does the colour of urine indicate regarding an athlete's hydration levels? Suggest ways athletes can avoid dehydration.

4 If you were the operations manager for an AFL team, how would you help your players avoid DVT?

>> essay questions

1 Design a training program for the members of your class. Include a brief periodisation schedule for them as they work towards the PE Studies practical exam in October.

2 Design a detailed action plan for an athlete injured in your chosen sport. Assume the injury will place the player on the short-term injury list for four weeks. Outline how you will know when to re-introduce the player to full competition.

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SECTION 6
SPORTS PSYCHOLOGY

Chapter 15 Motivation, concentration and arousal

Chapter 16 Performance issues

3A.18 Analyse mental skills and strategies used pre-, during and post-performance to manage stress, motivation, concentration, self-confidence and arousal levels, i.e. self-talk, relaxation, performance routines and goal-setting imagery.

Chapter 17 Group cohesion and participation in activity

3B.9 Apply Carron's model of group cohesion to analyse own performance within a group setting in physical activity, i.e. the relationship between social loafing and group cohesion, the influence of social loafing on individual and group performance, and being able to identify strategies to improve group cohesion.

15 Motivation, concentration and arousal

Figure 15.1 *Australia II* in the 1983 America's Cup

Mental skills training

Mental skills training, also known as psychological skills training (PST), deals with the cognitive behavioural aspects of sport psychology. These skills can be taught, learned and practised. The purpose of this chapter is to describe the concepts of motivation, arousal regulation (the 'inverted-U hypothesis') and concentration. In addition, the relevant training of these skills will be discussed. It is important to realise these skills are not only practised and used in training, but also pre-, during and post-competition. Athletes, coaches and sports psychologists have understood the importance of mental skills and the training and development of these skills across a diverse range of sports for decades.

Here is a quote from John Bertrand, who was the skipper of *Australia II* in 1983, the first team to win the America's Cup from the United States in its 132-year history:

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'I believe very firmly in the power of the mind lies the key to winning, as opposed to performing well and losing. After the Montreal Olympic Games I became a keen and serious student of sport psychology so as soon as I was appointed skipper of *Australia II*, I began to look for the right man to deal with the mental attitudes of my crew.'

The psychological strategies presented in Table 15.1 have been shown to enhance the likelihood of successful performances. Chapter 16 addresses the first three psychological strategies shown in Table 15.1, related to developing confidence, mental rehearsal and imagery. This chapter focuses on the last three strategies outlined in Table 15.1, relating to the development of motivation, concentration and arousal regulation.

Table 15.1 Using the mind to enhance performance

Psychological strategies to enhance performance	
1	To enhance self-confidence, practise specific plans to deal with challenges during performance
2	Use mental rehearsal prior to competition
3	Develop detailed competition plans that include various potential situations and coping strategies
4	Practise routines to react and cope with a variety of challenging circumstances and distractions prior to and during performance
5	Focus your concentration on the upcoming performance, rather than the past; block out negative or irrelevant thoughts
6	Regularly practise the same skill under different levels of arousal and anxiety levels, and a variety of circumstances and conditions

Player motivation

Adults place a greater emphasis on accomplishment and competition than children do. Research shows that children are motivated to participate in sport to have fun, improve skills, belong to a group, be successful and gain recognition, get fitter and find excitement. Some adults play sport because they are paid to do so, while others are there for the health and fitness benefits. Other athletes are interested more in the social aspects of being involved. The coach needs to be aware of what the players hope to gain from their involvement.

Motivating factors can be extrinsic or intrinsic.

- Extrinsic factors are external to the athlete; for example, prize money, certificates, chocolate frogs, progress charts and trophies.
- Intrinsic factors come from within the individual; for example, being satisfied with one's performance (shooting the ball in the basket) or simply enjoying the competition.

Coaches cannot control their athletes' motivation levels. However, they can help athletes work towards desirable goals, and therefore control their motivation to compete. A focus on effort levels and personal achievement, such as achieving a personal best, is more motivating than a focus purely on winning, which depends on uncontrollable factors.

extrinsic motivating factors
factors external to the athlete, such as prize money

intrinsic motivating factors
factors that come from within the individual, such as enjoying the competition

Figure 15.2 Extrinsic forces can motivate performance as much as intrinsic forces

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A continual improvement in an athlete's performance indicates that aspects of the coaching regime are succeeding. Brent Rushall cited four criteria for identifying a performer's behaviour as being motivated (Rushall, 1984, p. 145):

- Motivated athletes attend practices, are punctual, successfully complete tasks, encourage others and are involved in activities such as club social functions.
- Motivated athletes more regularly achieve desired behaviours in training and competition.
- The athlete's 'character' takes on the features of the desired behaviour.
- Performing the behaviour requires seemingly fewer rewards.

Coaches must be consistent in their methods of motivation. Inconsistency can lead to motivational problems with athletes, and jealousy can be destructive within a playing group.

Checkpoints

1 Describe intrinsic motivation.

2 Explain how extrinsic motivation differs from intrinsic motivation.

3 Discuss whether professional athletes are more likely to be motivated intrinsically or extrinsically, and explain why.

4 Describe four criteria that could be used for identifying a motivated athlete.

Forms of motivation and reinforcement

positive motivation when positive, reinforcing events occur after desired behaviour

negative motivation when negative or punishing consequences are imposed after undesirable behaviour

reinforcer method of motivation, either positive or negative

There are two methods of developing motivated behaviours: positive motivation and negative motivation.

- Positive motivation is where positive reinforcing events have taken place after the individual has displayed desired behaviour. For example, positive acknowledgement of good play ('that's terrific', 'well done'), badges, jellybeans, performance information, positive feedback.
- Negative motivation is where negative or punishing consequences are imposed after undesirable behaviour. For example, making the athlete perform sit-ups or star jumps as punishment for an incorrect move during training; disapproving comments or a rebuke; a demotion in grade.

The same reinforcer or method of motivation should not be used continually, as the athletes need variation and an element of novelty for motivating behaviours to remain effective.

While positive motivation should be applied regularly, particularly with young performers, negative motivation should be used if a performance is inadequate or incorrect. This provides a contrast between the coach's positive and negative motivations, and maintains the power and impact of the positive reinforcers. Negative motivators should never be applied more than positive reinforcers. The Australian Coaching Council recommends that coaches should provide ten times more positive reinforcers than negative. Striving for and achieving a personal best (PB) in a performance is a positive reinforcer that all athletes can achieve.

Here are some tips for scheduling reinforcement effectively.

- During the earlier stages of learning, frequent, continuous, positive and immediate reinforcement is most effective; in the later stages, less frequent, intermittent reinforcement is more desirable.
- Appropriate behaviour should be rewarded.
- Reward successful steps towards achieving the desired response.

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- Reward the execution, not just the outcome.
- Reinforce effort if a learner is trying their best, even if they are not succeeding.
- Reward good sportsmanship and desirable social skills.
- Provide specific feedback about the correctness of their results.
- Provide motivational feedback to inspire continued or greater effort.
- Use verbal feedback ('well done!') and non-verbal feedback (hand clapping, smiling) when the athlete performs something well (Weinberg & Gould, 2007).

Sport motivation scale (SMS)

The sport motivation scale (SMS) consists of seven subscales that measure:

- three types of intrinsic motivation (IM)
  - IM to know
  - IM to accomplish things
  - IM to experience simulation
- three forms of regulation for extrinsic motivation (EM)
  - identified
  - introjected
  - external
- amotivation.

Using the scale below, indicate the extent that each item corresponds to one of the reasons you are presently participating in your sport.

Table 15.2 Sports motivation scale

		Does not correspond at all		Corresponds moderately			Corresponds exactly	
1	For the pleasure I feel in living exciting experiences	1	2	3	4	5	6	7
2	For the pleasure it gives me to know more about the sport that I practise	1	2	3	4	5	6	7
3	I used to have good reasons for doing sports, but now I am asking myself if I should continue doing it	1	2	3	4	5	6	7
4	For the pleasure of discovering new training techniques	1	2	3	4	5	6	7
5	I don't know anymore; I have the impression that I am incapable of succeeding in this sport	1	2	3	4	5	6	7
6	Because it allows me to be well regarded by people that I know	1	2	3	4	5	6	7
7	Because, in my opinion, it is one of the best ways to meet people	1	2	3	4	5	6	7
8	Because I feel a lot of personal satisfaction while mastering certain difficult training techniques	1	2	3	4	5	6	7
9	Because it is absolutely necessary to do sports if one wants to be in shape	1	2	3	4	5	6	7
10	For the prestige of being an athlete	1	2	3	4	5	6	7
11	Because it is one of the best ways I have chosen to develop other aspects of myself	1	2	3	4	5	6	7
12	For the pleasure I feel while improving some of my weak points	1	2	3	4	5	6	7

Table 15.2 Sports motivation scale (continued)

13	For the excitement I feel when I am really involved in the activity	1	2	3	4	5	6	7
14	Because I must do sports to feel good about myself	1	2	3	4	5	6	7
15	For the satisfaction I experience while I am perfecting my abilities	1	2	3	4	5	6	7
16	Because people around me think it is important to be in shape	1	2	3	4	5	6	7
17	Because it is a good way to learn lots of things that could be useful to me in other areas of my life	1	2	3	4	5	6	7
18	For the intense emotions that I feel while I am doing a sport that I like	1	2	3	4	5	6	7
19	It is not clear to me anymore; I don't really think my place is in sport	1	2	3	4	5	6	7
20	For the pleasure that I feel while executing certain difficult movements	1	2	3	4	5	6	7
21	Because I would feel bad if I was not taking time to do it	1	2	3	4	5	6	7
22	To show others how good I am at sport	1	2	3	4	5	6	7
23	For the pleasure that I feel while learning training techniques that I have never tried before	1	2	3	4	5	6	7
24	Because it is one of the best ways to maintain good relationships with my friends	1	2	3	4	5	6	7
25	Because I like the feeling of being totally immersed in the activity	1	2	3	4	5	6	7
26	Because I must do sports regularly	1	2	3	4	5	6	7
27	For the pleasure of discovering new performance strategies	1	2	3	4	5	6	7
28	I often ask myself; I can't seem to achieve the goals that I set for myself	1	2	3	4	5	6	7

Pelletier, Tusob, Fortier, Vallerand, Brikre & Blais, 1995

Copy the grid below and use it to work out your score for each subscale.

Table 15.3 Subscale scoring grid

		Items				Total
Internal motivation	Internal motivation to know	2	4	23	27	
	Internal motivation to accomplish things	8	15	12	20	
	Internal motivation to experience stimulation	1	13	18	25	
External motivation	External	6	7	10	22	
	Introjected	14	16	21	26	
	Identified	9	11	17	24	
Amotivation		3	5	19	28	

Pelletier, Fortier, Vallerand, Tuson, Briere & Blais, 1995

High scores represent a higher level of the construct.

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Figure 15.3 While world records are confined to only a few elite athletes, everyone can achieve PBs.

Arousal

Arousal is the amount of readiness or activation a person experiences when faced with a task. It refers to the intensity dimensions of motivation at a particular moment along a continuum from low (coma state) to high (frenzy). Table 15.4 summarises when high and low arousal can occur and what the results might be in a performance.

Table 15.4 Arousal and performance

Low arousal	High arousal
Occurs when: • people are bored • people are tired or not directly involved in a team game.	Occurs when: • people are tense, highly excited or anxious.
This leads to: • muscles feeling heavy and lethargic • a drop in concentration • decreased enthusiasm • increased apathy.	This leads to: • muscles becoming tense • movements becoming jerky • a drop in coordination • increased mistakes or errors • decreased success rate.

As you can see in Figure 15.4, a zone of best performance exists at a moderate level of arousal. Keeping within this zone ensures sufficient arousal to give a high-quality performance, while not being over-stressed or off-task. This zone is individualised and in a different place and different shape (heights and widths) for different people. Some people may operate most effectively at a level of arousal that would leave other people lacking motivation or interest. It is likely that someone who performs well in low-level competition might experience difficulties in high-level competition. Alternatively, someone who performs only moderately at a low level of competition might perform better under more pressure.

If the level of arousal is low, performance is likely to be poor. People show low levels of arousal when they lack motivation or are bored, tired or not directly involved in the action of a team game. Muscles feel heavy and lethargic, concentration drops, enthusiasm decreases and apathy rises. Conversely, if high levels of arousal are experienced, performance will also suffer and most likely not be optimal. This often happens to people who are tense, highly excited or anxious. Muscles become tense, movements become jerky, coordination drops and mistakes increase. Under these conditions the activity can become threatening and unpleasant and result in poorer performances.

Athletes must take responsibility for controlling their own arousal levels, particularly in team situations. If some members are in their optimum zone, paying attention to a coach's motivating half-time talk may move them to a state of being over-aroused. Similarly, if some team members need to be relaxed, applying relaxation techniques to the entire team may move others to a state of demotivation.

demotivation
reversal from a state of being motivated and aroused

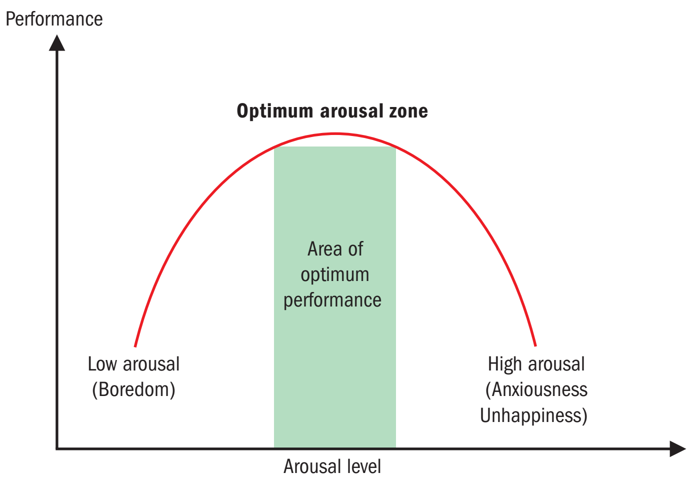

Figure 15.4
The relationship between arousal and performance: notice the optimum arousal zone

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Arousal regulation strategies

Athletes need to recognise the relationship between how they feel on the inside and their performance levels on the outside.

They should think about how they felt when they were in 'the zone' and their performances were outstanding, compared to feelings linked with poor performances. In this chapter, several arousal reduction and arousal promotion techniques are described.

the zone
when performance becomes automatic and requires little thought, full of flow and unaffected by outside distractions; occurs during situations of optimal arousal and confidence

Progressive muscle relaxation (PMR)

A popular method of arousal reduction used among athletes is muscle relaxation. This involves progressively tensing and relaxing major muscle groups, usually working from head to toe, until all muscles are relaxed.

A muscle group is contracted slowly and held 'tight' for five to ten seconds, then slowly released, all the way down the body in the following order: forehead → face → neck → upper arms → forearms → fingers → chest → stomach → buttocks → thighs → calves → toes.

This allows athletes to tense muscles and then 'let go' of this tension, which in turn reduces mental tension. Athletes use this technique during time-outs, change of ends, time spent on the bench or stoppages in play to bring them back into the zone and improve subsequent performances.

Table 15.5 Progressive muscle relaxation (PMR) steps

Progressive muscle relaxation (PMR) steps
1 Obtain a CD player and blank CD of at least 60 minutes' recording capacity.
2 Obtain a progressive muscle relaxation script. (See Chapter 16 for an example.)
3 Prepare to make a CD recording. Select a recording site that will be free from distractions and outside noises. Read the progressive muscle relaxation script with the recording button turned on. While you are reading, attempt to be inspirational, as if you were your own coach. You may wish to have someone else make the recording. If that is the case, have them read the script before making the recording.
4 This CD is to be used to enhance your skill of attaining a physically relaxed state.
5 A schedule of practice sessions should be developed. It is best to practise these exercises on a daily basis.

Breath control

Some athletes use breathing techniques to help them relax and refocus while preparing for the next action or part of a match. Figure 15.5 shows a sequence that is favoured by many athletes.

refocus
ability to gain renewed attention or concentration

This sequence assists athletes by blocking out distractions, providing a mental break from the activity, relaxing muscles and helping them stick to a game plan. For example, tennis players sigh and breathe out just before taking a big shot. This expulsion of air is to release tension.

As you think about the next part of your performance:

- relax your neck, shoulder, chest and arm muscles
- take a slow and deep breath and force your chest to rise and stomach to extend (don't hunch or raise your shoulders) until your lungs are filled
- exhale slowly and feel your chest return to its resting position
- as you exhale, go through a prepared routine that is going to refocus your attention and future efforts.

As you exhale you might focus on:

- gaps in the softball field where you are likely to hit the ball
- where point of contact is being made in a tennis serve
- specific parts of the racecourse approaching key areas, such as corners, bends and the pit lane.

Figure 15.5 Controlled breathing brings about arousal modification and enables refocusing of thoughts

Biofeedback

Biofeedback is a physically based technique used to modify physiological or autonomous body functions during training, and carry them over into competition. Electronic instruments provide athletes with auditory or visual feedback on a range of physiological parameters, such as heart rate, muscle tension and skin temperature. These electronic devices give a direct reading or emit sounds relative to the intensity of the stimulus.

For example, during training a baseball pitcher might feel tension in their shoulder and neck muscles. Feedback from attached electrodes is provided via a loud beeping noise. By using relaxation techniques, the pitcher can try to reduce the intensity of the noise as their muscles become more relaxed. A log is kept, outlining which relaxation techniques are most effective at reducing tension, and these are practised and implemented during game situations to bring about effective pitches. Biofeedback has also been used to improve the performance of rifle shooters. They become aware of their heartbeat using feedback from electronic signals and use this information to practise firing between heartbeats, leading to improved performance levels. Essentially, after much training and experience, biofeedback enables athletes to become more tuned into their physiological functions and bring these under their control more effectively.

biofeedback
receiving feedback regarding autonomous body functions such as heart rate, blood pressure and body temperature, and using this information to bring about mental adaptation

autonomous
the highest stage of learning, where actions become automatic and require little thought

log
training diary or record

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Coursework

The whole class participates in a physical activity that introduces potential anxiety-producing factors. Students decide on a team game that the whole class can participate in; for example, basketball, indoor hockey, netball. Introduce any of the following stressors.

- A knock-out competition
- Observation of the activity by the principal
- Videotaping the activity for later viewing by the class or year level
- Every turnover or error results in a penalty of five sit-ups or push-ups.

As the class completes the activity, incorporate some of the relaxation techniques discussed earlier. During breaks in the play, or at the completion of the activity, discuss the following.

- How did the external conditions increase anxiety?
- What type or types of 'arousal reduction' techniques were tried?
- How effective were the techniques at reducing student anxiety and 'refocusing' them on the performance?

Use the weblink for this chapter to access *Athletic Insight: The Online Journal of Sport Psychology* for some great current issues, access to back issues, a question and answer section and great links to other psychological skills training and sports psychology sites.

Sport psychology

Arousal promotion techniques

Elevated breathing rate

In the same way that breathing control can reduce tension and focus energy, short sharp breaths activate the central nervous system and increase its state of awareness. As athletes take more rapid breaths, they tend to focus on the performance ahead of them and use this as a centreing technique to shut out distractions. Quite often you will see tennis players, after losing a few games in a row, put their heads into their towels at the change of ends and take 15 to 20 quick deep breaths. At the same time they are focusing on their strokeplay, game strategy and body mechanics: footwork, service action, etc.

Act energetic

Sometimes athletes feel lethargic or tired. This can occur in the last quarter of a netball game or even before the game starts. Acting energetically tends to increase arousal levels. You might recall seeing football team-mates bumping into each other, slapping each other and getting physical with each other in the changerooms or before taking to the field. This is a way of getting 'pumped up'.

Positive talk and sounds: 'Talk it up!'

The mind is a powerful tool that controls how we think and perform. The use of emotive words such as *tough, aggressive, hard-hitting, dependable, forceful, strong* and *commitment* when talking to ourselves or others has been found to increase arousal levels. Is it any wonder that they commonly appear in coaches' speeches?

Listening to upbeat, up-tempo music can also increase arousal levels and hence performance. It is common to see athletes using headphones to listen to MP3 players before a game or even during breaks. Athletes participating in events that take several hours often use music to 'keep them up' and in the optimum arousal zone. You may recall seeing high jumpers or pole vaulters listening to music during the lengthy wait between jumps. Some athletes even try to get the crowd behind them and rev them up by encouraging them to clap or cheer rhythmically.

Coursework

Self-talk exercise

Identify the negative and positive thoughts you have before and during a sports performance. Develop a positive thought to counter that negative thought, so that you can say it to yourself when the negative thought occurs. Copy Table 15.6 and add some positive and negative thoughts of your own.

Table 15.6 Self-talk exercise

Negative thoughts	Positive thoughts
I don't play well in the wet.	No – I've played well in the wet before, keep it simple.
What if I miss the kick?	I've done this kick a million times in practice – think how good it will be when I kick the goal!

Energising mental imagery

mental imagery ability to picture events by thinking about them

Energising mental imagery involves visualising something that is uplifting and energising to the athlete, and commonly involves performing with fine form. Examples include:

- swimmers visualising themselves moving sleekly through the water like seals
- surfers seeing themselves cutting through the waves like shark fins
- footballers imagining that they have the strength of rhinos when they are going to tackle opponents
- netballers seeing themselves bounding over the court like gazelles.

Pre-competition workout

Depending on the activity, a pre-competition workout typically takes place a couple of hours before the actual game, performance or competition, as shown in Table 15.7. This allows athletes to become accustomed to the playing field and conditions, and gives them time to go through set plays and pre-game conditioning, including stretching. Following this, the players come out onto the field and perform warm-ups immediately before the game. As well as preparing themselves physiologically, they can practise some of the psychological techniques for enhancing performance in front of thousands of spectators, and are less likely to be distracted by them at the outset of the game.

Table 15.7 Example of a pre-match routine

Pre-match routine
Night before
• Eat a high-carbohydrate medium-protein meal with plenty of fluid
• Go to the cinema or watch an absorbing video
• Have an early night

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Morning of game
• Wake at usual time and have normal breakfast • Spend 15 minutes imagining goals for the game • Relaxation • Head to ground to arrive 30 minutes prior to team meeting • Walk onto the pitch to acclimatise to the ground
At the ground
• Team meeting: focus on the key points highlighted by the coach • Monitor weight to assess hydration • Individual warm-up activities • Ground warm up • Fifteen minutes prior: assess arousal level and regulate accordingly • Five minutes before: imagine performing successfully

KEEP IT REAL!

Psychological tests are used to identify an athlete's strengths and weaknesses, allowing sport psychologists to develop specific training in psychological skills. Figure 15.6 shows Iceberg profiles of successful and less successful athletes across a range of mental health predictors. (An Iceberg profile looks like an iceberg: all the negative traits such as depression, anger and tension, are below the surface and one positive trait – vigour – is above the surface. [Weinberg & Gould, 2007.]) The athletes were runners, wrestlers and rowers.

A successful athlete's Iceberg profile based on the Profile of Mood States (POMS) instrument shows vigour above the average (or mean) for the general population and tension, depression, anger, fatigue and confusion below the mean for the population. Research data collected using POMS has provided some support for the notion that athletes tend to have better mental health than non-athletes.

a

b

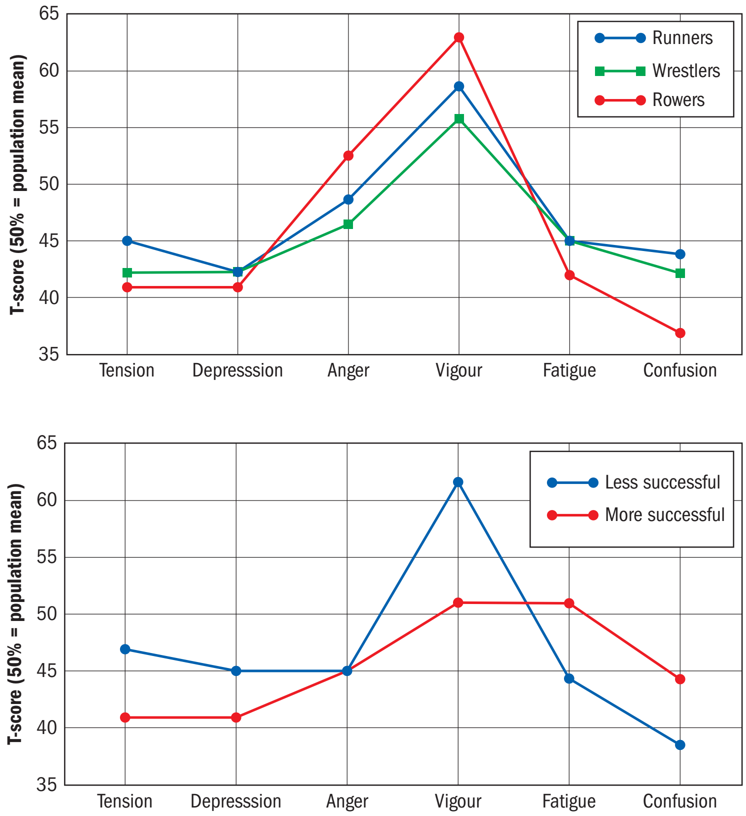

Figure 15.6 Psychological profiles of a) athletes in three different sports b) more and less successful elite athletes

Checkpoints

1. **a** Define positive motivation.
   b Provide three examples of negative or punishing consequences imposed after an athlete displays an undesirable behaviour.
   c Explain why positive motivation should be used more often than negative motivation when working with young performers.
   d Describe four tips to schedule reinforcements effectively.
2. Identify three factors that can lead to low arousal, and explain how this can affect performance.
3. Describe what can happen to performance when an athlete is experiencing high arousal.
4. Describe two arousal-reduction strategies and two arousal-promotion strategies.

Concentration

One of the best definitions of concentration contains three parts:

- Focusing on relevant environmental cues. This is also known as 'selective attention' and enables players to block out irrelevant cues such as spectators and other noise.
- Maintaining attention focus over time. This involves maintaining focus over extended periods of time and not allowing concentration lapses to occur.
- Having awareness of the situation. This is the ability to size up a game situation, opponents and other environmental factors and bring about the most appropriate response; for example, elite athletes are able to do the right thing at the right time during games, even under pressure-packed conditions. (See Table 15.8)

Table 15.8 Components of concentration

Focus on environment	• Also known as selective attention • Enables players to block out irrelevant distractions such as spectators
Staying focused	• Maintaining focus over an extended period of time • Not allowing concentration lapses to occur
Situational awareness	• Being able to quickly evaluate the game situation, opponents and other environmental factors • Being able to make the correct decision under pressure

You can see that concentration and attention are used interchangeably, and this commonly occurs in the field of psychology. Nideffer (1976) described attention in sport in terms of 'width' and 'direction'. The width describes how narrow or broad the attention is, and the direction describes either an internal or external focus.

With Nideffer's model, there can be four possible types of attention mode, as shown in Figure 15.7.

- Broad-internal focus is used to focus on thoughts and feelings; for example, a fast bowler preparing to run into the wicket to bowl.
- Broad-external focus is used to focus outwards on an opponent's actions; for example, watching an opponent try to breakaway in a cycling race.
- Narrow-internal focus is used to focus thoughts and mentally rehearse upcoming movements; for example, a springboard diver.
- Narrow-external focus is used to focus on very few external cues; for example, a footballer focusing on the ball while waiting to take an unopposed chest mark.

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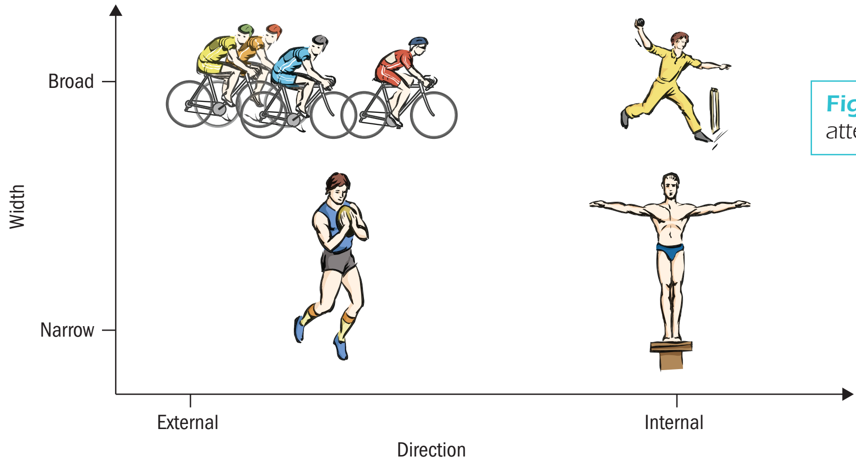

Figure 15.7 Four types of attention mode (Nideffer's model)

future-oriented thinking
thinking ahead about what you are going to do and what might happen

In any situation, an athlete's attention needs to shift to meet the demands of the environment. Many factors can lead to an athlete experiencing inappropriate attention focus, and their performance can deteriorate as a consequence. This might occur because they focus on past performance errors and are not able to 'let things go'. It is easy to remember, 'The last time I did this I made this mistake', or 'I hope that doesn't happen again'. Sometimes distractions are caused by future-oriented thinking. This is typically expressed by 'what if' thoughts: 'What if I get injured?' 'What if I fail?' 'What will the rest of my team think if … ?' By focusing on the negatives, concentration drops and performance follows it.

Athletes' increased awareness of their arousal level and level of attention is the foundation to psychological skills training relative to performance. This awareness informs the use of interventions such as relaxation, visualisation, goal setting and positive self-talk discussed in Chapter 16. Coaches commonly encourage athletes to 'concentrate' or 'focus'. However, many athletes do not really understand exactly what this means.

Nideffer's theory of attentional and personal style

Robert Nideffer's 'Theory of Attentional and Personal Style', developed in 1976, explains the relationship between cognitive processes, emotional arousal and performance (Howland, 2006). The theory nicely incorporates the association between physical and mental components of a performance. Physical components of performance might include the execution of motor skills, and mental components may include decision making or problem solving.

According to Howland (2006) the seven theoretical constructs of Nideffer's theory include the following.

1 Attentional focus, or focus of concentration, shifts along two dimensions: a dimension of width (broad to narrow), and a directional dimension (internal and external). See Figure 15.9.
2 Each person can develop all four attentional styles, and individuals have preferred attentional styles.
3 Different performance contexts place different demands on the four attentional styles, and require different amounts of shifting between the four styles.
4 With increasing levels of arousal, shifting between the four styles breaks down, resulting in an involuntary narrowing and more internal focus.
5 Perceived passage of time passed is associated with the amount of shifting that occurs between external and internal focus.
6 Being in 'the zone' and performance 'flow' depend on an individual's ability to move smoothly between physiological and cognitive transition points.
7 Interpersonal and intrapersonal performance characteristics predict situations an individual will find emotionally stressful. Behaviours that athletes rely on most are exhibited during emotional stress.

Choking

choking
when performance deteriorates because of pressure or importance placed on an upcoming event or action

Choking can also cause concentration to falter. Choking occurs when athletes sense a build-up of pressure, or when there is a lot riding on the outcome of the next phase of play. Increased pressure often results in focus shifting to internal and narrow, and the ability to shift attention focus decreases. Impaired timing and coordination, fatigue, muscle tension, negative self-talk, decreased selective attention, and poor judgement and decision-making usually accompany choking. (See Figure 15.8.)

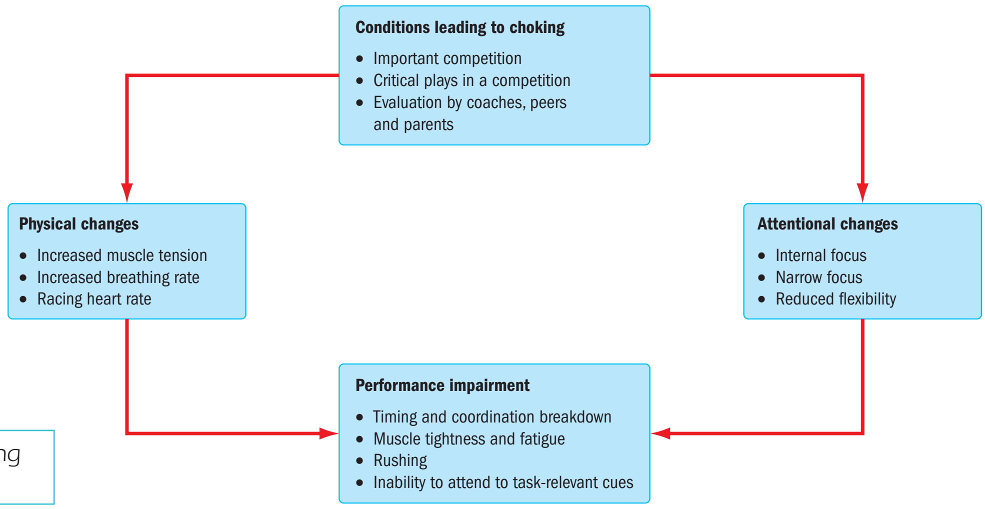

Figure 15.8 The choking process

Improving concentration

Simulation training provides an ideal way of practising in real-game scenarios. (Simulation training is described in more detail in Chapter 16.) Athletes practise shutting out irrelevant cues and sharpening their selective attention. Athletes learn to use cue words that trigger specific responses during competition. Cue words should be either instructional ('follow through', 'move your feet', 'follow the wide serve in') or motivational ('keep chasing every ball', 'don't worry: relax') and, as well as helping to maintain focus, they should ensure appropriate responses occur at key times.

Routines act as templates and facilitate automatic behaviour that is not affected by outside distractions or loss of concentration. Routines bring structure to performance processes and emotional states, while ensuring attention is focused on present, task-related cues. Related to this is the need to adhere to game plans wherever practical, and ensure that process goals are met. Golfers often go through a set routine before putting. They can be observed walking behind the lie of the ball to view the lie of the green. Sometimes golfers hold their putter up to line up the ball and complete a practice swing before they actually putt. Table 15.9 provides an example of a pre-performance routine used by tennis players.

Table 15.9 Example of a tennis pre-performance routine

Tennis forehand
Determine body positioning and footwork required
Decide which part of the court the shot will be played into
Adjust grip on racquet to enable shot to be played
Take a deep breath
See and feel the ball travelling to the point where you expect it to go
Watch the ball travel over the net after you have made contact with it

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Overlearning skills is another practice that helps maintain concentration levels at their highest. This ensures that athletes are at an autonomous stage and can free up their attention to concentrate on aspects other than the skills or movements required to bring about successful performance. This applies not only to physical or motor skills but importantly extends to psychological skills as well.

KEEP IT REAL!

In the first round of the 2009 Sydney Medibank International, Australian tennis player Samantha Stosur played the number-one seed Serena Williams. The score was one set all and Samantha Stosur was serving for the match at five games to four and was up 40–love, holding three match points. She choked, dropped her service, finishing off the game with two double faults. She lost the set and the match. Being let off the hook, Williams went on to reach the tournament semi-finals.

Checkpoints

1. Define ‘concentration’.
2. Describe the difference between the four types of attention.
3. Refer to Figure 15.7 ‘Four types of attention mode’ on page 305 and provide an example of when each type would be used. Make sure your examples are different from those already provided.
4. Give an example of when you have used an internal focus while performing a skill or participating in a specific sport.
5. Explain how the use of a routine helps an athlete improve their concentration.

Coursework

Concentration

Background

A concentration practice known as quiet-eye (QE) training has been shown to improve basketball free-throw accuracy (Marle & Vickers, 2001).

Quiet-eye training is a systematic pre-performance routine used by players to improve accuracy. Research has shown players’ accuracy improved from 54 per cent to 77 per cent after receiving QE training.

Aim

The aim of this laboratory is to examine the effect of QE training on free-throw accuracy.

Method

1. Have each member of your class complete a pre-test shoot 20 times from the free-throw line. Record each person’s score out of 20 on a board upon completion.
2. Rank players from the highest score to the lowest score, and divide the class into two groups: high scoring and low scoring.
3. Randomly assign half of the students in each group to the two conditions:
   - Control condition: free practise for 15 minutes;
   - Experimental condition: use the QE routine outlined below to practise shooting from the free-throw line for 15 minutes.
     – Take stance, focus gaze at the basketball rim, repeat ‘nothing but net’ three times while bouncing the ball.

- Maintain QE for 1.5 seconds, focusing on a specific part of the rim and say 'sight focus'.
- Shoot quickly using a fluid action; release gaze only once ball is released.

4 Students should have a five-minute break prior to the post-test trial.

Results

All students complete a post-test by having another 20 shots from the free-throw line and recording their results.

Record your pre-test and post-test results in a table similar to that shown on page below. Graph your results for each condition and group using raw scores and per cent change separately.

Skill level	Control condition group			Experimental condition group		
High-scoring names	Pre-test score (/20)	Post-test score (/20)	% change	Pre-test score (/20)	Post-test score (/20)	% change
Low-scoring names						

Figure 15.9 'Nothing but net!'

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Discussion

1 Which group showed the most improvement between the pre- and post-test: the control or the experimental condition? Discuss why you think this was the case. Also compare results for the high- and low-scoring groups relative to their condition.

2 What are the limitations of your research?

3 What conclusions can you draw from this laboratory?

Checkpoints

1 a What causes ‘choking’?
 b Provide examples you have witnessed or experienced where athletes have choked.
 c Discuss at least three psychological techniques you might suggest to deal with choking.

2 Provide at least three examples of how future-oriented thinking has caused your performance levels to drop. Discuss this with reference to your confidence levels.

3 Cue words are often used in conjunction with positive self-talk.
 a Provide at least two examples of cue words and positive self-talk.
 b Briefly outline how cue words and positive self-talk bring about improved performance levels.

4 a What is the relationship between physiological training and psychological training?
 b Briefly discuss any similarities between arousal and confidence.
 c Provide examples where an athlete might be overconfident, and discuss the effect this might have on their performance.

5 a How can game plans potentially improve concentration and confidence?
 b Provide an example of a game plan you could use while playing your favourite sport.

6 Reflect on the last time your performance deteriorated because of pressure and anxiety.
 a List the factors that caused you to feel pressured and raised your anxiety levels.
 b Discuss the way you felt while experiencing this pressure, physically and mentally.
 c Discuss several arousal-regulation techniques that you could have used, and the effects these would have had on your performance.

TEST YOUR KNOWLEDGE

1 Optimal arousal can be achieved when:
   A providing increased arousal levels to someone who is anxious
   B providing arousal reduction techniques to someone who is nervous
   C providing a performer with music that 'psychs them up'.
   D None of the above.

2 Placing Olympic athletes under psychological stress and having them build up to adapt, cope and work effectively under these conditions until they are eventually immune to it can be achieved via:
   A stress-inoculation training
   B biofeedback
   C elevated breathing routine (EBR)
   D progressive muscle relaxation.

>> short-answer questions

1

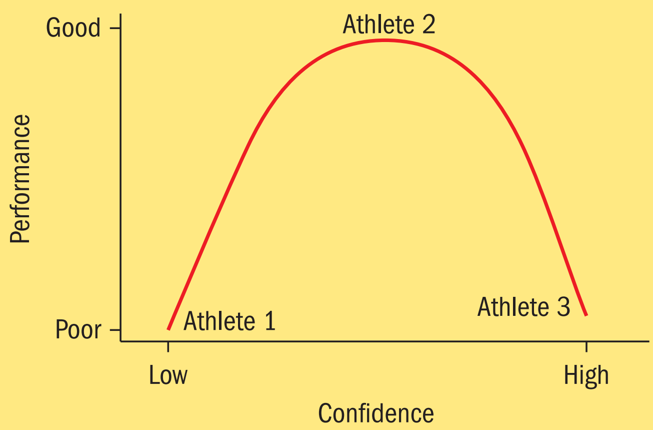

Figure 15.10 Inverted-U graph

   a From the graph, identify which of the three athletes is most likely to perform at their best.
   b Describe two strategies that would be appropriate for Athlete 1, other than mental imagery.

2 In the 2009 Australian Open women's quarterfinals, Australian tennis player Jelena Dokic was down a break of serve two games to three to the world number three player Dinara Safina. Jelena used several different types of attention.
   a While Jelena waits to receive serve, she stared into the ground. During this state, she tried to relax and stay focused.
   b As Safina began to serve, Jelena's attention focus shifted to the flight and spin of the ball.
   c During the change of end, Jelena focused on her game plan and her strategy for the third and final deciding set.

State what type of attention Dokic was using in each scene.

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>> essay questions

1 Imagine that you are the captain of the local A-grade netball team and you are about to play in the semi-finals against a team you usually beat easily by over ten goals. You are worried your team is a little flat and not pumped for a final. Explain how you are going to ensure they are mentally prepared to get off to a strong start. Address three arousal promotion techniques in your response.

2 Describe the way athletes 'look' when they are feeling negative, by commenting on the body language they display. How is this different from the body language displayed by a highly motivated and confident athlete? Also describe the most effective way reinforcements should be provided to athletes.

16 Performance issues

In this chapter, we continue examining a series of sport psychology concepts and the training of these mental skills. Psychological skills training (PST) is performed and refined continually during training, pre-competition, performance and post-competition. You need to be able to analyse mental-skills strategies used pre-, during and post-performance. This chapter will focus on strategies to develop the following mental skills.

- Stress management
- Imagery, mental rehearsal and simulation
- Goal setting
- Confidence building
- Phases of preparation

Stress management strategies

The first key component of stress management is maintaining a healthy lifestyle that includes healthy eating, regular exercise, plenty of sleep and taking time out to relax mentally and physically. Relaxation is an important part of stress management. Relaxation occurs when we experience deep muscle relaxation. This involves lowering brain and spinal cord activity following the reduction of nerve impulses running between the brain and the muscles, joints, etc.

The following section outlines several techniques that can be used to help people relax and reduce their stress levels.

Progressive muscle relaxation

Progressive muscle relaxation (PMR) is one of the most common relaxation techniques used by athletes. PMR was introduced in Chapter 15 as an example of an arousal-reduction strategy. Progressive muscle relaxation involves using your body to compare the difference between tension and relaxation. There are several steps that need to be learnt, and it requires 20 to 30 minutes daily to be practised effectively. Some people practise these skills before going to work; others practise them before going to sleep. Having a comfortable location in which to practise these skills is essential. It takes time to learn to identify which muscle groups exist and how to tense and relax them. Muscles should be tensed for four to eight seconds. Controlled deep and slow breathing should also be used during PMR. Following is a specific example of a script used during PMR (Humphrey, Yow & Bowden, 2000).

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Coursework

Use the example script below to participate in a PMR session.

Progressive muscle relaxation script

Muscles of the upper extremities

This group includes the muscles of the hands, forearms, upper arms and shoulders. A number of muscles in the body trunk can be grouped with the muscles of the upper extremities. Their function is to attach the upper limbs to the trunk and move the shoulders and arms. Following are some ways to tense these muscles.

1. Clench the fist and then open the hand, extending the fingers as far as possible.
2. Raise one arm shoulder high and parallel to the floor. Bend at the elbow and bring the hand in towards the shoulder. Try to touch your shoulders while attempting to move the shoulder away from the hand. Flex the biceps of the opposite arm in the same manner.
3. Stretch one arm out to the side of the body and try to point the fingers backwards towards the body. Repeat this procedure with the other arm.
4. Hold the arm out the same way as above, but this time have the palm facing up and point the fingers inward toward the body. Do the same with the other arm.
5. Stretch one arm out to the side, clench the fist and roll the wrist around slowly. Repeat with the other arm.

Muscles of the lower extremities

This group includes muscles of the hips, thighs, legs, feet and buttocks. Following are ways to tense some of these muscles.

1. Hold one leg at a time out straight, point your toes as far forwards as you can. Do the same with the other leg.
2. Do the same, but point your toes as far backwards as you can.
3. Turn each foot outwards as far as you can and release. Do the opposite by turning the foot inwards as far as you can.
4. Try to draw the thigh muscles up so that you can see the form of the muscles.
5. Make your buttocks tense by pushing down if you are sitting in a chair. If you are lying down, try to draw the muscles of the buttocks in close by attempting to force the cheeks together.

These suggestions include several options for tensing various muscles of the body. As you practise them, you will also discover other ways to tense muscles and then let go. In the early stages, it's possible to cramp your muscles, so proceed carefully.

Humphrey, Yow & Bowden, 2000 pp. 120–122

Reducing stress through biofeedback

Biofeedback is used far less by athletes than the other relaxation techniques mentioned. Biofeedback training is highly complex. It can only be conducted in the presence of someone trained in the use of biofeedback. Progressive muscle relaxation (PMR) and biofeedback techniques can also be used during arousal reduction. Biofeedback training involves the use of electronic technology. See page 300 in Chapter 15 for more details.

Behaviour modification and stress reduction

Some people display behaviour that can cause stress within themselves or to the people around them. Behaviour modification means trying to change undesirable behaviours via external influences such as a teacher, coach or counselor (Humphrey et al, 2000). For example, a psychologist may help an individual undertake a journey of self-exploration to identify their concerns about meeting personal goals, self-esteem, changing values, social needs, personal competence and ability. Once an individual has a better understanding of their self-concerns, they can be assisted with strategies to change their behaviours.

Steps to behaviour modification include the following.

- Identifying behaviours; for example, an athlete hangs their head after a poor shot in squash
- Counting the behaviour: how often is it occurring? Identifying the factors that occur right before this behaviour is displayed and what follows the behaviour (the consequence); for example, decline in performance and further frustration
- Changing behaviour. This requires some form of reinforcement schedule; for example, after a poor shot, the athlete uses positive self-talk such as 'head up!' to remind themselves not to hang their head. Many behavioural-modification programs include the use of rewards for desirable behaviour and punishment for undesirable behaviour
- Evaluating the intervention program and assessing whether the strategies used decreased the undesirable behaviours

Stress-inoculation training (SIT)

inoculate
by being exposed to certain situations, the body develops immunity to that situation and is able to shut it out

conceptualisation
to arrive at a concept or generalisation as a result of experiences or thoughts

As the name suggests, this practise inoculates athletes against the effects of stress by having them adapt, cope and effectively work while facing small amounts of stress and building up an immunity to it. Coping comes in the form of developing positive thoughts, mental images and self-confidence statements.

Athletes are taken through an initial conceptualisation stage where awareness of positive versus negative thoughts, self-talk and imagery are developed. The next stage sees them practise coping strategies such as positive self-talk and imagery and finally they apply these coping skills in low-stress situations. As the levels of stress are increased, the athlete learns how to cope and adapt at each level and carries this over from practise to performance.

Imagery, mental rehearsal and simulation

Some athletes attain optimum arousal and concentration levels by trying to imagine themselves performing skills before actually doing them. This is known as mental rehearsal, mental imagery or visualisation. Imagery is a form of simulation and is similar to other sensory experiences – seeing, feeling and hearing – but the experience actually occurs in the mind via thought. (Refer to Table 16.1) It allows users to create, modify or strengthen pathways important to the coordination of muscles by training powerful thought processes. Imagery should involve as many senses as possible, as well as involving imagination or visualisation.

Table 16.1 Use of the senses by a baseball player using imagery

Kinaesthetic sense	Visual sense	Auditory sense	Tactile sense
Sensory impressions arising in the muscles and joints that provide information about the movement of the body and its parts	Imagine seeing the ball leave a baseball pitcher's hand, watching the release point, watching the rotation of the seams	You hear the sound of the ball hit the bat	You notice how the bat feels in your hands when you grip the handle

ISBN 9780170227124

Imagery can be kinaesthetic, auditory and tactile, and the more senses are involved, the more powerful the experience is. Kinaesthetic senses allow us to feel our body as it moves through different actions, and sensory nerves in muscles, joints and tendons provide us with feedback. Even before you have hit a golf ball, you can sense if your body parts are moving correctly and you know whether the ball is likely to end up where you want it. Auditory senses are used to monitor the way your playing environment sounds. In tennis, you can pick the different sounds from your opponent's racquet as they apply topspin or slice to a shot and prepare accordingly. Tactile sense allows you to take in how the equipment you are using feels. For example, a softball player feels the way their bat has been prepared for an outfield drive compared to a bunt without even looking at their hand position or feeling the different firmness of grip. Effective imagery involves a lot more than simply 'seeing' how performances occur. It is beneficial to use as many senses as possible during the rehearsal stage.

kinaesthetic
sensing the motion, weight or position of the body as muscles, tendons, and joints move

Have you ever gone over a performance in your head before actually doing it? Next time you see footage of a ski jumper, look at what they do before the actual jump. They tend to close their eyes and picture the various manoeuvres they are going to perform – you might even see them turning, twisting, bending and rotating body parts. They then produce the same sequence after they have jumped.

Mental rehearsal can only work effectively if athletes are in a relaxed state. Try to create clear and life-like images. Recreate details exactly as they would appear in the performance itself, which includes yourself, the setting, spectators, and so on. Most importantly, picture yourself succeeding. Try doing this five to ten minutes at a time; remember, the more often you rehearse, the more likely it is going to lend itself to successful performance.

Before take-off, world champion aerial skier Alisa Camplin mentally rehearses a jump, including its twists, turns and landing (which are all examples of kinaesthetic imagery). Imagery improves performance by:

- improving neural pathways between the brain and muscles, and enhancing muscle activity
- providing a mental template of rehearsed sequences that can be used as is, or adapted to suit variations in performance environments
- enabling athletes to practise and prepare for events and eventualities they are *likely* to encounter during competition
- enabling athletes to practise and prepare for eventualities they are *unlikely* to train for or experience in reality
- working in conjunction with other psychological skills by preparing athletes for physical and psychological problems that don't normally occur, so when they do occur, responses are appropriate, confident and effective
- allowing athletes to pre-experience the achievement of goals. This builds confidence that goals can be achieved, thus facilitating improved performance levels that might not otherwise have been reached
- slowing down complex skills so that key components can be isolated and correct movements felt
- allowing potential technique problems to be identified.

Figure 16.1 Alisa Camplin uses kinaesthetic imagery to mentally rehearse jumps before take-off

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Coursework

Aim: To investigate the effect mental rehearsal has on performance

Procedure: Have ten free throws at the basketball ring. Record your success. Following this, move away from the area and mentally rehearse the free throw for the next five to ten minutes. Picture yourself standing at the free-throw line, bouncing the ball before you shoot, bending your elbow and releasing it from your hand, seeing the flight through the air and the ball going through the hoop. Do this over and over in your mind and go through the whole routine as if you were a spectator watching yourself. Repeat the procedure and have another ten free throws. This time, before you take each shot, use your rehearsal routine.

Discuss the following aspects of performance.

1. What was your success rate out of ten without rehearsal and with rehearsal?
2. Rehearsal also acts to decrease anxiety. How can this be beneficial to athletes?
3. If you found that rehearsal had no effect on your success, briefly comment why.
4. The basketball free throw has hundreds of movements associated with it. Write down five to ten key movements that you focused on as part of your rehearsal.
5. When can mental rehearsal lead to poorer performance results?

Simulation

simulation when real-life situations are practised or experienced

Simulation is similar to imagery. It aims to train the brain to cope with circumstances that will occur during a game or competition. However, simulation is carried out by making the physical training environment as similar as possible to the game setting. For example, training in front of spectators; adjudicating or umpiring a competition; or playing full contact games. In essence, simulation is very similar to the principle of specificity.

Simulation is thought to be superior to imagery in training, as the stimuli introduced are often more vivid because they exist in reality. However, simulation requires greater effort to set up and implement, and is less flexible in terms of the range of scenarios that can be practised for. Simulation and imagery should be used together for maximum effect.

Visuo-motor behaviour rehearsal

Visuo-motor behaviour rehearsal (VMBR) is an extension of mental imagery and is linked to simulation. It combines the psychological aspect of generating a mental image with feedback from the performance of the physical skill. VMBR involves three phases: first, an initial optimal arousal phase for entering a psychological zone conducive for mental imagery; second, visualising performance through various imagery techniques; and, finally, performing the actual skill under game or simulated conditions.

By repeating this process with the intended skill during training, it is hoped that real-time feedback will allow the athlete to mentally coordinate the visualisation and imagery component with actual performance. When this happens, minor changes in either the skill or the imagery process can occur together and performance levels improve. Before VMBR can begin, imagery techniques must be learned and understood within the context of performance; otherwise, the process can be detrimental to the activity. If the individual is concentrating too heavily on mental-imagery techniques due to unfamiliarity with procedure, less attention can be devoted to the actual activity.

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Mental practice and imagery in relaxation

Mental practise involves the rehearsal of a physical activity in the absence of an overt muscular movement (Humphrey, Yow & Bowden, 2000). An individual therefore imagines the way they will perform a specific activity. Imagery is the development of a mental image that will enhance performance of an activity. During mental practice, a swimmer may think through what they are going to do during a 100-metre freestyle race. The swimmer may 'picture' a mental image of the conditions and context of the race and how they will perform in these conditions. For example, they may imagine a swimmer is in front of them before the turn, and how they are going to perform the turn to gain ground and maximise their push off the wall for the final 50 metres.

Imagery can be used to obtain a state of relaxation. The athlete could imagine they are going to relax various muscle groups, and then do so. Imagery could also be used to promote a relaxed state by using comparative statements such as 'melt like ice into the chair' or 'float like a feather'.

Checkpoints

1 **a** It is believed that the more senses used during imagery, the better the potential performance improvements. Briefly discuss why this might be the case.

b Provide an example of mental rehearsal, using as many senses as possible, for a basketball free throw and a tennis serve.

2 Imagery allows athletes to consider situations they might never encounter while training, but might one day face while competing. Briefly discuss the advantages of doing this.

3 **a** What are the key differences between mental rehearsal and simulation or visuo-motor behaviour rehearsal (VMBR)?

b Why is it important that athletes be confident in their use of imagery before they try simulation and VMBR?

Meditation

Meditation has been used within Eastern practices for more than 2000 years for its powerful impacts on the mind, body and soul. Meditation involves the exercising of an individual's attention. Meditation gives the mind a rest while it allows a temporary shut down of cognitive processes, such as decision making. Concentration is the most important factor to ensure success while meditating. Concentration must be highly developed to control the natural flow of the brain to go from one idea to the next and lower brain activity to eliminate all random thoughts that continually appear in the mind. There are many types of meditation used by athletes.

The process of meditation involves the following principles.

- Concentration: Focus your thoughts on one specific thing, such as a beautiful, peaceful place, or the sound or shape of a bird.
- Some people like to use a word to chant (called a mantra) during their meditation session.
- Practise during a quiet time of day, not immediately after a very active state.

Goal setting

Goal setting occurs when athletes set down clear targets, priorities and expectations. Athletes are more committed when they have a goal. Goal setting has been shown to increase work output by up to 50 per cent. Goals need to be set for both training and competitions.

There are three types of sporting goals: outcome goals, performance goals and process goals.

Outcome goals

Outcome goals focus on end results, times, finishing place or medals. These goals are sometimes difficult to achieve because they are linked to the performance levels of opponents, which is something an athlete does not have direct control over. Examples include making the school netball team, running a personal-best time or being selected to play for Western Australia.

Performance goals

Performance goals focus on comparing present performance levels with those attained previously, and are independent of other competitors. As long as they are realistic, they will lead to improvements; for example, improving a fitness pre-test result from above average to excellent, or improving your golf handicap from 12 to eight. Performance goals lead to less anxiety and greater self-confidence because they depend on an athlete's own behaviour, not on their opponents'.

Process goals

set play
a series of pre-practised movement patterns that follow a set sequence

Process goals focus on actions such as physical movements and strategies that athletes must execute during their sport in order to maximise their performance; for example, a swimmer maintaining a smooth S-shaped pull under the water during a freestyle race, or a hockey player executing a set play during a short corner.

Athletes have greatest control over their performance goals, so it is best to set these first to achieve greater success. Process goals are effective at improving performance levels because they positively influence other factors such as confidence and the belief that you can influence your own behaviour. It is important that several performance and process goals accompany every outcome goal that is set: achieving these short-term goals enables the long-term goals to be realised. Long-term goals aim at a broader target and are often set at the start of a season, whereas short-term goals continually provide a more manageable focus point for an athlete and act as the stepping stones for achieving the long-term goals as shown in Figure 16.2. The National Coaching Association has set down the following 'SMARTER' way of writing down goals as listed in Table 16.2.

Goal-setting improves performance by:

- focusing attention on important elements of the skill or skills being performed
- activating and organising an athlete's efforts
- encouraging the athlete to persevere
- promoting the development of new learning strategies

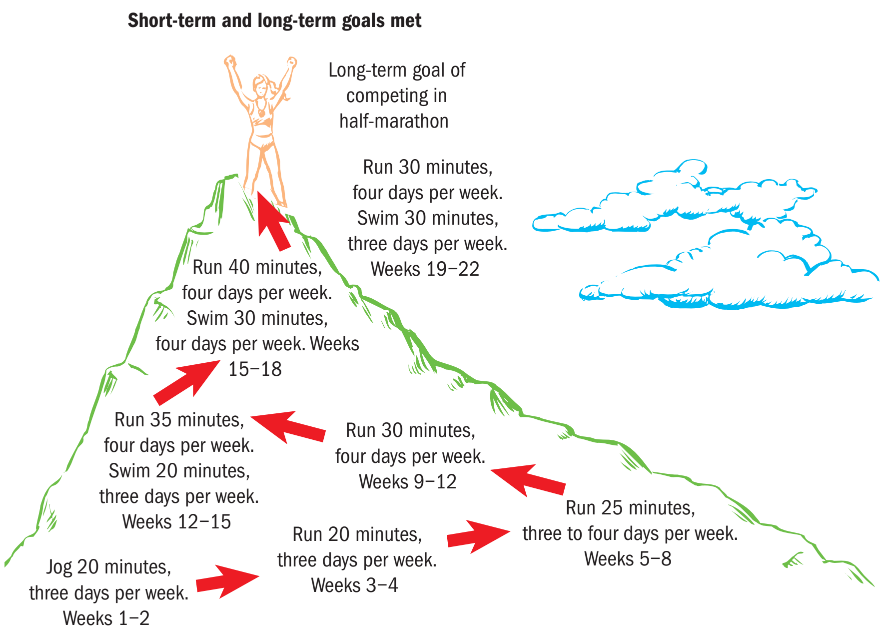

Figure 16.2 Climbing the endurance mountain: a progression of short-term performance goals contribute to the ultimate peak performance

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- refining movements and set plays
- contributing towards a positive psychological state.

Table 16.2 Guidelines for goal setting

SMARTER	Description	Example (for golf)
Specific	Goals need to be specific and as clear as possible to focus attention	To hit the ball off the tee with a 3 wood golf driver in a straight line
Measurable	Progress should be evaluated against a standard of previous performance	To land on the fairway from the tee 14 times out of 18 holes of golf
Accepted	Accepted by all parties involved in preparing the athlete, e.g. coach, family, etc.	OK, all agreed
Realistic	Goals should extend the athlete but be achievable within their ability	80% success rate
Time-phased	Include a specific date for competition	14 November
Exciting	The athlete needs to be challenged and inspired	Yes
Recorded	Goals should be written down	Recorded in training diary

Confidence-building

Self-confidence is the belief individuals possess that they will be successful. Confident sports people believe in themselves and their abilities, both physical and mental, to reach their potential. Self-confident people exhibit positive emotions. They remain calm and focused under pressure, are more likely to work to achieve their goals and remain on-task for long periods of time. Confident people are more likely to take calculated chances during their games and adopt a 'never give-up' attitude.

Confidence levels and performance attainment closely reflect the inverted-U shape demonstrated by the arousal theory, shown in Figure 16.3. It is important that athletes reach the optimum confidence zone and are not underconfident or overconfident.

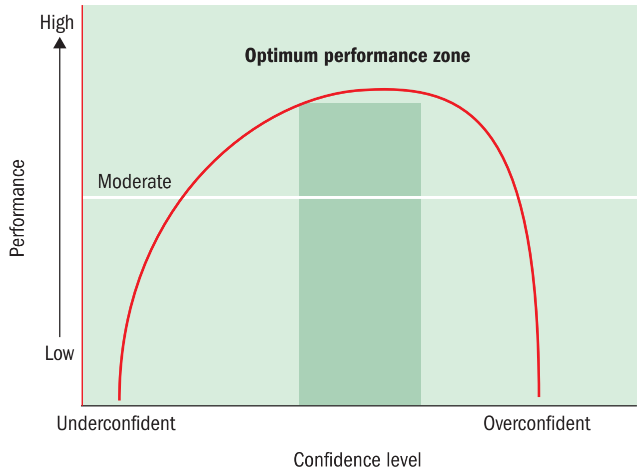

Figure 16.3 The inverted-U illustrating the confidence–performance relationship

Improving confidence

Success is critical in enhancing confidence. This starts at training, where it is important for skills to be executed with some degree of success. As skills are mastered, the attention should shift to game plays and strategies; linked to this should be the mastery of psychological skills. When all of these are practised, hopefully under game-simulated conditions, and athletes experience success, it is likely that confidence levels will rise.

Athletes need to act and think positively, even when experiencing adverse competition conditions. They should focus on the next segment of play and act as confidently as they do when things are going their way. Using positive self-talk that is instructional and motivational – and includes cue words – maintains an athlete's high confidence levels and guards against performance deterioration. Positive images are also important in maintaining high confidence levels.

Confidence levels remain high if athletes feel that they are adequately trained to succeed in the activity being undertaken. While physical in nature, specific conditioning ensures that athletes are confident about their chances of meeting the physical demands of a contest, and this impacts positively on self-confidence and other psychological measures. The ability to follow game plans or routines ensures confidence levels remain high. Knowing what to expect by having practised many physical and mental scenarios, and how to respond to them, removes uncertainty and ensures optimal performance levels.

Catchy Fact

Tennis player Serena Williams has said that she often doubts herself, but thinking positively to overcome those doubts is what is important. Serena made her comment after winning the 2009 Australian Open for the fourth time.

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Psychology research

Visit the Australian Institute of Sport website to discover more about research undertaken in the sports psychology area, and research by other AIS staff. This site provides current research findings and links to worldwide psychological research findings.

Checkpoints

1. Describe when and how relaxation occurs.
2. Outline the process of meditation.
3. Explain how biofeedback can be used to reduce stress.
4. Identify the steps involved in behaviour modification.
5. Provide an example of an outcome goal, a performance goal and a process goal.
6. Using the SMARTER guidelines for goal setting, outline a goal for a sporting activity. Make sure your example is different to the example provided in Table 16.2.

trait
an identifying characteristic or habit

trait sport confidence
an individual's typical style of behaving, and their confidence level during those behaviours

state sport confidence
the effect of a situation on behaviour and confidence within that specific time and circumstance

Measuring confidence

Psychologists consider situations and psychological traits in order to understand and predict behaviour. Below are instruments designed to measure trait sport confidence and state sport confidence. Trait sport confidence refers to an individual's typical style of behaving, and their confidence level during those behaviours; for example, an athlete may feel nervous and fidgety pre-game but be fine once the game starts. State sport confidence is the effect of a situation on behaviour and confidence within that specific time and circumstance. For example, a basketballer may tense up and restrict their movement when trying to shoot from the free-throw line because there are only ten seconds of play left and they must make the shot to tie the game.

Table 16.3 Measuring sport confidence

Trait sport confidence inventory				
Think about how self-confident you are when you compete in sport. Answer the following three questions based on how confident you *generally* feel when you compete in your sport. Compare your self-confidence with that of the most self-confident athlete you know. Please answer as you really feel, not how you would like to feel (circle number).				
1	Compare your confidence in your ability to execute the skills necessary to be successful to that of the most confident athlete you know.	Low 1 2 3	Medium 4 5 6	High 7 8 9
2	Compare your confidence in your ability to perform under pressure with that of the most confident athlete you know.	Low 1 2 3	Medium 4 5 6	High 7 8 9
3	Compare your confidence in your ability to concentrate well enough to be successful with that of the most confident athlete you know	Low 1 2 3	Medium 4 5 6	High 7 8 9
State sport confidence inventory				
1	Compare the confidence you feel right now in your ability to execute the skills necessary to be successful with that of the most confident athlete you know.	Low 1 2 3	Medium 4 5 6	High 7 8 9

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Table 16.3 Measuring sport confidence (continued)

2	Compare the confidence you feel right now in your ability to perform under pressure with that of the most confident athlete you know.	Low 1 2 3	Medium 4 5 6	High 7 8 9
3	Compare the confidence you feel right now in your ability to concentrate well enough to be successful with that of the most confident athlete you know.	Low 1 2 3	Medium 4 5 6	High 7 8 9

Weinberg & Gould, 2007 p. 34

Coursework

Measuring confidence

1. Complete both surveys in Table 16.3.
2. Research what is meant by the terms 'trait sport confidence' and 'state sport confidence'.
3. Explain the difference between the two terms.
4. Describe your results on each survey.
5. How did your score compare to the person next to you?
6. Describe two strategies for building an athlete's state sport confidence.

KEEP IT REAL!

At the 2009 World Canoe Championships in Spain, Australian canoeist Leanne Guinea used imagery to prepare herself for the women's open age C1 event. About 40 minutes prior to her first run on the fast-flowing water, she quietly walked towards each gate and observed how competitors' canoes were reacting to the course. She watched with focus, then imagined herself going through each gate, imagining the angles she had to put her body into to manoeuvre through the gate.

As she did this, Guinea slowly moved her body, with her arms pretending to hold a paddle, and visualised the power of the water against the boat. She imagined the type of strokes she was going to use, the angle and placement of her paddle and the angle she would position her canoe to get through each downstream and upstream gate. Guinea always uses imagery exercises; on this occasion it led to outstanding performances in both of her runs, allowing her take home the gold medal and be crowned the 2009 Women's World C1 Champion.

Figure 16.4 Leanne Guinea, 2009 World C1 champion

Figure 16.5 The Australian Women's Ice Hockey team

KEEP IT REAL!

This is an interview with Kelly Stock, assistant captain of the 2008 Australian Women's Ice Hockey team. Kelly was also a member of the team that won gold at the 2007 World Championships in Division 3. In 2007, Australia topped the Division 3 table undefeated, against opponents from Belgium, Great Britain and Hungary.

What do you do when one of your team-mates is really flat during a game?
We generally have three lines of players, so we get approximately one minute on the ice and two minutes off, resting on the bench. Generally, I encourage my line mates to not hang their heads and get them to focus on the next minute on the ice, and stay really positive myself.

Do you use self-talk? Do you say this out loud or internally?
Yes, generally three to four hours prior to a game. I tell myself to relax, it's going to be fine, to remember why we are here, to have fun. I don't say this out loud but to myself, silently.

Do you use goal setting?
Yes, the national coach is very big on goal setting. He encourages us to have personal goals and team goals. Interestingly the team goal is to play as a team on and off the ice; as an assistant captain, one of my goals is to bring the team together on and off the ice and play like a team. Another team goal for the 2008 World Championships was to win enough games to stay in Division 2. Prior to each game, each player had to share with the team one specific goal they wanted to focus on in their game.

What does a typical pre-game routine consist of?
Off-ice warm up for 30 minutes, including dynamic stretching, fast-feet activities, warm-up team-building activity or communication activity. The activities are designed to ensure the team's level of alertness is increased, and that they are relaxed. We then have a warm-up on ice, we do some sprints and goal shooting. Five minutes before the game, the coach gives us a quick pep talk and someone has a little joke or gimmick to share to make the team laugh and stay relaxed.

Do you use imagery to enhance performance?
Yes, definitely. We use it during training, between games and during competition. For example, I play in offence, so I often imagine what kind of shot I will use during a penalty shoot out: will I use a background shot, a wrist shot or fake the goalie out. I imagine this regularly during the week between games, and also right before I take the shot. I imagine which shot I am going to use and where the puck and goalie go, and I imagine a successful shot going into the back of the net. Right before a game, I imagine the one thing I am going to focus on and see myself performing this successfully.

Phases of preparation

After reading Chapter 15 and this chapter, it should have become clear to you that mental skills training is not just something done in training or competition. Practising, refining and using psychological skills is a constant part of preparation and performance, prior to competition in training, pre-game, during competition and during recovery. Terry Orlick (2008) has identified four distinct yet interrelated phases of preparation. All four phases are important and each phase needs to be part of the athlete's preparation to maximise their performance. Table 16.4 outlines each of these phases.

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Table 16.4 Phases of preparation

Order	Phase	Description
1	Preparation stage leading up to the event	• During this phase the athlete does everything they can to be as physically, mentally and emotionally fit as possible. In terms of technical preparation, only fine tuning should be considered rather than large scale changes. • Keep doing what works and fine-tune anything that can refine your skills further. It is essential in this phase to ensure you have quality training and quality rest. Going into a competition tired is a recipe for poor performance.
2	On-site familiarisation phase	• The more familiar you are with the playing environment, the more confident you will be. An equestrian rider always walks the jumping or cross-country course prior to competition. A golfer walks or drives the buggy around the course prior to competition. A softball third base player inspects the surface around the base; a cricketer inspects the wicket prior to the match whether they are a bowler or a batter. • If players have been to that venue before they can use this information when using imagery about the upcoming game or performance. If they have not, they may get information from team-mates, coaches or websites to familiarise themselves for challenges such as long fence lines, hilly terrain, fast greens, etc. • Wherever possible, train at the location prior to the event, or warm up on the playing area.
3	On-site performance phase	• This involves completing the pre-game routine and warm up that you do prior to every competition. The routine should be kept as close to what you usually do as environmental conditions will permit. • Stay focused during this phase, stick to your plan. Do not get distracted by opponents' preparations nearby. During this phase, remind yourself of your game plan and specific goals and how you are going to achieve them.
4	Post-performance phase	• If you have prepared effectively during the first three phases, after the competition, regardless of the outcome, you should not have any regrets relating to not feeling adequately prepared. Not feeling prepared is a significant contributor to athletes' levels of stress. If you have prepared well for this performance you should feel proud that you have done your best.

Adapted from Orlick, 2008 pp. 206–210

Figure 16.6 The on-site familiarisation phase usually involves inspection of the playing surface

Hopefully you now have a much better understanding of the fundamental psychological skills that are required for successful performance. These skills need to be developed, practised and refined regularly in training, pre-competition, during competition and post-competition.

TEST YOUR KNOWLEDGE

>> multiple-choice questions

1 Imagery is thought to bring about improved performance by:

A providing a mental template of rehearsed actions that can be effected quickly
B improving the neural pathways between the brain and muscles and speeding up reactions
C enabling performers to prepare for eventualities they are likely to encounter in competition.
D All of the above.

2 Goal setting has been shown to increase athlete's work output by:

A 10–20%
B 30–40%
C 40–50%
D 60–75%.

>> short-answer questions

1 **a** Outline appropriate short-term goals for a player in this program, keeping the focus on improving their shooting. Ensure you apply the SMARTER principles while filling in the blank cells.

SMARTER	Description	Example (Basketball shooting)
Specific	Goals need to be specific and as clear as possible to focus attention	
Measurable	Progress should be evaluated against a standard of previous performance	
Accepted	By all parties involved in preparing the athlete (coach, family, etc)	OK, all agreed
Realistic		80% success rate
Time-phased		14 November
Exciting	The athlete needs to be challenged and inspired	Yes
Recorded	Goals should be written down	Recorded in training diary

b Before each game, your basketball team works through a set pre-game routine to warm up on the court. Describe how this may psychologically prepare the players for the game.

2 During a Western Australian women's baseball Division 1 semi-final, the scores are tied eight runs all going into the final inning. There is one batter out and a runner at first-base. To send the game into extra innings the defensive team (which is the away team) has to make two more outs before the home team get another run to cross the plate. However, the pitcher (who is a state-level pitcher) struggles to throw a strike under the pressure and walks the next three hitters, including the winning run across the plate.

a What has happened to the pitcher under the pressure of the game situation?

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b Describe two psychological skills that the coach could have this player work on to avoid this happening during a pressure situation in the future.
c Explain why it would be important to practise these skills in a training session to simulate the same circumstances.

>> essay questions

1 Explain how a gymnast could use imagery to prepare for a routine on the uneven bars. Ensure you refer to the use of her senses.

2 Write a long-term and a short-term goal for yourself for an activity of your choice. Explain each component based on the SMARTER principle.

ISBN 9780170227124

17 Group cohesion and participation in activity

It is often said that a great team is not simply made up of great individual players – it is much more. The chemistry of a winning team is based on the way they gel and work together to achieve a common goal. Dealing with group dynamics is often the most complex aspect of coaching: if a team doesn't work together it doesn't matter how skilled or fit they are, they will never perform at their best. This chapter focuses on group cohesion and its association with participation in physical activity.

Figure 17.1 Group dynamics are complex

A group is not simply several people located in the same place, time and context; a group must share a common purpose and need to interact to achieve their shared goal. According to Le Unes (2008) who cites Shaw (1976 p. 11), a group is defined as 'two or more persons who are interacting with one another in such a manner that each person influences and is influenced by each other person'.

The term 'cohesion' was defined by Carron (1984) as 'adhering or sticking together' and cohesion in sport as a 'dynamic process that is reflected in the group's tendency to stick together while pursuing its goals and objectives'.

A group is not necessarily a team; for example, a group may meet weekly to review a book as a book club. Cohesion is dependent on a combination of task and social cohesion. Task cohesion is displayed by the effectiveness of the group members to work together to achieve a common goal; for example, to win a grand final. Social cohesion reflects how well team members get along with each other and enjoy each other's company.

Weinberg and Gould (2007) identify several key characteristics of a team:

- Mutual interaction
- Task interdependence
- Collective sense of identity: 'we' rather than 'I'
- Distinctive roles; for example, positions, captain, defender, etc.
- Structured models of communication; for example, an American football quarterback calls a series of numbers so the offence know which play is to be used.
- Norms, or socially agreed rules, that guide team behaviour

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Figure 17.2 Baseball coaches use verbal and non-verbal communication

Carron's Model of Group Cohesion

Albert Carron was a pioneer in the area of sport cohesion theory. He developed a systematic framework for understanding cohesion in sport or exercise, as shown in Figure 17.3. Carron's model comprises four major factors that affect the development of cohesion in sport:

- Environmental factors
- Personal factors
- Leadership factors
- Team factors

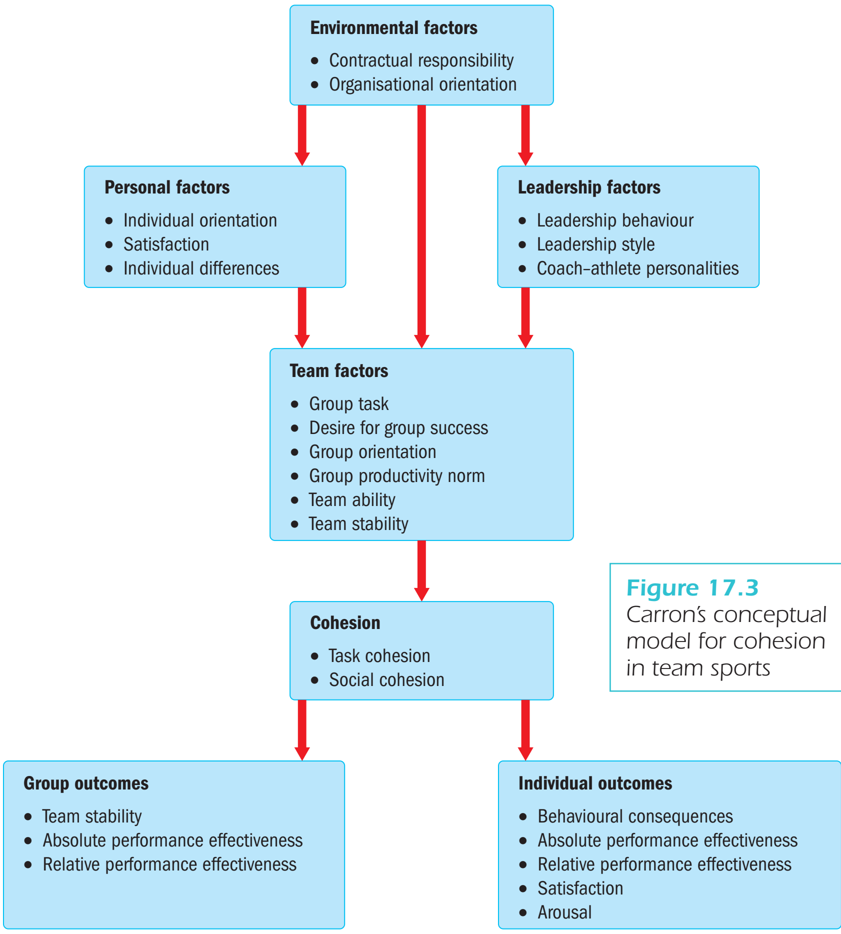

Figure 17.3 Carron's conceptual model for cohesion in team sports

Environmental factors

Environmental factors relate to the physical and social environment within which the team or group is nested. Geographic region and age group may determine which team a person must play within. Smaller groups tend to be more cohesive than larger groups, and level of competition also plays a role. For example, community-level sporting teams are generally more cohesive than state teams. Community-level teams in local competitions can spend around nine months of the year together if we take into consideration pre-season, in-season and post-season celebrations and trips, whereas state teams may spend a few months of the year in training and then a week or two at the national championships. Teams with unique and matching uniforms (see Figure 17.4), chants and clubhouses also share higher levels of cohesion than teams without these environmental factors.

Figure 17.4 Unique matching uniforms enhance team cohesion

Personal factors

Personal factors are the characteristics of each individual group member. Carron's model classifies personal factors into three categories:

1. Demographic attributes, such as age and gender.
2. Cognitions and motives, such as responsibility and anxiety.
3. Behaviour, such as adherence or social loafing

Research has identified two factors as key predictors of team cohesion:

- Similarity in expectations
- Individual satisfaction (Weinberg & Gould, 2007)

Leadership factors

Leadership factors consist of the leadership style and behaviours the players and coaches exhibit, and how they interact with group members to lead a team to work together. Effective leaders communicate expectations for the team clearly, consistently and positively. Leaders such as team captains and coaches need to be a good fit with the team's expectations.

Team factors

Team factors refer to the characteristics of the group. A group's shared desire for success is very important for team cohesion. A team is unified by its shared history, experiencing triumphs and loss together.

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KEEP IT REAL!

The Port Melbourne Baseball Club in Victoria won five women's Division 1 state league Grand Finals in less than ten years, since the beginning of women's baseball in 1993. What made these winning teams unique in the competition was their exceptional team cohesion. Not only did these girls share the common goal of winning a Division 1 state league premiership, they also enjoyed each other's company. They had a great time together on and off the field and supported each through slumps in performance. The girls' unique motto was announced aloud collectively before all big games: 'We can, we will, watch us!' They went on to to win five state league finals, a record yet to be surpassed by any other team in women's baseball. Although many of these players also played for Victorian and Australian teams, the team cohesion was greatest at club level.

Social loafing and its effect on group cohesion and group performance

In 1927, Max Ringleman discovered that collective group performance, while increasing group size, resulted in significantly less effort than the sum of individual efforts. Ringleman found when three people performed a rope-pulling task, they did not exert three times as much force as one individual. The notion that average individual effort declines with increases in group size became known as the Ringleman Effect; today, this phenomenon is known as 'social loafing'. Researchers believe social loafing may be due to an individual's desires to economise their effort when performing in a group context because they can hide in a crowd or escape recognition of blame because their efforts are not identifiable (Anshel, 1995).

Group cohesion is a dynamic process, and social loafing is a major factor that can affect team cohesion. Social loafing is defined as a decrease in individual effort resulting from the presence of co-workers (Lantane, Williams & Harkins, 1979). A decrease in group motivation produces social loafing as group size increases. The social-loafing phenomenon has been examined across a range of contexts including sporting contexts, cognitive challenges such as brainstorming or maze solving, song writing, etc. Social loafing threatens the productivity of a group and can result in resentment, a further decrease in motivation and ill-feeling that reduces cohesion, as shown in Figure 17.5. Table 17.1 outlines the conditions in which social loafing is most likely to occur.

Table 17.1 Social loafing

Social loafing is increased under the following conditions:	
1	The individual's output cannot be independently evaluated
2	The task is perceived to be low on meaningfulness
3	The individual's personal involvement in the task is low
4	When a comparison against group standards is not possible
5	The individuals contributing to the collective effort are strangers
6	The individual's team-mates or co-workers are seen as high in ability
7	The individual perceives that their contribution to the outcome is redundant
8	The individual is competing against what they believe to be a weaker opponent

Adapted from Weinberg & Gould (2007) p. 175

Coursework

Participate in a problem-solving activity that requires the group to lift group members over or through an obstacle; for example, the 'Electric Fence' activity. In the Electric Fence activity, the whole class or group must get across an imaginary electric fence safely without touching the rope or string tied between two trees or poles. Ensure all group members are aware of safe lifting technique and safety mats are placed under the rope. No-one is allowed to high jump over the rope. Start with one person on the other side of the rope to the rest of the group. Ensure the rope is set at waist height of the tallest person in the class. Repeat the activity to ensure that all class members return to their original side of the rope.

Questions

1. Discuss whether all group members contributed equally to the group task. Did some people hang back?
2. When you repeated the task as a group, was it the same group members assisting people to get over the electric fence while the same people hung back? Or did everyone contribute equally and take turns lifting people? Describe what happened.
3. Explain how you could modify this activity to ensure social loafing does not occur.
4. Describe three activities where you have either experienced social loafing or been a part of a group where other group members didn't try their hardest.

Catchy fact

A US study reported that social loafing was less likely to occur among swimmers during relay events. Swimmers generally perform better when swimming in relays when identifiability was high than when swimming in individual events (Williams, Nida, Baca & Lantane, 1989).

Figure 17.5 Social loafing can occur in team sports such as rowing

Strategies to reduce social loafing

The following strategies should be employed by coaches and sports psychologists to reduce social loafing.

- Ensure the performance and effort of individuals can be evaluated separately.
- Increase the group's opportunity to interact, and encourage communication.
- Modify tasks to maximise involvement of individuals; however, focus on the team result.
- Set goals at the team and individual levels.

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- Cater for unique and creative contributions by individuals to the overall team performance.
- Rotate responsibility and position whenever possible.
- Provide break periods to ensure players can recover between high-intensity efforts in training or competition.
- Meet with players regularly to discuss loafing.
- Use smaller groupings where possible to increase individuals' opportunities to contribute.

Checkpoints

1. Think about a team you have played with or a group you have been a part of that got on really well together. Describe what effect the group dynamics had on the team's performance and how you felt being a part of the group.
2. Read through the characteristics of a team identified by Weinburg and Gould (2007) on page 326 and apply them to a sporting context you have experienced.
3. Describe in your own words Carron's model of group cohesion. Explain how leadership factors can affect a team's cohesion.
4. What is meant by the notion of social loafing? Describe an example when you have experienced or witnessed social loafing.
5. Outline five strategies a coach could employ to reduce social loafing.

Measuring cohesion

To assess the association between group cohesion and performance, we must be able to measure cohesion (Weinberg & Gould, 2007). There are many instruments available to measure team cohesion; one approach is the Group Environment Questionnaire (GEQ) depicted in Table 17.2.

Table 17.2 Measuring cohesion

Group Environment Questionnaire (GEQ): Sample Items									
	Strongly disagree								Strongly agree
Attraction to group: task subscale I like this team's style of play.	1	2	3	4	5	6	7	8	9
Attraction to group: social subscale Some of my best friends are on this team.	1	2	3	4	5	6	7	8	9
Group integration: task subscale We all take responsibility for any loss or poor performance by our team.	1	2	3	4	5	6	7	8	9
Group integration: task subscale Our team would like to spend time together in the off-season.	1	2	3	4	5	6	7	8	9
Note: To score the GEQ, add up all answers for each subscale. The higher the score, the more strongly the individual feels about that particular aspect of group cohesion (scoring reverses for negatively worded items). For example, scores for 'Attraction to group task' can range from 4 to 36. Comparisons can be made among individuals or among groups.									

Adapted with permission from Carron, Widmeyer & Brawley, 1995

Coursework

Aim

To examine the influence of team-building activities on group cohesion

Procedure

- Students divide into two groups mixed up with people they would not normally work with and participate in an introductory activity such as a game of keepings off or netball.
- Students should complete the GEQ about their team.
- They then participate in a 25-minute session of team-building activities in their newly formed groups.
- Replay a five-minute game of keepings off or netball in the same teams.
- Immediately following this session, all students complete the GEQ again.

Results

- Plot GEQ scores pre- and post-team-building session on a clearly labelled graph.

Questions

1. Did participation in the team-building activities make any difference to group cohesion of your team? Refer to your data in your explanation.
2. If team cohesion is low, describe five strategies a coach could employ to increase group cohesion.
3. Describe two strategies a team captain could employ to increase team cohesion.
4. Thinking about a team or group you have played with, describe two strategies you have personally used to increase team cohesion.

Figure 17.6 Social loafing is less likely when an individual's performance can be identified

Research conducted in NSW (Anshel, 1995) examined social loafing among elite female rowers under individual and group conditions. Distance covered during a simulated rowing task was measured over 1.5 minutes and 10 minutes. Participants for the study consisted of a NSW state team of six females aged 20–24 years. The sample was kept small to control for skill level.

Previous research has shown that less proficient team members can be more susceptible to social loafing than higher skilled athletes. Each participant was told by the team coach to perform at a maximal effort, and that their score would be recorded and reviewed by the coach. Social loafing was only evident during the 10-minute task. Results indicate that performance was significantly lower in the group condition when compared to the alone condition. The researchers suggest that the rowers' performance effort was enhanced when their work outcome was identifiable during the alone condition.

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Strategies for enhancing cohesion

Although a high level of group cohesion does not guarantee enhanced group performance, it does create a warm and supportive environment that facilitates positive interactions between group members. The goal of building team cohesion is to develop strategies that will enhance player satisfaction, a sense of team spirit and sense of responsibility in contributing to the success and cohesiveness of the team. Strategies used to enhance group cohesion will depend on the type of group. Table 17.3 outlines strategies suggested by fitness class instructors to enhance group cohesiveness. Table 17.4 overviews principles underlying team building programs within sport settings (Weinberg & Gould, 2007).

Table 17.3 Specific strategies suggested by fitness class instructors to enhance group cohesiveness

Factor	Examples of intervention strategies
Distinctiveness	Have a group name. Make up a group T-shirt. Hand out neon headbands or shoelaces. Make up posters and slogans for the class.
Individual positions	Divide the swimming pool into areas by fitness level. Have signs to label parts of the group. Use specific positions for low-, medium- and high-impact exercisers. Let participants pick their own spot and encourage them to keep it throughout the year.
Group norms	Have members introduce each other. Encourage members to become fitness friends. Establish a goal to lose weight together. Promote a smart work ethic as a group characteristic.
Individual sacrifices	Ask two or three people for a goal for the day. Ask regulars to help new people. Ask people who are not concerned with weight loss to make a sacrifice for the group on some days (more aerobics) and people who are concerned to make a sacrifice on other days (more mat work).
Interaction and communication	Use partner work and have partners introduce themselves. Introduce the person on your right and left. Work in groups of five and take turns showing a move.

Carron and Spink (1993)

Table 17.4 Principles underlying the team-building program in a sport setting

Categories	Principle
Team structure	
Role clarity and acceptance	When group members clearly understand their roles in the group, cohesion is enhanced. When group members are satisfied and accept their roles in the group, cohesion is enhanced.
Leadership	Task and social cohesion in the group is influenced by the behaviour of the team leaders. A participatory style of coaching leadership contributes to enhanced cohesion.

Table 17.4 Principles underlying the team-building program in a sport setting (continued)

Conformity to standards	Conformity to group social and task norms contributes to enhanced cohesion. Group norms are highly resistant to change.
Team environment	
Togetherness	When group members are repetitively put in close physical proximity, feelings of cohesion increase.
Distinctiveness	The presence of group distinctiveness contributes to group cohesion.
Team processes	
Sacrifices	When high-status members make sacrifices for the group, cohesion is enhanced.
Goals and objectives	Group goals are more strongly associated with team success than are individual goals. Member participation in goal setting contributes to enhanced cohesion.
Cooperation	Cooperative behaviour is superior to individualistic behaviour for individual and group performance. Cooperative behaviour is superior to competitive behaviour for individuals and group performance. Cooperative behaviour contributes to enhanced cohesion.

Adapted from Prapavessis, Carron & Spink, 1997

Strategies for coaches and leaders to improve group cohesion

1 Effective communication

Create an environment that fosters open and honest communication to avoid the build-up of unnecessary tension or confusion. Encourage players or group members to express their concerns and how they feel about a situation, along with suggestions for alternatives or solutions. This saying by Abraham Lincoln is useful for coaches to foster among their line ups: 'He has the right to criticise who has heart to help'.

2 Clearly define roles

Coaches should clearly outline the role of each individual player to that player and also to the wider team or group. All group members need to feel as though their role is important, to ensure they remain motivated. Sometimes coaches need to develop empathy among players. For example, if a softball left fielder is frustrated with the performance of the pitcher, the coach may ask the left fielder to have a go at pitching during a training session so they realise how difficult it is to pitch to skilled hitters.

3 Develop pride within subgroups

In all sport subgroups, develop a special bond between team-mates playing in the same positions. A soccer coach should encourage the development of pride and camaraderie amongst the defenders.

4 Develop challenging team goals

Coaches need to set specific, measurable, realistic and challenging goals in conjunction with players. If goals are not attainable or too easily achieved, frustration or boredom can decrease motivation. Goal-setting principles are covered in more detail in Chapter 16.

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5 Encourage group identity

Teams need to feel special and important. The introduction of special team uniform items, such as matching walkout or warm-up uniforms. can enhance a team's sense of identity and unity. Inclusive social functions that complement the training and competition schedule also increase team cohesion.

6 Discourage destructive cliques

Coaches need to act quickly to minimise the opportunities for negative players to work together. For example, have these sorts of players train with different players or change room-mate assignments if the team is staying together for an away game. Negative players' energy can spread amongst team-mates and bring down self-esteem and team morale.

7 Minimise excessive turnover

Excessive turnover in playing line-up or coaching staff can reduce team morale. Coaches need to make newcomers feel welcome and help them to settle in so that they feel a part of the team or group. Successful coaches rely on experienced players to help new players settle into the group.

8 Schedule regular meetings

Meet regularly pre-, during and post-season as a team. Encourage open and constructive discussion among players and coaches. Coaches should encourage players to share what they admire in their team-mates' performances or contribution to the team's success. For example, some coaches use an exercise called 'Warm Fuzzies', which involves having players anonymously write down what they respect or admire about their team-mates; however, coaches should check that these responses are appropriate before redistributing them to the players. The same exercise can be conducted by having players write comments on their team-mates' photos on the clubroom or changeroom walls. Success does not necessarily have to be defined by winning. For example, during AFL pre-season games, many coaches are not interested in obtaining the win, instead using the opportunity to experiment and give inexperienced players an opportunity to try different positions.

Figure 17.7 Communication between team leaders is essential for success

9 Monitor the team climate

A team leader or coach needs to 'keep a finger on the pulse' so they are in touch with how the team is feeling about the decisions being made. Coaches can enlist a team captain or trusted player (Figure 17.7) to gauge the vibe of the group about a particular issue and provide the coach with valuable informal feedback.

Encourage players to articulate their motives

Another powerful exercise that can be used by coaches or group leaders to enhance team cohesion is to ask players to disclose something personal about themselves that influences their desire to play. The information may reveal something about their character, values and desires. Have players explain to the team their motives for playing, and what they hope to achieve or gain from participation during that particular season.

In addition to the strategies mentioned for coaches, there are several strategies that players or group members can use to enhance group cohesion, as shown in Table 17.5.

slump
an extended period of poor performance, especially in sport

Table 17.5 Building team cohesion

Strategies for players or group members to use to enhance team cohesion
Make an effort to get to know team-mates.
Provide assistance to team-mates, particularly if they are struggling with some aspect of their performance or when they are going through a slump.
Communicate openly and honestly with coaches, captain or leaders.
Resolve conflicts immediately, rather than complain behind the back of the coach or another player; players should communicate their concerns regularly.
Put 100 per cent effort into training and competition 100 per cent of the time. Even in training, it is important to be enthusiastic. Enthusiasm is contagious: be a carrier.
Provide team-mates with positive reinforcement; comments should be supportive and constructive.

Figure 17.8 Team-mates supporting each other

interpersonal communication
an exchange between two or more individuals

non-verbal communication
the use of signals, gestures and facial expressions to convey a message to another person

intrapersonal communication
self-talk; could be internal dialogue or words spoken aloud

Communication

For a team to be successful, effective communication is the key. This is no secret, but many teams struggle to communicate well. Either communication is not clear between players, between coaches, or between players and coaches. Communication needs to be clear, consistent and understood by both parties. Figure 17.9 outlines the basic process of communication. There are several types of communication used in sporting contexts, including interpersonal communication, non-verbal communication and intrapersonal communication.

Verbal messages must be clear, accurate and well-timed. A poorly timed piece of feedback (for example, just after losing a match) won't necessarily be appreciated by the performer or be constructive because it may not be taken in. Coaches need to use the limited

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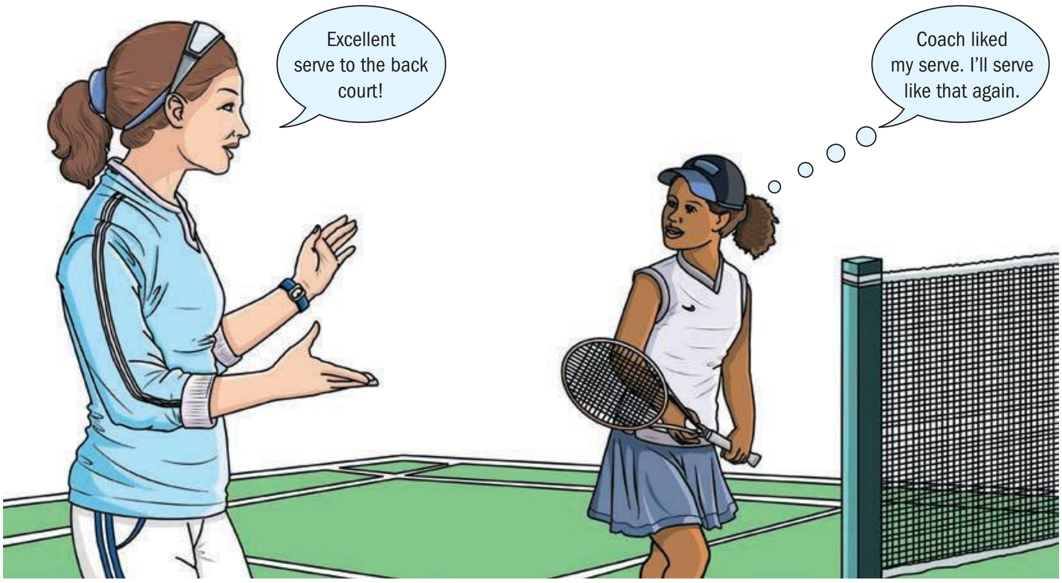

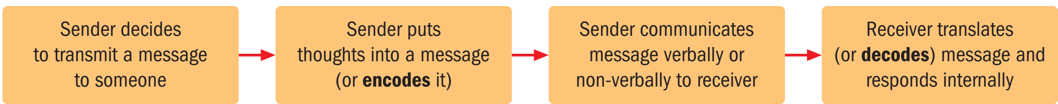

Figure 17.9 The communication process

time available in training to convey key messages in a succinct manner. If coaches waffle on, players switch off and valuable training time is lost that could be used to practise a set play or particular skill.

Table 17.6 Non-verbal communication exercise

Activity or sport context	Description of non-verbal communication	Meaning of message being sent to receiver or receivers
Lawn bowls skipper (captain)	Holds two fingers downwards towards the ground so team-mates 20 metres down the green can see.	This gesture is signalling to his team the opposition team has two bowls closer to the jack than they do.
Softball coach standing at third base in the coaching box		
Tennis linesman		
Badminton player during a doubles match		
Volleyball umpire		
A coach of a little league soccer team		
A surf lifesaver		
A cricketer in the field		
An AFL player running into space		
A netballer playing in offence		
A basketball referee		
A cricketer while batting		
A tennis player		
A crowd after a slam dunk is scored in basketball		

Non-verbal communication is very important in a team environment. Research has shown that up to 70 per cent of communication is non-verbal. Sometimes we convey non-verbal messages to our opponents subconsciously when we do not want to. For example, a batter in cricket may come to the crease displaying timid body language with hunched shoulders, a scared look on their face, and their head down. The batter's posture and physical appearance may send the message *I am not confident* to the bowler and opposition, who could use this information to further intimidate the player. The same timid-looking batter may be given out on a leg before wicket (LBW) decision, whereas the same ball bowled to a confident batter would not be given out by an umpire.

Coursework activity

Non-verbal communication exercise

Copy and complete Table 17.6 in your workbook. Think about the activities or sports listed, describe an example where athletes could use an example of non-verbal communication, then explain what it means.

Tips for effective communication

Coaches and athletes can employ the following tips for effective communication.

- Make your expectations clear to the players (if you are a coach) or to the coach or other team-mates (if you are an athlete). People very often achieve what you expect if you set high benchmarks and clear expectations.
- Use a communication style that comes naturally to you rather than trying to be someone you are not; people will see straight through this approach. People will only respond if they think you are genuine.
- Express empathy rather than sympathy. Communicate that you understand what the issue is, rather than feel sorry for players.
- Make eye contact with people when addressing them.
- Be consistent when giving out praise, reinforcement and punishments. Be the three Fs: Fair, Firm but Fun.
- Players can pick up non-verbal signals from a long distance away. After making an error, they often look to the coach for encouragement, but unfortunately are often met with an annoyed look or gesture from the coach or bench.
- To convey your message: be direct, clear and specific.
- Own your message; use 'I believe you need to …' rather than 'The team thinks you need to …'.
- Be objective; state facts rather than your opinions.
- State your requirements and your feelings clearly.
- Do not overload athletes with too much information at once; focus on one thing at a time.
- Be positive and supportive; people will not respond well to sarcasm, negativity or judgmental comments.
- Reinforce key messages and expectations with repetition (Weinberg & Gould, 2007).

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TEST YOUR KNOWLEDGE

>> multiple-choice questions

1 The term 'cohesion' was defined by Carron (1984) as:

A task interdependence
B adhering or sticking together
C dynamic pairing
D a cognitive process

2 From the following scenarios, when is social loafing **most likely** to occur?

A When an individual's performance can be identified.
B When the athlete is performing in a small group of three people.
C When the athlete is part of a large team of eight people.
D When the coach is observing the performance closely.

>> short-answer questions

1 Describe what is meant by these terms.

a Group cohesion
b Social loafing

2 **a** Outline five conditions that **increase** the likelihood of social loafing occurring.

b State three types of communication.
c Referring to one particular sport, describe two examples of non-verbal communication and the meaning of the messages.
d Discuss three guidelines for effective communication between coach and athletes.

>> essay questions

1 Explain the effect social loafing can have on group cohesion and group performance. Provide specific sporting examples in your explanation.

2 Explain six strategies to reduce social loafing. Apply these strategies to a specific sporting context.

References and further reading

Abernethy, B 2001 'Attention', in R Singer, H Hausenblas, & C Janelle (eds) *Handbook of Sport Psychology*, 2nd edn, Wiley, New York

Abernethy, B, Baker, J & Côté, J 2005 'Transfer of Pattern Recall Skills May Contribute to the Development of Sport Expertise', *Applied Cognitive Psychology*, vol. 19, no. 4, pp. 705–718

Abernethy, B & Russell, G 1987 'The relationship between expertise and visual search in a racquet sport', *Human Movement Science*, vol. 6, no. 4, pp. 283–319

Anshel, MH 1995 'Examining social loafing among elite female rowers as a function of task duration and mood', *Journal of Sport Behavior*, no. 18, pp. 39–50.

Applewhaite, C 2003, *Improve your Tennis IQ*, Quarto Publishing, London

Australian Football League 2008, 'Geelong defeated by Hawthorn', Footy Wire, retrieved from http://www.footywire.com/afl/footy/ft_match_statistics?mid=4134

Australian Open 2009, 'Match Statistics', retrieved from http://www.australianopen.com/en_AU/scores/stats/day10/1313ms.html

Australian Sports Commission 2009, 'AIS Supplement Group Classification', *Classification*, retrieved from http://www.ausport.gov.au/ais/nutrition/supplements/classifications#A#A

Australian Sports Commission 2009, 'Fluid – Who Needs It?', *Hydration*, retrieved from http://www.ausport.gov.au/ais/nutrition/factsheets/hydration2/fluid_-_who_needs_it

Australian Sports Commission 2008, 'High tech head start for cyclists', *Technology and Innovation News*, retrieved from http://www.ausport.gov.au/ais/innovation/news/high_tech_head_start_for_cyclists

Brian Mac Sports Coach 2009, 'Coaching styles', retrieved from www.brianmac.co.uk/styles

Buchanan, J 2007 *If Better is Possible*, Hardie Grant Books, Melbourne, Australia

Burke, L 2000 *The Complete Guide to Food for Sports Performance*, 2nd edn, Allen and Unwin, Sydney

Carron, A, Widmeyer, W & Brawley, L 1995, 'The development of an instrument to assess cohesion in sports teams: The environment questionnaire,' *Journal of Sport Psychology*, vol. 7, no 3, pp. 244–267

Carron, A & Spink, K 1993, 'Team building in an exercise setting,' *The Sport Psychologist*, vol. 7, no 1, p. 13

Castaneda, B & Gray, R 2007 'Effects of focus of attention on baseball batting performance in players of differing skill levels', *Journal of Sport and Exercise Psychology*, vol. 29, 59–76

Chelladurai, P & Doherty, AJ 1998, 'Styles of decision-making in coaching', in JM Williams (ed.), *Applied sport psychology: personal growth to peak performance,* 3rd edn, pp. 115–126, Mountain View, CA: Mayfield

Chelladurai, P & Saleh, S 1980 'Dimensions of leader behavior in sports: Development of a leadership scale', *Journal of Sport Psychology*, vol. 2, pp. 34–45

Clough, PJ, Earle, K & Sewell, D 2002 'Mental toughness: the concept and its measurement' in I. Cockerill, ed, Solutions in Sport Psychology, Thomson Publishing, London

Crust, L & Clough, PJ 2005 'Relationship between mental toughness and physical endurance', Perceptual & Motor Skills, no. 100, pp. 192–194

Crust, L & Lawrence, I 2006, 'A Review of Leadership in Sport: Implications for Football Management', Athletic Insight, retrieved as http://www.athleticinsight.com/Vol8Iss4/FootballManager.htm#Defining

Curriculum Council, 2005, Curriculum Framework 'Making Progress', Health and Physical Education support materials, Perth, Western Australia

Farrow, D, ed, 2006, *Expertise*, AIS, Canberra, Australia

Farrow, D & Kemp, J 2003, *Run Like you stole something*, Allen and Unwin, Sydney

Farrow, D & Raab, M 'The Recipe for Expert Decision Making', in D Farrow ed, 2006, *Expertise*, AIS, Canberra, Australia

Farrow, D, Baker, J & MacMahon, C, eds, 2007, *Developing Sport Expertise: Researchers and coaches put theory into practice*, Routledge, New York

Gilson, C, Roberts, K, Weymes, E, Pratt, M & Weymes, E 2000, *Peak Performance*, Harper Collins, London

ISBN 9780170227124

GPSports Performance Analysis 2009, 'GPSports Systems is the world leader in Athlete Performance Enhancement', retrieved from http://gpsports.com/gpsports_website/
Harrison, A 2009, 'Caffeine effects: Now caffeine's legal, is it worth taking?', Peak Performance Online, retrieved from www.pponline.co.uk
Howland, JM 2006, 'Mental skills training for coaches to help athletes focus their attention, manage arousal and improve performance', *Journal of Education*, vol. 187, issue 1, pp. 49–66
Humphrey, JH, Yow, DA & Bowden, WW 2000, *Stress in College Athletics*, The Haworth Half-Court Press, New York
Knudsen, DV & Morrison, CS 2002, *Qualitative Analysis of Human Movement*, 2nd edn, Human Kinetics, Champaign, Illinois
Kriegbaum, E & Barthels, KM 1996, Biomechanics: *A Qualitative Approach for Studying Human Movement*, Allyn & Bacon, New Jersey
Latanè, B, Williams, K & Harkins, S 1979, 'Many Hands Make Light The Work: The Causes and Consequences of Social Loafing', *Journal of Personality and Social Psychology*, vol. 37, no. 6, pp. 822–832
Le Unes, A 2008, *Sports Psychology*, Psychology Press, New York
Martens, R 2004, *Successful Coaching*, 3rd edn, Human Kinetics, Champaign, Illionois, USA
Nideffer, RM 1976, *The Inner Athlete*, Crowell, New York
Orlick, T 2008, *In pursuit of excellence: How to win in Sport and life through mental training*, 4th edn, Human Kinetics, Champaign IL
Pelletier, L, Tusob, K, Fortier, M, Vallerand, R, Brikre, N & Blais, R 1995, 'Toward a New Measure of Intrinsic Motivation, Extrinsic Motivation, and Amotivation in Sports: The Sports Motivation Scale (SMS)', Journal of Sport & Exercise Physiology, vol. 17, pp. 35–53
Perkins-Ceccato, N, Passmore, S.R & Lee, TD 2003, 'Effects of focus of attention depend on golfer's skill', *Journal of Sport Sciences*, no. 21, pp. 593–600
Prapavessis, H, Carron, A & Spink, K 1997, 'Team building in sport groups', *International Journal of Sport Psychology*, no. 27, pp. 251–268
Pyke, FS, ed, *Better Coaching: Advanced Coach's Manual*, 2001, 2nd edn, Australian Sports Commission, Canberra
Roos, P 2008, 'Coaches crossing codes', Australian Football League, retrieved from http://www.afl.com.au/tabid/208/default.aspx?newsid=64410
Rushall, B 1984, *Towards better coaching*, Australian Coaching Council, AGPS
Smyth D, Brown H, Judge W, McCallum C & Pritchard R 2006, *Live it Up 2,* 2nd edn, John Wiley and Sons Ltd, ACHPER, Victoria
Solso, RL 1995, *Cognitive psychology*, 4th edn, Allyn & Bacon, Boston
Somax Sports Corporation 2007, 'How Hank Haney Changed the Tiger Woods Swing', *The Efficient Golfer*, as retrieved from http://www.the-efficient-golfer.com/anal-tiger-woods.html
Stevens, MJ & Lane AM, 'Mood-Regulating Strategies Used By Athletes', *Athletic Insight*, retrieved from http://www.athleticinsight.com/Vol3Iss3/MoodRegulation.htm#Discussion
Sugarman, K 2007, 'Leadership Characteristics', *Sport Psychology*, retrieved from http://www.psychwww.com/sports/leader.htm
Tzu Sun 1988, *The Art of War* (translated by Thomas Cleary), Shambhala Publications Inc, Boston, Massachusetts
Weinberg, RS & Gould, D 2007 *Foundations of Sport and Exercise Psychology*, 4th edn, Human Kinetics, Champaign, IL, USA
Williams, KD, Nida, SA, Baca, L D & Latanè, B 1989, 'Social loafing and swimming: Effects of identifiability on individual and relay performance of intercollegiate swimmers', *Basic and Applied Social Psychology*, no. 10, pp. 73–81
Wrisberg, CA 2007, *Sport Skill Instruction for Coaches*, Human Kinetics, Champaign, IL, USA
Wulf G, McConnel, N, Gartner. M & Schwarz, A 2002, 'Feedback and attentional focus: Enhancing the learning of sport skills through external focus feedback', *Journal of Motor Behaviour*, no. 34, pp. 17–182

Glossary

A-band the area in the centre of the sarcomere, containing both actin and myosin filaments

acceleration the rate of change in velocity

acclimatisation becoming accustomed to a set of circumstances

acetylcholine (Ach) chemical substance responsible for the transfer of impulses from one neuron to another, or to muscles across the synaptic cleft or neuromuscular junction

acetylcholinesterase an enzyme responsible for breaking down acetylcholine

acidosis an abnormal increase in acidity

actin a thin protein filament found in a sarcomere, responsible for muscle contraction

adaptation a long-term physiological change in response to training loads that allows the body to meet new demands

adenosine diphosphate (ADP) substance produced from the breakdown of ATP to supply energy to working muscles

adenosine triphosphate (ATP) a chemical compound formed with the energy released from food and stored in all cells, especially muscles. ATP is split into adenosine diphosphate and phosphate to produce energy

aerobic performed in the presence of free oxygen

aerobic capacity the maximum amount of oxygen the body can take in, transport and use

aerobic energy system energy system that uses oxygen and is the most powerful of the three energy systems

aerobic glycolysis the breakdown of glucose in the presence of oxygen, with no fatiguing by-products

aerobic power rate at which the body can produce energy in the mitochondria using the aerobic pathway

aerobic training zone performing at between 70 and 85 per cent maximum heart rate

air resistance forces placed on a moving object due to the flow of air contacting the object

anabolic protein building

anaerobic oxygen is not present during performance

anaerobic glycolysis the incomplete breakdown of carbohydrate due to insufficient oxygen, producing lactic acid

anaerobic power ability to produce energy without oxygen

anaerobic training zone performing above 85 per cent maximum heart rate

androgenic natural or artificial male sex hormones responsible for the development of male sexual characteristics

angle of projection the angle at which an object is released into the air

angular momentum a measure of the amount of angular motion possessed by a rotating body

angular motion the motion of a body moving around an axis

ankle oedema swelling in the ankles caused by blood pooling because of loss of circulation

arousal the amount of mental energy or preparedness a person has prior to performance

ATP–PC creatine–phosphate energy system

ATP–PC system the first of the two anaerobic energy systems in which phosphocreatine (PC) is broken down to produce energy

audience a group of listeners, spectators, admirers or devotees

authoritarian coach who makes all the decisions with an emphasis on strict discipline

autonomous the highest stage of learning, where actions become automatic and require little thought

axis the fixed point around which an object rotates

axis of rotation an imaginary line that something revolves around

axon long nerve fibre that transmits electrical signals to other nerve cells

backspin lifting effect of a ball in flight due to the effects of air pressure

balance the ability of the body or an object to maintain stability or equilibrium when moving or stationary

base of support the area upon which a body is supported on the ground

baseline a standard that other measurements or facts can be compared with

Bernoulli's principle when high pressure air moves towards low pressure air, it creates lift

beta-blockers drugs used to slow the heart and prevent tremors

biofeedback receiving feedback regarding autonomous body functions such as heart rate, blood pressure and body temperature, and using this information to bring about mental adaptation

biomechanics the study of how the physical laws of mechanics apply to the human body

biopsy removal of a tissue sample for laboratory examination

bipennate muscle fibres branch out to both sides of the central tendon, e.g. gastrocnemius

blood doping when red blood cells are increased either by blood infusion or erythropoietin to increase the body's oxygen-carrying capacity

blood sugar the main sugar found in the blood, and the body's main source of energy

boast a shot that hits a sidewall or backwall before hitting the front wall

carbohydration fluid replacement using carbohydrate-filled fluids

carbohydrate loading the practice of increasing carbohydrate stores within the muscles and body

carbohydrates a chemical compound consisting of carbon, hydrogen and oxygen atoms; the body's preferred food fuel during exercise, e.g. fruit, cereal, vegetables, bread and pasta

cardiovascular endurance ability to perform physical activities that rely heavily on oxygen for energy production, over a prolonged period of time

cardiovascular system the system of organs (heart, blood vessels and blood) responsible for transportation of blood around the body

centre of gravity the point through which an object's total weight appears to act without causing rotation

chaining breaking a complex skill into its components, practising each part separately, then re-assembling the skill

choking when performance deteriorates because of pressure or importance placed on an upcoming event or action

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chronic fatigue syndrome (CFS) extreme fatigue that lasts six months or longer and does not improve with rest

coach individual involved in the direction, instruction and training of a sports team or individual sportspeople

coefficient of restitution measure of how much movement energy remains after a collision between two objects

cognitive the process of knowing, understanding and learning something

coincidence timing hitting an object with a body part or striking implement at the correct moment

complex skill a skill that cannot be performed after simple demonstration or explanation

conceptual being able to cognitively link similar movement concepts

conceptualisation arriving at a concept or generalisation as a result of experiences or thoughts

confidence strong belief in own ability and likely positive outcome

conservation of angular momentum a rotating body will continue to turn about its axis of rotation with constant angular momentum unless an external or eccentric force is applied to it

constructs factors, variables or determinants that explain and predict a behaviour

contractile the ability of muscle fibres to contract

contraction any movement resulting in tension being developed at a muscle

cool-down period where an athlete reduces activity levels and gradually returns to pre-exercise condition (recovery)

core body temperature temperature of the inner body

creatine phosphate (CP) compound that transfers phosphate and energy to ADP to generate ATP; a source of energy for muscle tissue

crossbridges oar-like projections from the myosin filaments that assist muscle cells to attach to others

cue a piece of information a performer receives from the environment

cytosol intracellular fluid; the liquid found inside cells

data collection collection of a range of data used for informing a coach and an athlete

deep vein thrombosis (DVT) blood clot that develops inside the veins of the leg muscles

dehydration a water deficit in the body occurring when fluid loss is greater than fluid intake

democratic head coach who delegates tasks to a range of support staff with expertise in different areas

demotivation reversal from a state of being motivated and aroused

depolarisation to remove the polarisation from something; to demagnetise

discrete skill a single movement with a distinct start and finish

distal situated farthest from point of attachment

DOMS delayed onset of muscle soreness; occurs after participating in unaccustomed exercise situations

drag a force pulling an object backwards due to a low pressure air pocket

eccentric force a force that acts outside an object's centre of gravity, causing it to rotate as well as move in a straight line

ectomorph slim, linear body type

elasticity the ability of surfaces to 'give', then return to their original shape

electrolytes mineral salts

endogenous a substance that is produced naturally by the body

end-plate potential when the nerve signal crosses the synaptic cleft and changes the polarity of the muscle fibre

energy ability to perform work

energy intake the amount and type of food you eat

energy systems any of the three metabolic systems responsible for the production of ATP

energy-system interplay a situation where all three energy systems contribute to ATP production, with one system being the major ATP producer

enzymes chemical substances that facilitate or speed up the rate of reactions occurring within the body

epinephrine an adrenaline-based hormone

ergogenic aid practice, substance or method (legal or illegal) that improves performance

erythrocyte a red blood cell

excess post-exercise oxygen consumption (EPOC) oxygen consumption during recovery

execute complete; carry out

exocytosis the release to a cell surface of secretions through vesicles

exogenous a substance that is not produced naturally by the body

extrinsic motivating factors factors external to the athlete, such as prize money

fascicle dense cluster or bundle

fatigue inability to carry out a given level of physical performance due to exhaustion, causing a decline in performance

feedback information a performer receives about how a skill was performed

FINA international ruling body for swimming

force strength or power applied to change the body's state of motion

force arm the distance from the force to the axis of a lever

force couple two or more forces act on a body to cancel any linear motion

form drag when an area of high pressure and an area of low pressure meet after a body has passed through

free fatty acids (FFAs) energy storage molecules; a byproduct of the breakdown of fats

friction the force that opposes the efforts of one body to move over another

full-ground rolling zone when a team moves as a whole to have more players near the ball, but with players maintaining their positions

fusiform tapered at each end

future-oriented thinking thinking ahead of time about what you are going to do and what might happen

games analysis analysis of a team game to reveal the fitness components, energy systems, muscle groups and skills used so that performance may be improved

gluconeogenesis the production of glucose, mostly in the liver, from amino acids, fats, and other non-carbohydrate substances

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glucose a sugar produced by the metabolism (or breakdown) of carbohydrates; a major source of energy for most cells of the body

glycaemic index (GI) a ranking of carbohydrates based on their immediate effect on blood glucose levels

glycogen major carbohydrate storage form in the body

glycogen sparing the ability to use fats earlier and faster during performance that accompanies aerobic orendurance training

glycogen synthase enzyme responsible for converting glucose into glycogen in the process of glucogenesis

glycolysis the breakdown of glycogen, either aerobically (with oxygen) or anerobically (without oxygen)

goal setting practice of stating or setting performance targets prior to an event actually happening

ground reaction force any force exerted by the ground on a body in contact with it

gynecomastia the development of abnormally large mammary glands in males, resulting in breast enlargement

haematocrit the percentage of red blood cells in the blood

haemoglobin oxygen-carrying pigment present in red blood cells

headwind a wind blowing against the direction of travel

homeostatic any self-regulating process by which a body system maintains stability while adjusting to changing conditions

hyperbaric chamber a large chamber in which the oxygen pressure is above normal for the atmosphere

hypertension unusually high blood pressure

hyperthermia unusually high body temperature

hypertonic sports drinks drinks containing a lesser proportion of water and a greater proportion of sugar than fluids in the human body

hyperviscosity excessively thick blood

hypohydration total body water or fluid below normal levels

hyponatraemia low blood sodium levels, sometimes caused by over-hydration

hypothermia dangerously low body temperature caused by prolonged exposure to cold

hypoxic when inadequate amounts of oxygen reach the body's tissues

hypoxic tent a tent that simulates high altitudes by pumping in hypoxic (or low-oxygen) air

H-zone the centre of the A-band, which is free from the myosin crossbridges

I-band the area of myofibril containing actin

imagery use of thoughts and images seen through the 'mind's eye'

impulse application of force over a period of time, which changes the velocity of a body or object

inoculate by being exposed to certain situations, the body develops an immunity to that situation and is able to shut it out

intensity the level of performance determined by heart rate or oxygen consumption

interdisciplinary drawing on more than one field

interpersonal communication an exchange between two or more individuals

intervention a program or event designed to prevent or modify an outcome

intrapersonal communication self-talk; could be internal dialogue or words spoken aloud

intravenous process of introducing substances, usually fluids, into the body via the veins

intrinsic motivating factors factors that come from within the individual, such as enjoying the competition

involuntary muscles that work without our conscious control

ion a particle that is electrically charged (positive or negative)

ion channels gaps in cell membrane that allow sodium and potassium ions to flow

isotonic contraction a contraction in which the muscle shortens with varying tension while lifting a constant load

key performance indicators areas recorded for statistical analysis, e.g. number of passes

kinaesthetic sensing the motion, weight or position of the body as muscles, tendons and joints move

kinaesthetic awareness an individual's awareness of their body parts in relation to each other and space; sensing the motion, weight or position of the body as muscles, tendons and joints move

lactate threshold the point where lactic acid begins to accumulate in the bloodstream

lactic acid (LA) a by-product of the lactic acid energy system resulting from the incomplete breakdown of glucose

lactic acid system the second anaerobic system, which involves the breaking up of glycogen and glucose. Lactic acid is the by-product

leadership the impact individuals have on group dynamics related to a team objective

lever a machine that transmits energy from one place to another through a rigid structure rotating around a fixed point

libero a specialised defensive player who always stays in the back row

ligament cord of thick, strongs fibres that connect bones to bone

line coach coach who looks after a distinct component of play (defensive or offensive)

line of gravity theoretical line drawn from the centre of gravity to the base of support

lockout when media and the public are not allowed into a training venue

log training diary or record

macrocycle the large block of training, which can be several months or a year

Magnus effect the movement of the trajectory of a spinning object towards the direction of the spin

medial towards the midline of the body

meditation means of controlling pre-game nerves and inducing a more relaxed state of mind prior to competition

mental imagery ability to picture events by thinking about them

mental rehearsal technique used to improve self-confidence through the visualisation process

mental toughness remaining focused and resilient even in challenging circumstances

mesocycle a block of weeks in a training cycle, usually 4–12 weeks

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microcycle training unit that repeats itself; usually a week, but can be 4–10 days

mitochondria cellular structures containing enzymes responsible for the production of energy under aerobic conditions

moment of inertia a measure of how difficult it is to change an object's rotary motion; the tendency of an object to maintain its current state of angular motion

momentum the amount of motion possessed by a moving body

motivation to encourage an individual in order to improve performance

motor end plate motor neuron end responsible for transmitting nerve signals to a muscle fibre

motor neuron nerve cell that conveys nerve impulses from the spinal cord or brain away from the central nervous system towards a muscle

motor pathway the course followed by a nerve impulse from the brain to an organ or muscle

movement patterns general series of musculoskeletal movements involving segments of the body moving in the same plane of motion

multifactorial more than one factor is involved

multipennate muscle fibres branch out repeatedly from a number of tendons, e.g. deltoid

muscle belly main body of muscle

muscle power muscular force that can be applied quickly; involves a combination of muscular strength and speed; explosive action

myelin sheath insulating layer that surrounds nerve fibres

myofibrils the part of the muscle fibre encasing the actin and myosin filaments

myoglobin the protein that carries oxygen in muscle cells

myosin a thick protein filament found in a sarcomere, responsible for muscle contraction

myosin crossbridge part of the myosin filament; when stimulated, it reaches out and attaches to the actin filament

NAD^+ nicotinamide adenine dinucleotide

negative motivation when negative or punishing consequences are imposed after undesirable behaviour

neuromuscular the voluntary control of muscles by nerves

neuromusculoskeletal system of nerves, bones and muscles within the body

nonverbal communication the use of signals, gestures and facial expressions to convey a message to another person

output outcome or action

overlearning repeated practise of skills, which sees them becoming automatic

overtraining fatigue brought on by excessive frequency, volume or intensity of training

oxygen debt (EPOC) when oxygen consumption stays above resting levels after exercise has finished

oxygen deficit when oxygen demands are greater than the body's ability to supply the necessary oxygen levels

oxygen uptake volume of oxygen breathed in and used by the body (VO_2)

passive recovery a recovery that utilises complete rest, or exercise at a slow walking pace

pattern recognition a player's ability to see similar game-play characteristics between sports

peaking when an athlete reaches their optimal level of performance at the required time

pennation a muscle with fibres that attach obliquely to the tendon

perceptual receiving information with the mind or senses

performance a sequence of movements in physical activity

periodisation breaking up a training program into blocks of time

periphery the outer layer; close to the skin

personal best (PB) a performer's best recorded result or performance at a particular skill or activity

phosphocreatine (PC) chemical fuel stored at the muscles that splits rapidly and easily to recharge energy (ATP) for muscular contractions

plateau period of unchanging oxygen demand

plyometrics a form of exercise that uses rapid movements to develop muscular power

positive motivation when positive, reinforcing events occur after desired behaviour

preferential recruitment when the body recruits fibres according to the intensity of the activity about to be undertaken

principle of maintenance the ability to maintain a desired fitness level

processing taking in information

profile a collection of data that maps out strengths and weaknesses

pronation an inward roll of the foot as the outer edge of the heel strikes the ground

protein fuel source used predominantly for growth and repair and as an energy source in extreme conditions

proximal situated nearest to point of attachment

psychological skills training (PST) rehearsal or practice of a variety of psychological techniques

psychomotor the function of muscles under the control of the mind

pyruvate converted form of glucose used for producing ATP with oxygen

pyruvic acid a substance formed when glycolysis occurs

qualitative analysis examination of quality, analysis of fundamental variables that cannot be precisely valued

quantitative analysis a direct measurable, numerical examination of specific variables

recovery returning an athlete to a state of performance readiness mentally and physically

recovery strategies strategies to improve blood flow after exercise; injuries must be attended to first, as some recovery strategies can make injuries worse

red blood cells iron-rich cells that carry oxygen around the body

refocus ability to gain renewed attention or concentration

reinforcer method of motivation, either positive or negative

relaxation absence of tension in a muscle

repetition one performance of an exercise

residual fatigue accumulation of fatigue from one training session to the next

resistance arm the distance from the load to the axis of a lever

respiration metabolic processes in cells leading to the production of energy by the breakdown of organic substances

rest the time between physical conditioning, allowing the body to remove wastes and replenish muscle stores

rhabdomyolysis the breakdown of skeletal muscle tissue when muscles overheat, releasing the products of damaged muscle cells into the bloodstream, including myoglobin, which can stop the kidneys from working

rotational velocity the speed of rotation measured in radians per second and rate of angular change of an object about the axis of rotation

rubric an assessment checklist, usually with numerical values, to help determine skill against designated measures

sarcolemma thin cell membrane that surrounds a striated muscle fibre

sarcomere a segment of myofibril in a striated muscle fibre

sarcoplasm the cytoplasm of a striated muscle fibre

sarcoplasmic reticulum internal membranes in muscle cells or fibres

self-talk performers 'talking to themselves', reminding themselves of their goals, relaxation techniques or next response

sensory neuron a nerve cell that conveys nerve impulses back to the spinal cord or brain from muscles, organs and cells

set play a series of pre-practised movement patterns typically used by sporting teams, which follow a set sequence

shaping simplifying a complex skill into its main component, then adding on the missing pieces

side spin turn of a ball in flight to left or right due to the effects of air pressure

signatories people, governments or organisations that have signed a contract or agreement and are bound by it

simple skill a motor skill that an individual can perform with very little practise

simulation when real-life situations are practised or experienced

sliding filament theory a theory to explain how muscular contraction takes place. When a muscle contracts, myofilaments slide between each other causing the muscle to bunch and release energy

slipstreaming riding in this slipstream, an area of reduced air pressure and forward suction that is directly behind a rapidly moving object

slump an extended period of poor performance, especially in sport

state sport confidence the effect of a situation on behaviour and confidence within that specific time and circumstance

steady state situation where the body is able to supply sufficient oxygen to meet the oxygen demands

strategy overall plan for achieving success

stress changes in the body's normal functioning when put under pressure

submaximal less than maximal effort; usually below 75 per cent maximum heart rate

summation of momentum the sequential movement of body parts to produce maximal speed

supercompensation effect elevated amounts of glycogen stored in the muscles and liver following periods where this is in short supply or used in response to exercise bouts

supination when the foot rolls toward the outside, with more weight placed over the outer toes

surface drag resistance to forward movement in water; skin friction

synapses region of communication; space between neurons and muscle fibres

synaptic cleft tiny space between two nerve cells or between the end plate and muscle fibre

tachycardia an excessively rapid heartbeat, faster than 100 beats per minute in a resting adult

tactics methods or actions used to achieve a goal

tailwind a wind blowing in the direction of travel

tapering reducing training volume and duration (but not intensity) in the week leading up to a major competition

telemetry transmitting data for recording and analysis

tendons cords of thick strong fibres that connect muscle to bone

the zone when performance becomes automatic and requires little thought, full of flow and unaffected by outside distractions; occurs during situations of optimal arousal and confidence

therapeutic used in the treatment of disease or disorders; used to maintain health

threshold the level that must be reached for a physiological effect to be triggered

top spin premature downward movement of a ball in flight due to the effects of air pressure

torque any action that causes an object to change its rotary motion

training journal document used to record physical and mental responses after an athletic performance

training program series of activities undertaken to improve performance

trait an identifying characteristic or habit

trait sport confidence an individual's typical style of behaving, and their confidence level during those behaviours

trajectory the flight path an object takes when released into the air

transfer of learning transfer or shift learning or training from one task to another

transfer of momentum process where momentum is transferred from one part of a body to another

translation when every particle within a body has the same motion

triglyceride the preferred state of fatty acids in order to enable storage

unipennate muscle fibres only branch out to one side of the tendon, e.g. the semimembranosis

vasoconstriction when blood vessels reduce their diameter to allow less blood to flow though

vasodilation enlarging of blood vessels to allow increased amounts of blood to flow through them

velocity the rate of the positional change of an object

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velocity of release the speed of a projectile at the moment it is released

venous pooling when large amounts of blood remain or 'pool' around working muscles following high-intensity activity

visual-perceptual training program specific training to develop visual awareness of clues given by the opponent, to help streamline the decision-making process

VO_2 max the maximum amount of oxygen that can be taken up, transported and utilised per minute

voluntary muscles that you can control to create movement

wellness score a rating an athlete gives themself, based on how they feel

white blood cells the body's defence system, fighting infection and building up the body's immunity

whole practice where the whole skill is practised

work the amount of time actively engaged in physical effort

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