3rd Edition

NELSON

PHYSICAL EDUCATION

VCE Units 1+2

Amanda Telford, Rachael Whittle, Rob Malpeli, Monique Sharp, Mark Corrie

Rob Malpeli *Coordinating Author*

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Nelson Physical Education VCE Units 1&2 Student Book
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Rachael Whittle
Rob Malpeli
Monique Sharp
Mark Corrie
ISBN 9780170480918

Senior Product Manager: Caroline Williams
Content Developer: Chantelle Bryant
Editor: Vanessa Lanaway; Anne Mulvaney
Proofreader: Jess Ni Chuinn
Series Designer: Nikita Bansal
Cover Design: Everyday Ambitions (Emilie Pfitzner)
Text Design: Alba Design (Rina Gargano)
Cover image: stock.adobe.com/Jacob Lund
Permissions researcher: Lumina Datamatics
Content Manager: Jess Lovell
Typeset by: Lumina Datamatics

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Printing: 1010 Printing China

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National Library of Australia Cataloguing-in-Publication Data
A catalogue record for this book is available from the National Library of Australia.

Cengage Learning Australia
Level 5, 80 Dorcas Street
Southbank VIC 3006 Australia

For learning solutions, visit **cengage.com.au**

Printed in China by 1010 Printing International Limited.
1 2 3 4 5 6 7 27 26 25 24

CONTENTS

UNIT 2

PHYSICAL ACTIVITY, SPORT, EXERCISE AND SOCIETY

AREA OF STUDY 1: HOW DO PHYSICAL ACTIVITY, SPORT AND EXERCISE CONTRIBUTE TO HEALTHY LIFESTYLES?

AREA OF STUDY 2: WHAT ARE THE CONTEMPORARY ISSUES ASSOCIATED WITH PHYSICAL ACTIVITY AND SPORT?

HOW TO USE THIS BOOK

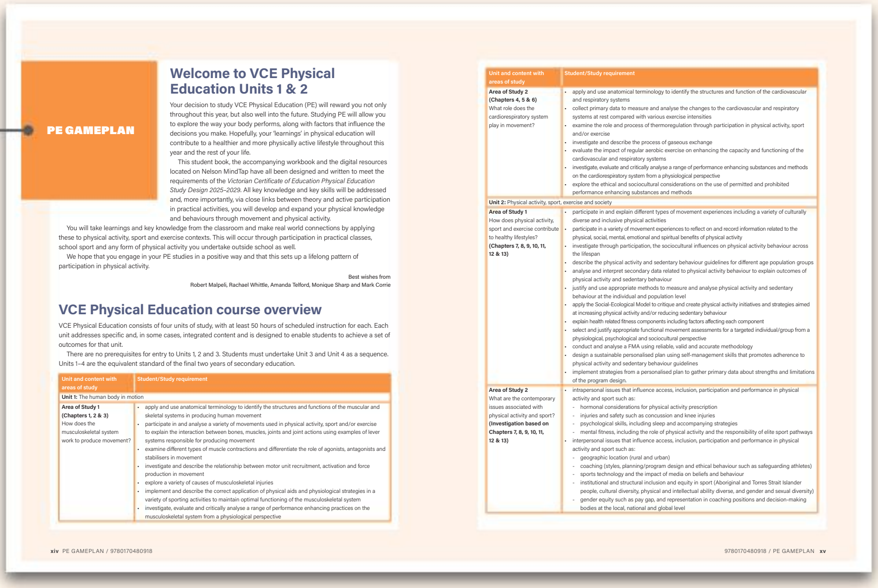
Nelson Physical Education VCE Units provides a complete teaching and learning solution designed to engage and support VCE Physical Education students.

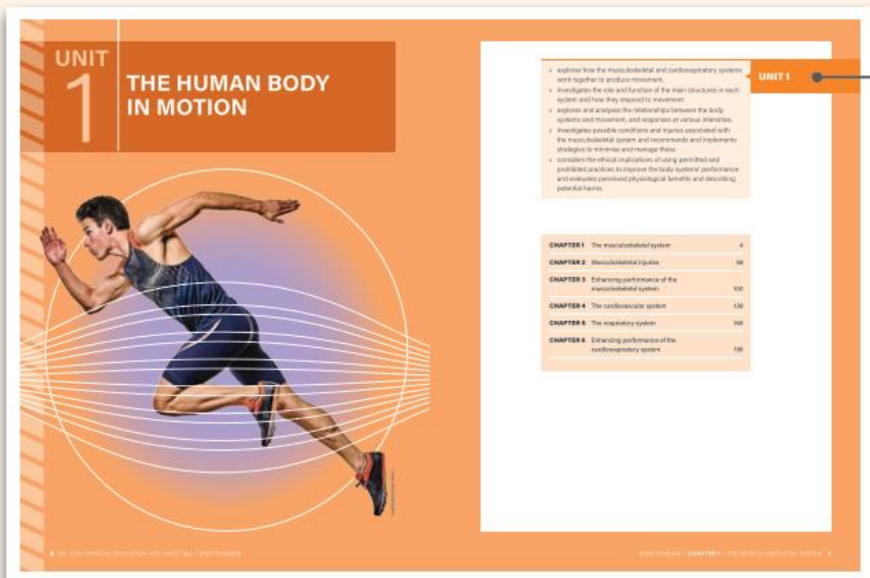
Written to comprehensively support the revised *VCE Physical Education Study Design (2025–2029)*, this edition has been informed by our highly experienced author team's deep expertise, up-to-date research and evidence-based pedagogical approaches to learning and assessment. The result is a fresh approach to this trusted series with a renewed focus on maximising opportunities for all students to actively engage, explore, practise and critically apply their key knowledge and skills.

Our expert author team have seamlessly interwoven explicitly aligned coverage of the content in the revised Study Design with preparation for both internal assessment and the end-of-Year 12 exam to help build students' confidence in their knowledge, equipping them for exam success and ultimate study score attainment.

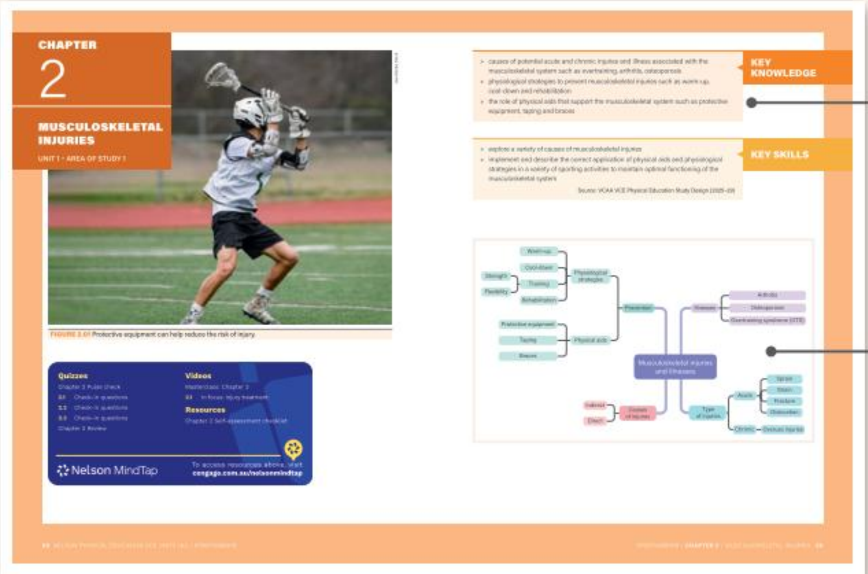
STUDENT BOOK FEATURES

The **PE Gameplan** section at the beginning of this student book provides students with a toolkit that they can refer to throughout the course. The PE Gameplan covers key concepts and skills, including unpacking data literacy, a glossary of command terms in a VCE Physical Education context, as well as in-depth advice on preparing for and tackling the end-of-year exam with valuable insights and useful tips.



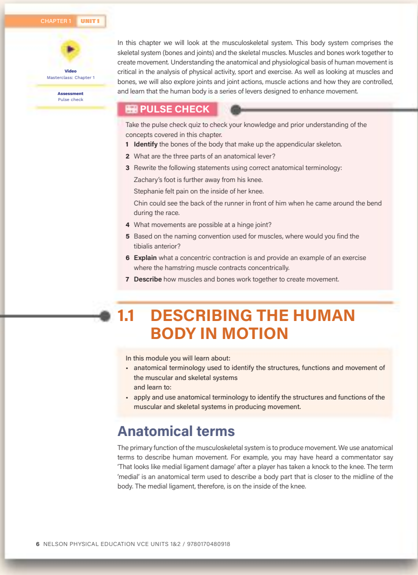


Unit opener pages provide an overview of the content that will be covered across the chapters in this unit.



Learning goals based on key knowledge and key skills from the Study Design are clearly described at the beginning of each module.

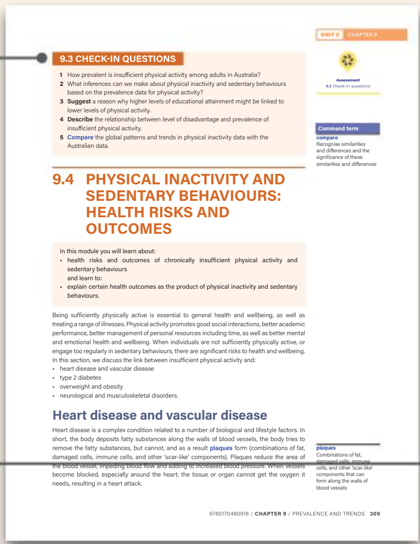
Concept maps at the beginning of each chapter clearly show the relationship between key concepts in the Study Design.

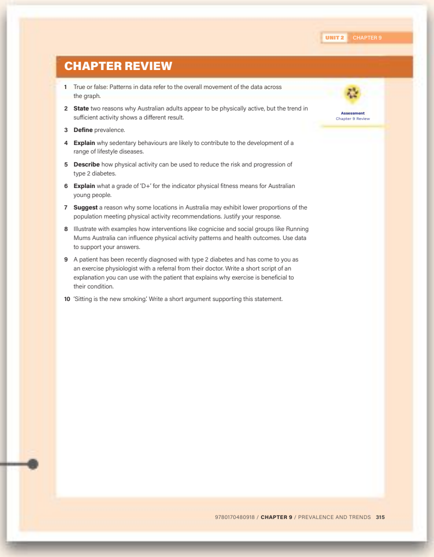


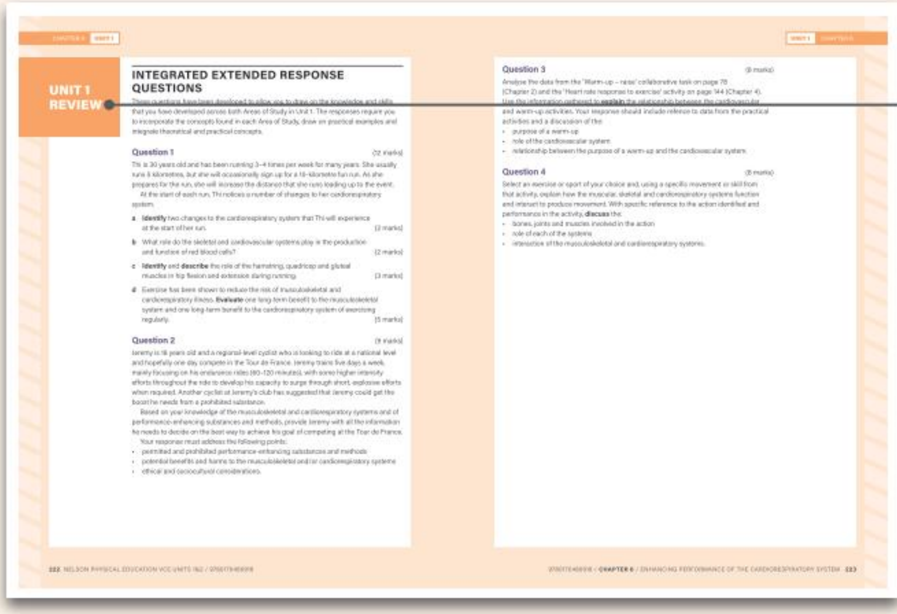
Pulse check quizzes at the start of each chapter are designed to activate and assess student's prior knowledge of the key concepts and topics to be covered in the chapter.

Study Design alignment is signposted throughout, including on the chapter opening page. Chapters are organised to explicitly follow the structure of the Study Design and are divided into modules to better support students.

Check-in questions at the end of each module and **Chapter review** questions use VCAA command terms and model a wide range of different exam-style questions to boost students' exam preparation and readiness. Answers to all questions are available on Nelson MindTap.



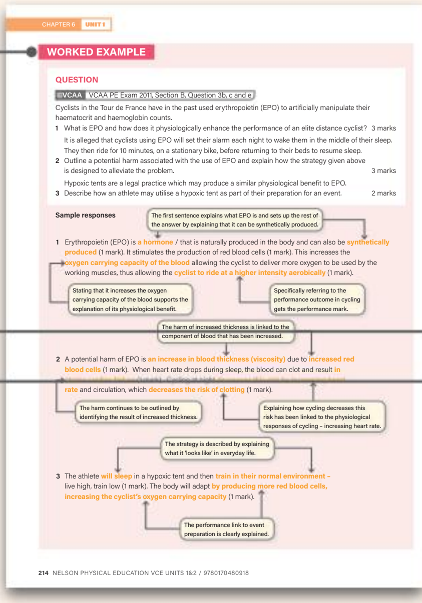


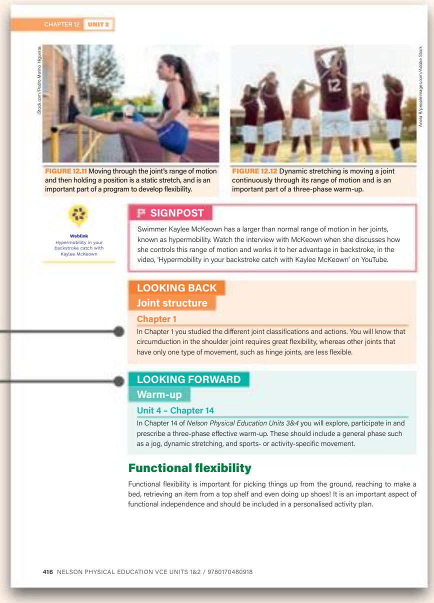


Unit reviews feature exam-style extended-response questions. These questions have been developed to allow you to draw on the knowledge and skills that you have developed across areas of study in each unit. Exemplar responses and advice on answering all questions are available on Nelson MindTap.

Worked examples of exam-style questions demonstrate the steps required to complete a task or solve a problem, and include helpful annotations, exemplar responses and advice on avoiding 'potential pitfalls' or common misconceptions.

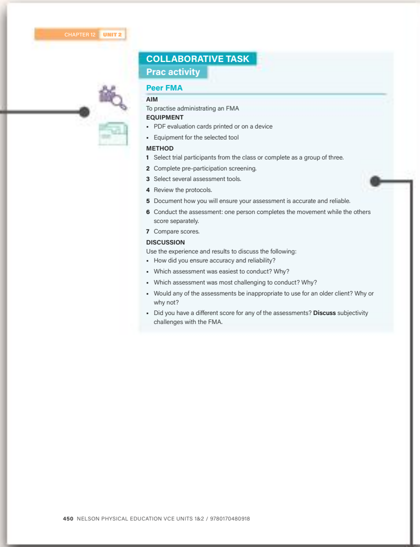
Highlighting the cross-threading of concepts throughout the course with **Looking forward** and **Looking back** feature boxes.





Real world applications and **Case studies** are designed to provide students with multiple opportunities to encounter, engage with, and elaborate on new knowledge and skills.

Reflective folio and **data analysis** icons act as reminders to students to document their findings and observations.


CHAPTER 12 UNIT 2

COLLABORATIVE TASK
Prac activity

Peer FMA

AIM
To practise administrating an FMA

EQUIPMENT
- PDF evaluation cards printed or on a device
- Equipment for the selected tool

METHOD
1 Select trial participants from the class or complete as a group of three.
2 Complete pre-participation screening.
3 Select several assessment tools.
4 Review the protocols.
5 Document how you will ensure your assessment is accurate and reliable.
6 Conduct the assessment: one person completes the movement while the others score separately.
7 Compare scores.

DISCUSSION
Use the experience and results to discuss the following:
- How did you ensure accuracy and reliability?
- Which assessment was easiest to conduct? Why?
- Which assessment was most challenging to conduct? Why?
- Would any of the assessments be inappropriate to use for an older client? Why or why not?
- Did you have a different score for any of the assessments? **Discuss** subjectivity challenges with the FMA.

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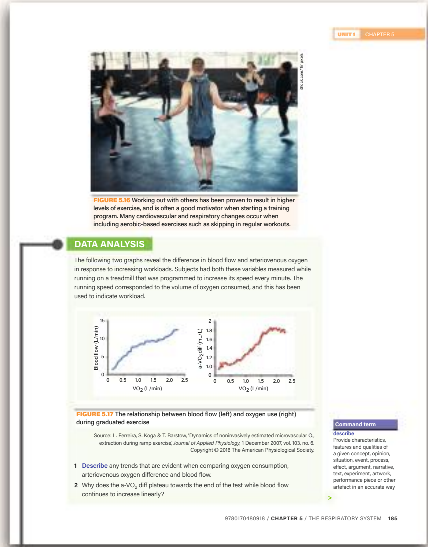

UNIT 1 CHAPTER 5

FIGURE 5.16 Working out with others has been proven to result in higher levels of exercise, and is often a good motivator when starting a training program. Many cardiovascular and respiratory changes occur when including aerobic-based exercises such as skipping in regular workouts.

DATA ANALYSIS

The following two graphs reveal the difference in blood flow and arteriovenous oxygen in response to increasing workloads. Subjects had both these variables measured while running on a treadmill that was programmed to increase its speed every minute. The running speed corresponded to the volume of oxygen consumed, and this has been used to indicate workload.

FIGURE 5.17 The relationship between blood flow (left) and oxygen use (right) during graduated exercise

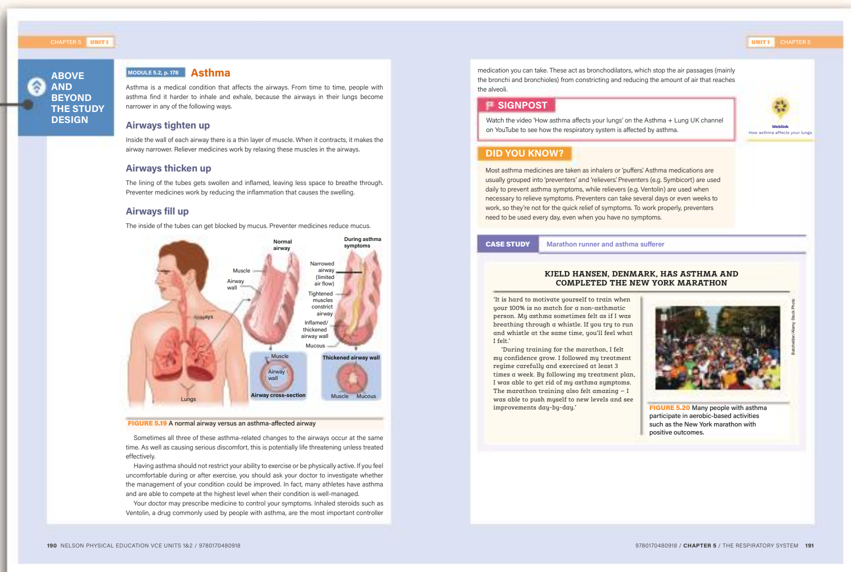
1 **Describe** any trends that are evident when comparing oxygen consumption, arteriovenous oxygen difference and blood flow.
2 Why does the a-VO_2 diff plateau towards the end of the test while blood flow continues to increase linearly?

Command term
describe
Provide characteristics, features and qualities of a given concept, opinion, situation, event, process, effect, argument, narrative, text, experiment, artwork, performance piece or other artefact in an accurate way

9780170480918 / CHAPTER 5 / THE RESPIRATORY SYSTEM 185

Maximising opportunities for students to apply and practise their knowledge and skills through **Collaborative tasks** and **Data analysis** activities. Reflective folio and data analysis icons prompt students to record their observations.

Above and beyond the Study Design sections provide students with opportunities to extend their understanding outside the scope of the Study Design, but with clear links to knowledge included in the Study Design.


ABOVE AND BEYOND THE STUDY DESIGN

Asthma

Airways tighten up

Airways thicken up

Airways fill up

FIGURE 5.19 A normal airway versus an asthma-affected airway

SIGNPOST

DID YOU KNOW?

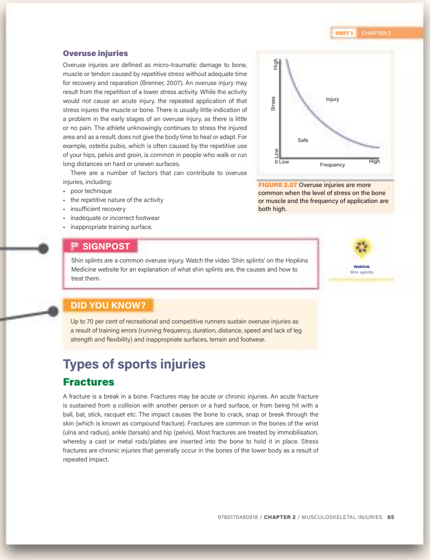
CASE STUDY Marathon runner and asthma sufferer

KJELD HANSEN, DENMARK, HAS ASTHMA AND COMPLETED THE NEW YORK MARATHON

FIGURE 5.20 Many people with asthma participate in aerobic-based activities such as the New York marathon with positive outcomes.

Signpost boxes provide directions for extending students' understanding of a concept with links to research, videos and other resources.

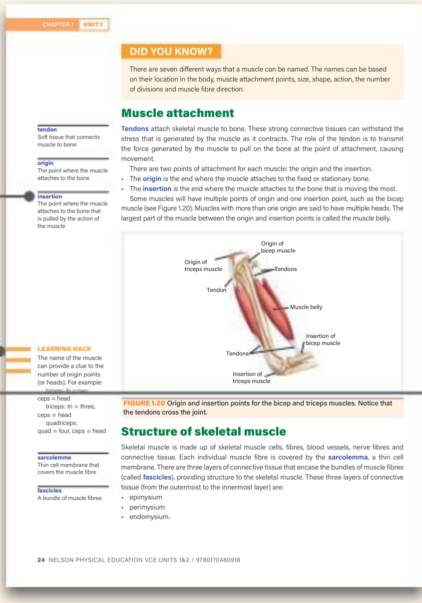
Did you know? boxes have been designed to spark students' interest and engagement with a topic or concept.

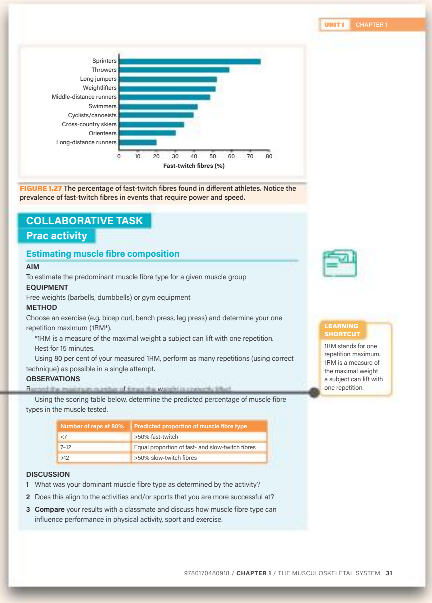


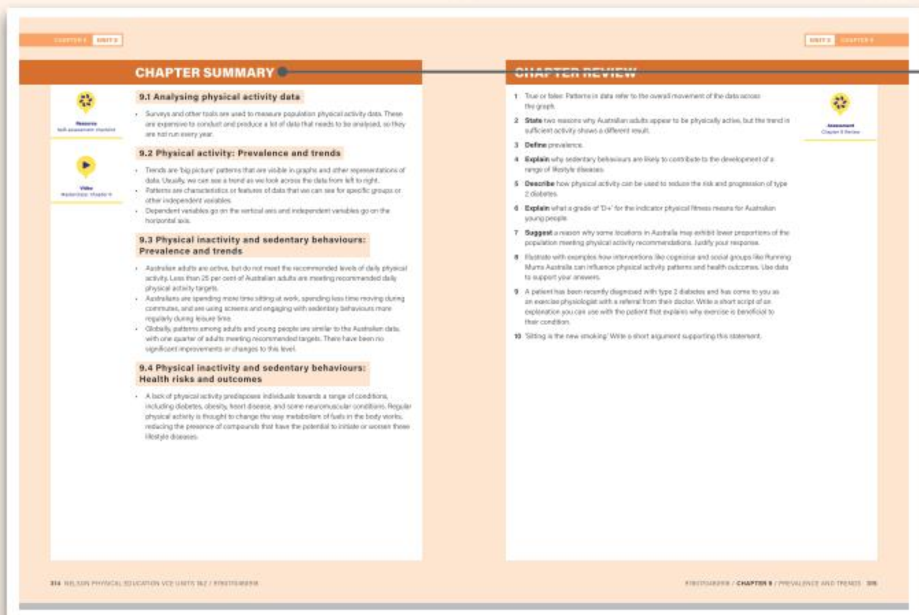
Command terms are highlighted in all questions with margin definitions to build awareness and exam readiness in students.

Integrated exam support can be found throughout the chapter, providing students with advice and useful insights as they work through each chapter, including:

- **Learning short cuts**
- **Learning hacks**
- **Key term definitions.**







Chapter summaries provide students with a one-page overview of the key knowledge in each chapter, ideal for revision and exam preparation.

NELSON MINDTAP

This series features Nelson MindTap, an online learning environment that puts you at the centre of your learning. Nelson MindTap for Nelson Physical Education gives you access to an eText with integrated activities and assessments.

Nelson MindTap

An online learning space that provides students with tailored learning experiences.

- Access tools and content that make learning simpler yet smarter.
- **Flexible formats**: choose how you navigate using either the online eText or offline PDFs.
- Margin links in the student book signpost multimedia student resources found on Nelson MindTap.

Video
Chapter 2
Masterclass

For students:

- **Watch** Masterclass and In Focus video tutorials featuring expert teacher advice to unpack new concepts and develop your understanding.
- **Revise** using quizzes and templates to practise your skills and build your confidence.
- **Navigate** your own path, accessing the content, analytics and support as you need it.
- **Track** your progress and guide your revision using self-assessment checklists.
- **Prepare** for the end-of-year exam with access to hundreds of exam-style and past exam questions; tailored and expert exam support as well as support for revision.

For teachers:

- **Tailor** content to different learning needs – assign directly to the student, or the whole class.
- **Monitor** progress using assessment tools like Gradebook and Reports.
- Get expert and detailed advice on **preparing SACs** with scaffolded support and detailed modelling.
- Use **teaching plans** and curriculum guides to support easy program and assessment planning.
- **Chapter summary** presentations are in PowerPoint for you to edit and build upon.

Complimentary access to these resources is only available to teachers who use this book as part of a class set, book hire or booklist. Contact your Cengage Education Consultant for information about access and conditions.

Security and privacy:

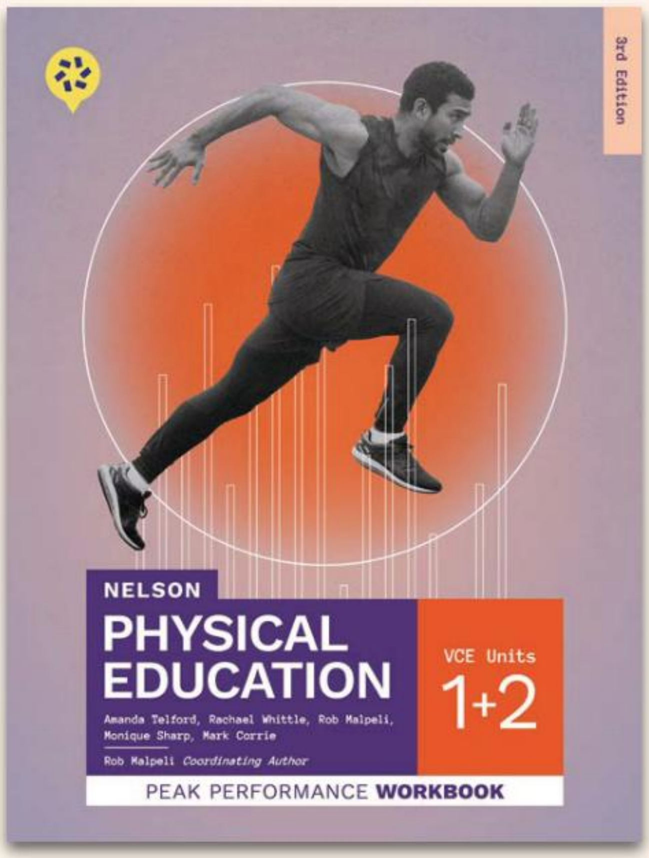
Nelson MindTap joined the Safer Technologies 4 Schools (ST4S) Product Badge Program in 2024. The annual ST4S assessment is part of our commitment to supporting the online security and safety of students and schools. Learn more at st4s.edu.au.

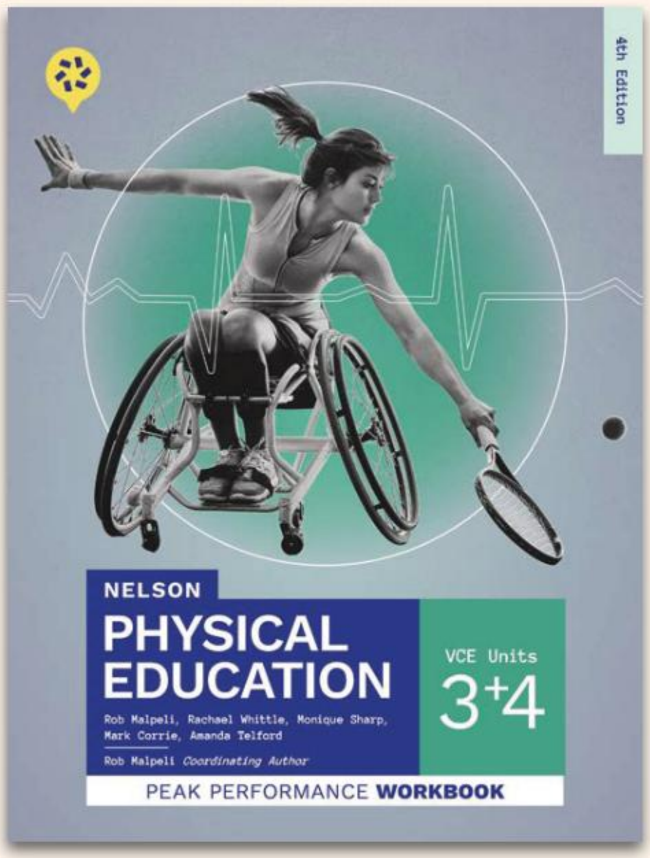
NELSON PHYSICAL EDUCATION VCE PEAK PERFORMANCE WORKBOOKS

The Nelson Physical Education Peak Performance workbooks for VCE Units 1&2 and Units 3&4 provide complete coverage of the *VCE Physical Education Study Design (2025–2029)*. These comprehensive workbooks scaffold questions to gradually build student understanding and skills. They are designed to provide students with the opportunity to apply their knowledge in a range of question types, while also preparing them for their internal assessments and the VCE Physical Education exam in Year 12.

WORKBOOK FEATURES

- A range of multiple-choice, short-answer and extended-response questions for valuable end-of-year exam practice is included.
- The workbooks include both past VCAA exam questions and exam-style questions to emulate the exam as closely as possible.
- Unique exam-style questions are crafted by a trusted author team with experience in writing the VCE exam, and are designed to maximise exam success.
- Questions contain up-to-date data and research and case studies to allow students to apply their skills and understanding to real-world situations.
- Exemplar answers are provided to all questions.





ABOUT THE AUTHORS

Professor **Amanda Telford** (PhD) is a teacher and researcher in health and physical education, wellbeing, physical activity and educational leadership within the National School of Education, Faculty of Education and Arts, at the Australian Catholic University. Amanda has over two decades experience in senior learning and teaching leadership roles as a former secondary teacher and academic across four universities, including as Associate Dean Education (Learning & Teaching), Deputy Head of School (Learning & Teaching), Interim Associate Dean (Partnerships), Course Co-ordinator for the Master of Education and director/program manager of Health and Physical Education teacher education degrees. Amanda is a multi-award-winning teacher, researcher and author. She has co-authored over 100 learning and teaching publications, including over 50 peer-reviewed journal articles and over 50 textbooks and book chapters used nationally and internationally at secondary and tertiary level. Amanda has collaborated on more than 45 research projects (over 3 million dollars of grants) with a learning and teaching, physical activity and/or wellbeing focus. As co-founder and co-director, with Rob Malpeli, of Peak Phys Ed, Amanda has been the conference director of the Discovery Health and Physical Education conferences since 2009, supporting thousands of teachers nationally.

Dr Rachael Whittle (PhD) is a highly respected educator with extensive experience in the development of VCE Physical Education curriculum, and has vast teaching experience in both secondary and tertiary education settings. She has developed and delivered teacher professional learning, both nationally and internationally, on her area of expertise, which is senior secondary Physical Education curriculum, pedagogy and assessment. Rachael was involved in the development and assessment of high-stakes examinations for VCE Physical Education in Victoria for almost 20 years. Her research focus for her doctoral studies focused on influences on academic performance in VCE Physical Education.

Rob Malpeli is based at The Knox School, Victoria. Rob works across multiple schools throughout Victoria, but also in other states, and has been a leading light in senior Physical Education for over 30 years. His texts and resources are used in Victoria, New South Wales, Queensland, Western Australia and New Zealand. Rob has led professional learning sessions in HPE for teachers across multiple states over the last 20 years. He has been involved in curriculum benchmarking and focus groups that investigate curriculum improvements, and was previously a member of the Study Design panel.

Monique Sharp is currently Head of Health and Physical Education at Melbourne Girls Grammar School. She has taught VCE Physical Education for over 10 years and is an experienced assessor. Monique spent two years working in an exercise physiology laboratory and RTO, administering laboratory tests such as the VO_2 maximum test and working to deliver and assess Certificate III and IV fitness and training. She has written chapters in textbooks for Years 7–10 in the NSW syllabus. She has delivered lectures and created support material for a variety of support organisations, including the Australian Council for Health, Physical Education and Recreation (ACHPER) in the VCE space.

Mark Corrie is the Assistant Principal at Scoresby Secondary College, where he continues to teach VCE Physical Education. He has been a Physical Education exam assessor for over 30 years. A respected presenter at numerous conferences for both teachers and students throughout the state, Mark was also a member of the VCAA review board that developed the previous (2017–2024) and current (2025–2029) study designs for VCE Physical Education.

I would like to dedicate this book to an absolutely incredible physical educator Dr Toni Hilland who I had the opportunity to work closely with at RMIT (2018–2022). Toni has been an inspiration to so many people in her village as an educator, strong advocate in the fight against breast cancer, friend, mother and winner of the 2022 Amazing Race on Channel 10.

Toni your passion, talent, sense of humour, bravery and love will remain in our hearts forever!

Amanda Telford

PE GAMEPLAN

Welcome to VCE Physical Education Units 1&2

Your decision to study VCE Physical Education (PE) will reward you not only throughout this year, but also well into the future. Studying PE will allow you to explore the way your body performs, along with factors that influence the decisions you make. Hopefully, your 'learnings' in physical education will contribute to a healthier and more physically active lifestyle throughout this year and the rest of your life.

This student book, the accompanying workbook and the digital resources located on Nelson MindTap have all been designed and written to meet the requirements of the *VCE Physical Education Study Design 2025–2029*. All key knowledge and key skills will be addressed and, more importantly, via close links between theory and active participation in practical activities, you will develop and expand your physical knowledge and behaviours through movement and physical activity.

You will take learnings and key knowledge from the classroom and make real world connections by applying these to physical activity, sport and exercise contexts. This will occur through participation in practical classes, school sport and any form of physical activity you undertake outside school as well.

We hope that you engage in your PE studies in a positive way and that this sets up a lifelong pattern of participation in physical activity.

Best wishes from
Amanda Telford, Rachael Whittle, Rob Malpeli, Monique Sharp and Mark Corrie

VCE Physical Education course overview

VCE Physical Education consists of four units of study, with at least 50 hours of scheduled instruction for each. Each unit addresses specific and, in some cases, integrated content and is designed to enable students to achieve a set of outcomes for that unit.

There are no prerequisites for entry to Units 1, 2 and 3. Students must undertake Unit 3 and Unit 4 as a sequence. Units 1–4 are the equivalent standard of the final two years of secondary education.

Unit and content with areas of study	Student/Study requirement
Unit 1: The human body in motion	
Area of Study 1 **(Chapters 1, 2 & 3)** How does the musculoskeletal system work to produce movement?	• apply and use anatomical terminology to identify the structures and functions of the muscular and skeletal systems in producing human movement • participate in and analyse a variety of movements used in physical activity, sport and/or exercise to explain the interaction between bones, muscles, joints and joint actions using examples of lever systems responsible for producing movement • examine different types of muscle contractions and differentiate the role of agonists, antagonists and stabilisers in movement • investigate and describe the relationship between motor unit recruitment, activation and force production in movement • explore a variety of causes of musculoskeletal injuries • implement and describe the correct application of physical aids and physiological strategies in a variety of sporting activities to maintain optimal functioning of the musculoskeletal system • investigate, evaluate and critically analyse a range of performance enhancing practices on the musculoskeletal system from a physiological perspective

Unit and content with areas of study	Student/Study requirement
Area of Study 2 **(Chapters 4, 5 & 6)** What role does the cardiorespiratory system play in movement?	▪ apply and use anatomical terminology to identify the structures and function of the cardiovascular and respiratory systems ▪ collect primary data to measure and analyse the changes to the cardiovascular and respiratory systems at rest compared with various exercise intensities ▪ examine the role and process of thermoregulation through participation in physical activity, sport and/or exercise ▪ investigate and describe the process of gaseous exchange ▪ evaluate the impact of regular aerobic exercise on enhancing the capacity and functioning of the cardiovascular and respiratory systems ▪ investigate, evaluate and critically analyse a range of performance enhancing substances and methods on the cardiorespiratory system from a physiological perspective ▪ explore the ethical and sociocultural considerations on the use of permitted and prohibited performance-enhancing substances and methods
Unit 2: Physical activity, sport, exercise and society	
Area of Study 1 How does physical activity, sport and exercise contribute to healthy lifestyles? **(Chapters 7, 8, 9, 10, 11, 12 & 13)**	▪ participate in and explain different types of movement experiences including a variety of culturally diverse and inclusive physical activities ▪ participate in a variety of movement experiences to reflect on and record information related to the physical, social, mental, emotional and spiritual benefits of physical activity ▪ investigate through participation, the sociocultural influences on physical activity behaviour across the lifespan ▪ describe the physical activity and sedentary behaviour guidelines for different age population groups ▪ analyse and interpret secondary data related to physical activity behaviour to explain outcomes of physical activity and sedentary behaviour ▪ justify and use appropriate methods to measure and analyse physical activity and sedentary behaviour at the individual and population level ▪ apply the social-ecological model to critique and create physical activity initiatives and strategies aimed at increasing physical activity and/or reducing sedentary behaviour ▪ explain health-related fitness components including factors affecting each component ▪ select and justify an appropriate FMA for a targeted individual/group from a physiological, psychological and sociocultural perspective ▪ conduct and analyse a FMA using reliable, valid and accurate methodology ▪ using self-management skills, design a sustainable personalised plan that promotes adherence to physical activity and sedentary behaviour guidelines ▪ implement strategies from a personalised plan to gather primary data about strengths and limitations of the program design
Area of Study 2 What are the contemporary issues associated with physical activity and sport? **(Investigation based on Chapters 7, 8, 9, 10, 11, 12 & 13)**	▪ intrapersonal issues that influence access, inclusion, participation and performance in physical activity and sport such as: - hormonal considerations for physical activity prescription - injuries and safety such as concussion and knee injuries - psychological skills, including sleep and accompanying strategies - mental fitness, including the role of physical activity and the responsibility of elite sport pathways ▪ interpersonal issues that influence access, inclusion, participation and performance in physical activity and sport such as: - geographic location (rural and urban) - coaching (styles, planning/program design and ethical behaviour such as safeguarding athletes) - sports technology and the impact of media on beliefs and behaviour - institutional and structural inclusion and equity in sport (Aboriginal and Torres Strait Islander people, cultural diversity, physical and intellectual ability diverse, and gender and sexual diversity) - gender equity such as pay gap, and representation in coaching positions and decision-making bodies at the local, national and global level

Unit and content with areas of study	Student/Study requirement
	▪ key concepts within the selected contemporary issue linked to participation in physical activity and/or sport in society ▪ local, national and/or global perspectives of the selected issue ▪ historical, current and future implications of the selected issue ▪ propose ethical strategies to enhance access, inclusion, participation and performance in physical activity and sport ▪ propose ethical strategies to enhance access, inclusion, participation and performance in physical activity and sport

Assessment in VCE Physical Education

Units 1 and 2 Physical Education assessments

Unit and content with areas of study	Assessment tasks
Unit 1: The human body in motion	
Area of Study 1 How does the musculoskeletal system work to produce movement?	**Internal Assessment Tasks** All assessments at Units 1 and 2 are school based and levels of achievement are a matter for schools to decide. A suitable assessment task for Outcomes 1 and 2 is: ▪ A written report analysing participation in at least four physical activities that demonstrates the integration of theoretical knowledge and practical application of how the musculoskeletal and cardiorespiratory systems work together.
Area of Study 2 What role does the cardiorespiratory system play in movement?	Additionally, at least one task for the assessment of each of Outcomes 1 and 2 is to be selected from the following: ▪ a practical laboratory report linking key knowledge and key skills to a practical activity or practical activities ▪ a case study analysis ▪ a data analysis ▪ an extended response question that uses a visual planning tool such as a concept/mind map to synthesise information and develop a response ▪ a visual presentation such as an annotated poster ▪ a multimedia presentation, including two or more data types (for example, text, still and moving images, sound) and involving some form of interaction or simulation ▪ an oral presentation such as a podcast or debate.
Unit 2: Physical activity, sport, exercise and society	
Area of Study 1 How does physical activity, sport and exercise contribute to healthy lifestyles?	For this unit students are required to demonstrate two outcomes. As a set these outcomes encompass the areas of study in the unit. A suitable assessment task for Outcome 1 is: ▪ A written plan designed to either increase physical activity levels and/or reduce sedentary behaviour for an individual or a selected group based on reflections from participation in physical strategies/programs designed to promote physical activity and limit sedentary behaviour.
Area of Study 2 What are the contemporary issues associated with physical activity and sport?	Suitable tasks for assessment of Outcome 2 may be selected from the following: ▪ an extended response question that uses a visual planning tool such as concept/mind map to synthesise information and develop a response ▪ a multimedia presentation, including two or more data types (for example, text, still and moving images, sound) and involving some form of interaction or simulation ▪ an oral presentation ▪ a written report.

Using a reflective folio to consolidate learning

Students undertaking VCE PE must maintain a reflective folio of practical activities completed in each of Units 1–4. These can include activities conducted in a classroom, field or gym setting. They do not necessarily need be dedicated as 'pracs', for example, they might involve a teacher demonstration of a concept followed by a brief set of activities performed in and around the classroom, and might not require students to change into their PE gear. This will strengthen the understanding of concepts across areas of study and be used for reflection and assessment purposes.

Making connections

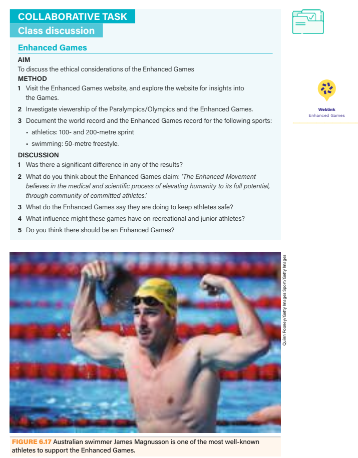
The use of a Reflective folio throughout Units 1–4 gives students the opportunity to reflect on their participation and make interdisciplinary theoretical connections that extend beyond the key knowledge and key skills being explored at that time. Due to the standalone nature of Units 1 and 2 and the absence of Area of Study 3, students completing Units 1 and 2 are encouraged to use the Reflective folio to make connections to knowledge across each unit in an integrated manner.

Source of data

Your Reflective folio will be a source of primary data (see data collection section) and as a requirement for satisfactory completion of each unit.

The Reflective folio gives students the opportunity to reflect on and record perspectives on their participation in each activity completed. When you reflect on an activity, don't just describe what happened during the session. Instead, think about how the activity connects to the content being covered in class and what you learned as a result of your participation. Reflective folio data may include:

- a description of the activity and any session goals
- physical experiences of the activity – how did it feel physically?
- emotional experiences within the activity – was it enjoyable?
- social experiences within the activity – if applicable, describe the interaction and/or teamwork within the activity
- mental experiences within the activity – describe your motivation to undertake and complete the activity. What was the level of challenge during the activity?
- spiritual experiences within the activity – was the activity relaxing? Did you find yourself thinking deeply within the activity?
- theoretical links within the activity – guide questions and discussion points provided by teachers give students the opportunity to connect concepts. What other theoretical concepts explored this year can you connect to this activity?


COLLABORATIVE TASK
Class discussion

Enhanced Games

AIM
To discuss the ethical considerations of the Enhanced Games

METHOD
1 Visit the Enhanced Games website, and explore the website for insights into the Games.
2 Investigate viewership of the Paralympics/Olympics and the Enhanced Games.
3 Document the world record and the Enhanced Games record for the following sports:
- athletics: 100- and 200-metre sprint
- swimming: 50-metre freestyle.

DISCUSSION
1 Was there a significant difference in any of the results?
2 What do you think about the Enhanced Games claim: *'The Enhanced Movement believes in the medical and scientific process of elevating humanity to its full potential, through community of committed athletes.'*
3 What do the Enhanced Games say they are doing to keep athletes safe?
4 What influence might these games have on recreational and junior athletes?
5 Do you think there should be an Enhanced Games?

Weblink
Enhanced Games

Quinn Rooney/Getty Images Sport/Getty Images

FIGURE 6.17 Australian swimmer James Magnusson is one of the most well-known athletes to support the Enhanced Games.

You will find a Reflective folio icon beside practical activities throughout this student book as a reminder to record the primary data and your observations after each activity.

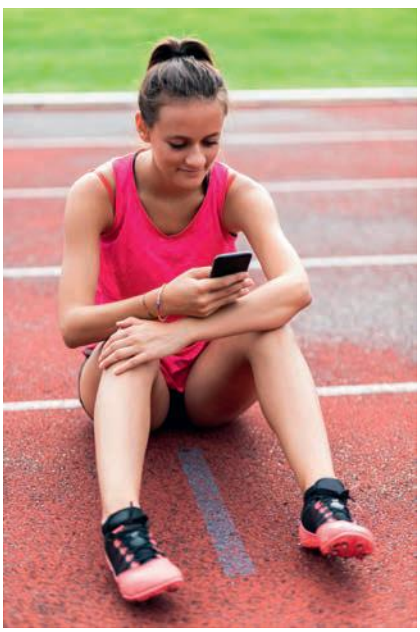
Resource
Reflective folio template

Recording your reflections

Reflective folio entries can be in one or more formats: written, visual (drawing, photo), audio (a self-recorded audio) or audiovisual (self-recorded video). Some students may decide to record their reflective folio on their mobile phones via interview-style recordings. Students are expected to make direct reference to their involvement in practical activities via entries in their Reflective folio.

Participant:		Goal:	
Day/date:	Time:	Venue:	Weather:
Session details			
Frequency			
Intensity			
Time			
Type			
Form of physical activity			
Reflection: ▪ Barriers ▪ Enablers ▪ Benefits ▪ **guide questions set by teacher**			
Sketch			

Westend61 GmbH/Alamy Stock Photo



You can use your smart phone to complete your reflections.

Understanding command terms

While being assessed in VCE Physical Education, you will be asked questions that include specific ‘command terms.’ These are ‘action words’ and are also known as ‘cognitive verbs.’ They ask you to demonstrate your level of understanding of key knowledge. The following table is based on one provided by VCAA that lists the command words and their definitions. We have added sample questions as examples of their use in the form of an exam question.

Term	Explanation	Sample question using command term
account of	Describe a series of events or transactions.	Give an **account of** how participation in the 'early bird fitness classes' has affected your motivation to participate in higher levels of physical activity.
account for	State reasons for; report on.	After considering the heart rate data, **account for** why there was a higher frequency of walking and jogging by the midfielder in the second half of the game.
analyse	Identify components/elements and the significance of the relationship between them; draw out and relate implications; determine logic and reasonableness of information.	**Analyse** the effect working above the lactate threshold has on performance.
apply	Use; employ in a particular situation or context.	**Apply** your understanding of force summation in a demonstration of the hockey push.
assess	Make a judgment about, or measure, determine or estimate, the value, quality, outcomes, results, size, significance, nature or extent of something.	**Assess** the validity and reliability of the fitness test chosen to measure levels of muscular endurance.
calculate	Determine from given facts, figures or information; obtain a numerical answer showing the relevant stages in the working; determine or find (e.g. a number, answer) by using mathematical processes.	**Calculate** the maximum heart rate for a 30-year-old and state the range of their continuous training zone.
clarify	Make a statement or situation more comprehensible.	**Clarify** what is meant by the term 'reciprocal inhibition.'
compare	Recognise similarities and differences and the significance of these similarities and differences.	**Compare** three characteristics of slow-twitch and fast-twitch muscle fibres.
construct	Make, build, create or put together by arranging ideas or items (e.g. an argument, artefact or solution); display information in a diagrammatic or logical form.	**Construct** a flow chart to show the sequencing of body parts involved in performing the shot-put.
contrast	Show how things are different or opposite.	**Contrast** the different distances a baseball can be struck from the tee when using different types of grip.
deduce	Draw a conclusion from given information, data, a narrative, an argument, an opinion, a design and/or a plan.	Based on your data/survey results, **deduce** a program that might increase the number of students who meet the sedentary behaviour guidelines.
define	Give the precise meaning and identify essential qualities of a word, phrase, concept or physical quantity.	**Define** the term 'qualitative movement analysis.'
demonstrate	Show ideas, how something can be done or that something is true by using examples or practical applications, or by applying algorithms or formulas.	**Demonstrate** your understanding of how constraint-based coaching can be used to improve performances in hockey.
describe	Provide characteristics, features and qualities of a given concept, opinion, situation, event, process, effect, argument, narrative, text, experiment, artwork, performance piece or other artefact in an accurate way.	**Describe** the type of coaching and feedback a national level soccer player is likely to be receiving.
discuss	Present a clear, considered and balanced argument or prose that identifies issues and shows the strengths and weaknesses of, or points for and against, one or more arguments, concepts, factors, hypotheses, narratives and/or opinions.	**Discuss** possible reasons why there is a sharp drop-off in participation rates in sport and recreational pursuits among students once they complete Year 10.
distinguish	Make clear the differences between two or more arguments, concepts, opinions, narratives, artefacts, data points, trends and/or items.	By referring to the case study data, **distinguish** why males will almost always have faster running times in the marathon than females.

Term	Explanation	Sample question using command term
evaluate	Ascertain the value or amount of; make a judgment using the information supplied, criteria and/or own knowledge and understanding to consider a logical argument and/or supporting evidence for and against different points, arguments, concepts, processes, opinions or other information.	**Evaluate** the effectiveness of performing a warm-up on the ability of a muscle to produce force.
examine	Consider an argument, concept, debate, data point, trend or artefact in a way that identifies assumptions, possibilities and interrelationships.	**Examine** the playing intensities in the last 3 minutes of the game and discuss the energy system interplay. Your response should include fatigue factors that might influence energy system use.
explain	Give a detailed account of why and/or how with reference to causes, effects, continuity, change, reasons or mechanisms; make the relationships between things evident.	**Explain** why people living in areas with high-density housing are likely to have lower participation rates in physical activity than those living in regional areas.
extract	Select relevant and/or appropriate detail from an argument, issue or artefact.	Refer to the table and **extract** any evidence that supports the notion that centre players have higher levels of aerobic power than key defenders.
extrapolate	Infer and/or extend information that may not be clearly stated from a narrative, opinion, graph or image by assuming existing trends will continue.	The graph shows the heart rate during 3 minutes of a passive recovery. **Extrapolate** and draw what you believe this would be like if the subject had performed an active recovery.
identify	Recognise and name and/or select an event, feature, ingredient, element, speaker and/or part from a list or extended narrative or argument, or within a diagram, structure, artwork or experiment.	**Identify** the top three barriers VCE students find to participating in more physical activity than they currently do.
infer	Derive conclusions from available information or evidence, or through reasoning, rather than through explicit statements.	Use the graph to **infer** the relationship between practice frequency and performance improvement.
interpret	Draw meaning from an argument, point of view, description or diagram, text, image or artwork and determine significance within context.	Use the information presented in the case study to **interpret** the influence peers have on participation in physical activity.
investigate	Observe, study or carry out an examination in order to establish facts and reach new conclusions.	**Investigate** the effectiveness of different types of practice on performing open and closed skills.
justify	Show, prove or defend, with reasoning and evidence, an argument, decision and/or point of view using given data and/or other information.	**Justify** the decision to include performing bone-strengthening activities in the Australian physical activity guidelines for older adults (65+ years of age).
list	Provide a series of related words, names, numbers or items that are arranged consecutively.	**List** two factors that affect the application of muscular power.
name	Provide a word or term (something that is known and distinguished from other people or things) used to identify an object, person, thing, place etc.	**Name** the mechanism that summarises the redistribution of blood to different parts of the body during exercise.
outline	Provide an overview or the main features of an argument, point of view, text, narrative, diagram or image.	**Outline** two reasons why an informed consent process needs to be undertaken before any fitness testing is conducted.
persuade	Induce (someone) to do something through reasoning or argument; convince.	After considering the evidence presented, **persuade** another classmate that warm-ups do not reduce the likelihood of injury during competitions.

>

Term	Explanation	Sample question using command term
predict	Give an expected result of an upcoming action or event; suggest what may happen based on available information.	**Predict** what would happen to the rate of improvement if the subject applied overload to training volumes by 5% every week.
propose	Suggest or put forward a point of view, idea, argument, diagram, plan and/or suggestion based on given data or stimulus material for consideration or action.	**Propose** a way of improving the outcomes of the training program given the training diary entries and reflections.
recall	Present remembered ideas, facts and/or experiences.	**Recall** the key stages in the socio-ecological model.
recommend	Put forward and/or approve (someone or something) as being suitable for a particular purpose or role.	**Recommend** two ways in which bone density can be maintained once people retire from full-time work at the age of 65.
recount	Retell a series of events or steps in a process, usually in order.	**Recount** the four parts of a RAMP protocol.
state	Give a specific name or value or other brief answer without explanation or calculation.	**State** the antagonist muscle while performing a biceps curl (elbow flexion).
suggest	Put forward for consideration a solution, hypothesis, idea or other possible answer.	**Suggest** the main cause of fatigue experienced by the netball centre by referring to the graph below.
summarise	Retell concisely the relevant and major details of one or more arguments, text, narratives, methodologies, processes, outcomes and/or sequences of events.	**Summarise** primary and secondary data about enablers and barriers to physical activity in your chosen group and provide three recommendations that might increase the uptake and continued participation in physical activity.
synthesise	Combine various elements to make a whole or an overall point.	The movement sequence **synthesised** elements from each of the three fundamental movement skills developed as a child.

Collecting and using data

As well as the key knowledge covered in class, you will be required to conduct research and collect data. Knowing how to collect, analyse and draw appropriate conclusions from your data will increase your understanding of key factors influencing participation and performance in physical activity. During the study of Physical Education you will be required to draw on a combination of primary and secondary data.

Primary data

Primary data is data that you collect (either individually or as a team).

- Observations: these are data gathered while watching performances, events or behaviours, and should be supported by note-taking for future reference. Recording/data sheets and checklists are often used when collecting data in this way. The data can be either qualitative or quantitative, or a combination of both. Plan ahead, think about what it is you are hoping to observe/capture and, if possible, practise beforehand to become familiar with what is involved.
- Digital recordings: these include recordings made using mobile phones, tablets, drones and other digital video equipment. Prepare ahead of time and consider what needs to be captured/collected, the best positioning of the recorder, and whether wide-angle or close-up will give best capture. Downloading and saving your recordings allows them to be archived and shared with others, as well as ensuring they are not deleted or recorded over.

- Reflective folios: this record of your feelings, opinions and thoughts on participation in an activity is an important way of collecting primary data. This is qualitative data, on the whole, and provides links to key knowledge covered in class as well as the performance context and outcomes.
- Interviews: these are generally conducted face to face and allow you to collect qualitative data. It is a great idea to record discussions (audio or video) so this can be stored and referred to in future. Plan ahead, prepare questions you will ask and rehearse these on a classmate. Be prepared to expand on your list of questions and change them based on the responses provided by the person being interviewed.
- Surveys/questionnaires: these involve respondents answering a set of questions in writing or online. Both qualitative and quantitative data can be collected. Questions need to be carefully constructed: you cannot provide further explanation as they are completed remotely.

Secondary data

Secondary data is data that has been collected by others, which you can use to increase your understanding and apply to your existing knowledge.

- Published sources: these include textbooks, magazines, newspapers, journals, TV news reports, and reports by governments and sporting associations.
- Online sources: this option offers the easiest access and can include websites, online journals, news sites and blogs.

Acknowledging sources and citations

While conducting research, you need to keep a record of details that will be cited in your reference list or bibliography. You should check with your teacher as to which style or format is required (e.g. APA, Harvard). In most cases, details need to include:

- author surname(s) and initial(s)
- year of publication
- title of book/document
- date of publication/posting
- publisher/organisation name
- page(s)/URL/web address.

Using AI in your research

Before using artificial intelligence (AI) for any of your research, make sure that you check with your teacher that your school allows this.

If you use AI to generate text or images, you should acknowledge this in your citations, just as you would for a human author, artist or photographer. If your school and your teacher allow you to use AI, you must cite each time you include something AI-generated.

Several citation guides have released official or semi-official guidance on how to cite AI-generated content. You can cite AI in your work using the APA guidelines below:

- author – the creator of the AI (e.g. OpenAI, Google)
- date – the date the content was generated
- title – the name of the AI tool (e.g. ChatGPT, Bard)
- version – the version of the AI tool (be as specific as possible)

- description – in brackets, clarify whether this is a large language model, or another specific type of generative AI
- location – the URL for the tool. If possible, give the URL for the specific content. (**Note**: It is now possible to send someone a URL of your ChatGPT conversation. This is the URL you should use in your citation.)

How to cite your sources

Citations and their formatting are time-consuming and might seem irritating, but they are an important part of providing reliable information to an audience. Writing gets its credibility from sourcing the claims it makes. Readers need to be able to fact-check a writer's sources and trace where the claims made in a piece come from.

Data collection and analysis follows a detailed step-by-step process and should include:

Defining goals

Starting with a clear objective is an essential step in the data collection process. Before you start collecting data, you need to first understand why you are collecting data and what you anticipate doing with it.

Data collection

What *type* of data do you need to help your investigation, and where are you going to source it from – primary or secondary sources?

Data 'cleaning'

Data cleaning converts 'raw' data into data that is suitable for analysis. This process involves removing incorrect, invalid and inaccurate data and checking for any inconsistencies.
This is a vital step in the data analysis process because the accuracy of your analysis will depend on the quality of your data.

Data analysis

In this step, you'll begin to make sense of your data to extract meaningful insights, information and recommendations. Here are three different data analysis techniques and processes you might consider:

- **Descriptive analysis** seeks to answer the question, 'What happened?'
  This method will identify what is doing well and what needs improvement.
- **Diagnostic analysis** seeks to answer the question, 'Why did this happen?'
  This method of analysis is the most abstract and involves detecting correlations between different variables.
- **Prescriptive analysis** seeks to answer the question, 'What should we do?'
  This method of analysis determines the best course of action based on previous analyses.

Communication of findings

This involves converting the data into formats that can easily be understood by the people you are communicating with. Consider converting large amounts of information that might be in a table, survey or interview and 'chunking' it into graphs, infographics or short summary videos. This should include summaries and conclusions of your findings.

Adapted from Erdelyi, L. (2020), 'The five stages of the data analysis process', Lighthouse Labs

Tests and exams

Test and examination format

Many schools will use end of unit tests and/or exams as part of their student assessment. These may include the following sections:

Section A: multiple-choice question

Section B: short-answer and extended-answer questions, including integrated questions with multiple parts.

Section C: extended and integrated response questions, requiring students to make connections to knowledge across each unit in an integrated manner.

This may include questions that refer to visual and/or written material, including scenarios.

Examination conditions

Any Unit 1 and 2 examinations, when conducted by schools, are developed by your teachers and, if there are multiple classes, will usually be sat under the same conditions. These are internally marked by PE teachers at your school.

Chinnapong/Shutterstock.com

Reading time

As the name suggests, during this time you can *only* read and not write anything down. You are not allowed to pick up your pen, so do not even write your name or student number. Wait for the supervisor or teacher to give you the all-clear to start writing. Reading time is vital to familiarise yourself with each question and the associated stimulus material (graphs, images, tables etc.) and start to mentally plan your responses. It is also important that you mentally note the command terms in questions and zero in on how you are being asked to respond to a question (more on this to come).

Reading time is when you work out a 'plan of attack' – how you intend to approach the responses. You do not need to answer the questions in any specified order or numerically and should answer questions you feel most comfortable first – this forms part of your plan. Some students like to answer the multiple-choice section first, while others leave this until they have attempted the other section(s) – it's totally up to each individual student.

Research has shown that students who answer questions they feel most comfortable with first approach the exam with a more positive mindset, tend to have more time to devote to longer questions, and generally perform better than those who are more challenged by questions they consider in numerical order. It is worth noting that the VCAA tends to develop exams in which Question 1 is fairly straightforward in an effort to ease any nerves students may have. Many Unit 1&2 tests and exams used by teachers will follow the same format. This should allow you to proceed with higher levels of confidence than had the question been more difficult to respond to, requiring more information-processing and cognitive thought in creating a response.

Writing time

Do not start writing anything until you have reread the question and underlined or highlighted the command terms and anything that is relevant from the stimulus material. Images, graphs, tables etc. are not placed in exams to make them look pretty or to confuse students.

Unpacking any stimulus material

All stimulus material needs to be carefully considered and referred to in some way in your response. Before responding, underline the axis labels and heading, highlight the key parts of a table (this could be column headings) and look for trends and relationships between variables being presented for your consideration.

a. Identify **one** method of data collection that a coach could have used to obtain the data above and provide **one** benefit of using this method. 2 marks

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Identifying command words

Command terms or 'action words' are also known as cognitive verbs (see the list on pages xv–xvii). These actions are used to demonstrate your level of understanding of key knowledge and in most cases appear at the start of a question. This tells you how you should respond.

Let's consider two different commands for an otherwise identical question and how this significantly changes the way you are expected to respond.

Sample question: **Justify** why progression was applied during week 6 of the training program.
Justify: show, prove or defend an argument
Sample answer: *Progression was applied during week 6 because the subject indicated that training was becoming easy and the fitness test results showed significant improvement from pre-test values.*

Sample question: **Identify** how progression was applied during week 6 of the training program.
Identify: recognise and name an example
Sample answer: *Progression was applied during week 6 by increasing the duration of the continuous run from 25 minutes to 27 minutes. Additionally, the training diary reveals an additional repetition was undertaken for each of the long-interval runs. The subject went from three sets of 5 x 600 m runs at 85% maxHR to three sets of 6 x 600 m.*

Multiple-choice questions

Multiple-choice questions will not include the same command words, and are generally structured to ask you 'what', 'why', 'which', 'how' etc. They will most likely refer to stimulus material, and once again this needs to be carefully considered before you try to eliminate the responses that cannot be correct, and thus end up with the correct, or most correct, response. Once you have 'knocked out' each incorrect response, put a line through this letter on the exam booklet. Why? If you find yourself thinking that there could be two possible responses to a multiple-choice question, asterisk the question or use another signal that reminds you to come back to it before the end of the exam. If you have already drawn a line through incorrect options, you will then only need to decide between two, rather than all four, options. Never leave a multiple-choice question unanswered: at least make an educated guess!

What the marks and answer lines for a question can tell you

Pay attention to the marks allocated per question (or question part) as well as the number of lines or amount of space provided for your response. Both indicate the depth and level of detail your response needs. For example, a question asking you to outline may be worth 2 marks, whereas another that seeks you to explain may have 4 marks associated with it and twice the number of lines provided. If.you find yourself needing to write more than the space provided, it may be that you have included irrelevant information.

Remember – clear and concise responses score better than long and convoluted ones. If you find it difficult to contain your responses into the space provide during trial exams, make sure to work on this. Otherwise, you may find yourself running out of time and not answering all the questions on the exam or rushing to complete them all (both will result in you performing below your best). Similarly, if you have many lines left after you have finished your response, ask yourself if you have addressed all aspects of the question.

Do not restate the question in your answer or simply state facts and/or chunks of information, hoping the teacher will sift through these to find marks for the correct parts!

The key knowledge you have attained during the year has been applied to practical activities, SACs and other internal tasks via key skills you have developed. These skills will allow you to interpret, analyse, explain and evaluate what is in the question and structure an appropriate response.

Extended-response questions

Extended-response questions will consist of multiple parts and require students to call upon their knowledge of different key concepts and parts of coursework contained in different units of study. It's often a good strategy to make a list of bullet points you intend to include before starting your response. This will encourage you to think about all relevant aspects and possible links between them. This is like creating a plan before writing an English essay and referring back to it to ensure you have covered everything.

Make sure you address every part of the extended question being asked. You can use diagrams to assist your response and demonstrate your understanding (in some questions this is a stated requirement). Extended responses require careful attention to ensure you have linked together the different parts of the course, as required. For example, you might be required to discuss different practice settings and types of feedback that can be used alongside biomechanical principles to improve movement sequences. Or you could be required to discuss how energy system fatigue needs to be considered when designing a program to target certain fitness components for improvement, while maintaining others identified as strengths.

FINAL NOTE

Participating in practical activities with regular reflections throughout the year will strengthen links between the theory/key knowledge covered in class and physical activity (real world and sporting) contexts. Making strong connections between the two throughout the year, as well as own personal participation in sport outside school, is vital in consolidating key learnings and understandings.

Jeffrey Isaac Greenberg 18+/Alamy Stock Photo

UNIT 1

THE HUMAN BODY IN MOTION

snaptitude/Adobe Stock

- explores how the musculoskeletal and cardiorespiratory systems work together to produce movement.
- investigates the role and function of the main structures in each system and how they respond to movement.
- explores and analyses the relationships between the body systems and movement, and responses at various intensities.
- investigates possible conditions and injuries associated with the musculoskeletal system and recommends and implements strategies to minimise and manage these.
- considers the ethical implications of using permitted and prohibited practices to improve the body systems' performance and evaluates perceived physiological benefits and describing potential harms.

UNIT 1

CHAPTER

1

THE MUSCULOSKELETAL SYSTEM

UNIT 1 – AREA OF STUDY 1

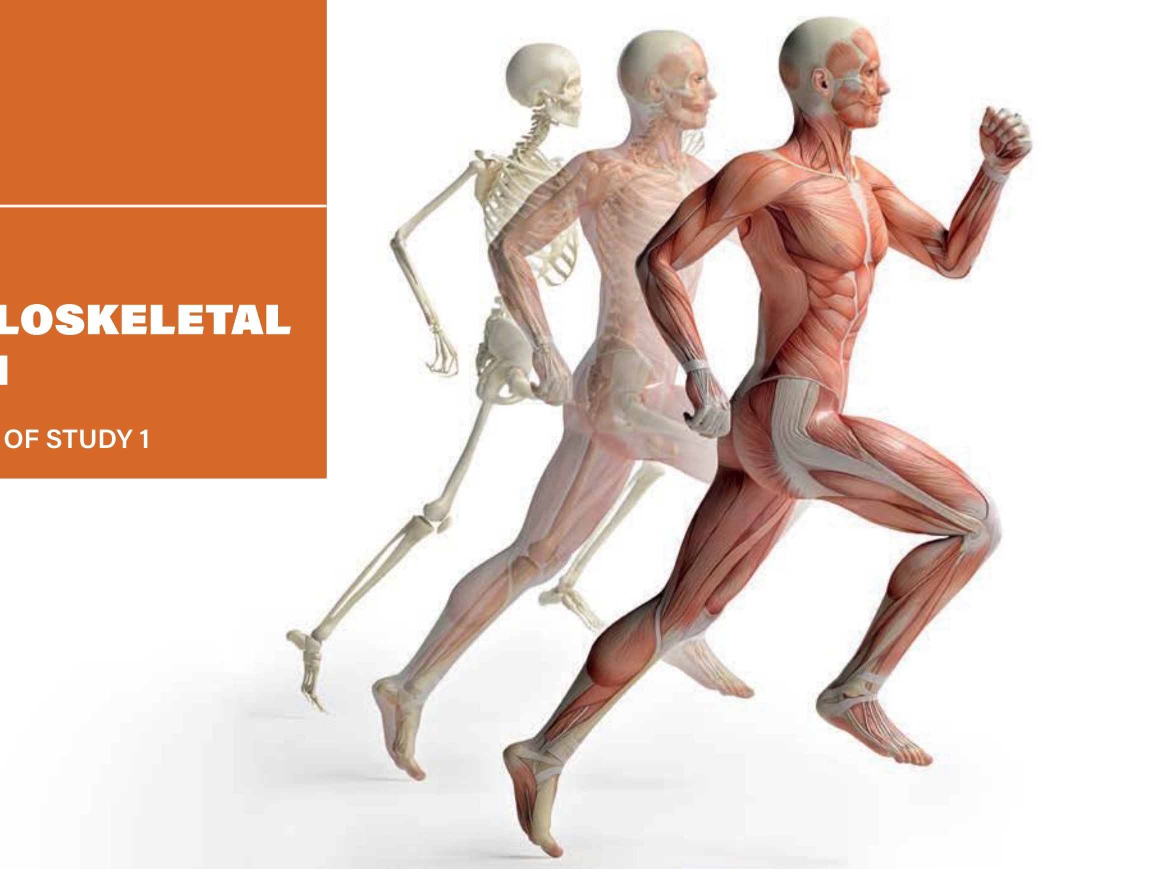


FIGURE 1.01 The interaction between the muscular and skeletal systems is what puts the body in motion!

Quizzes

Chapter 1 Pulse check

1.1 Check-in questions

1.2 Check-in questions

1.3 Check-in questions

1.4 Check-in questions

Chapter 1 Review

Videos

Masterclass: Chapter 1

1.1 In focus: Planes and axes of motion

1.2 In focus: Joint actions

1.3 In focus: Sliding filament

1.3 In focus: Motor unit recruitment

Resources

1.2 Worksheet: Labelling the skeleton

1.3 Worksheet: Labelling muscles

1.3 Template: Musculoskeletal analysis of movement

Chapter 1 Self-assessment checklist

Nelson MindTap

To access resources above, visit **cengage.com.au/nelsonmindtap**

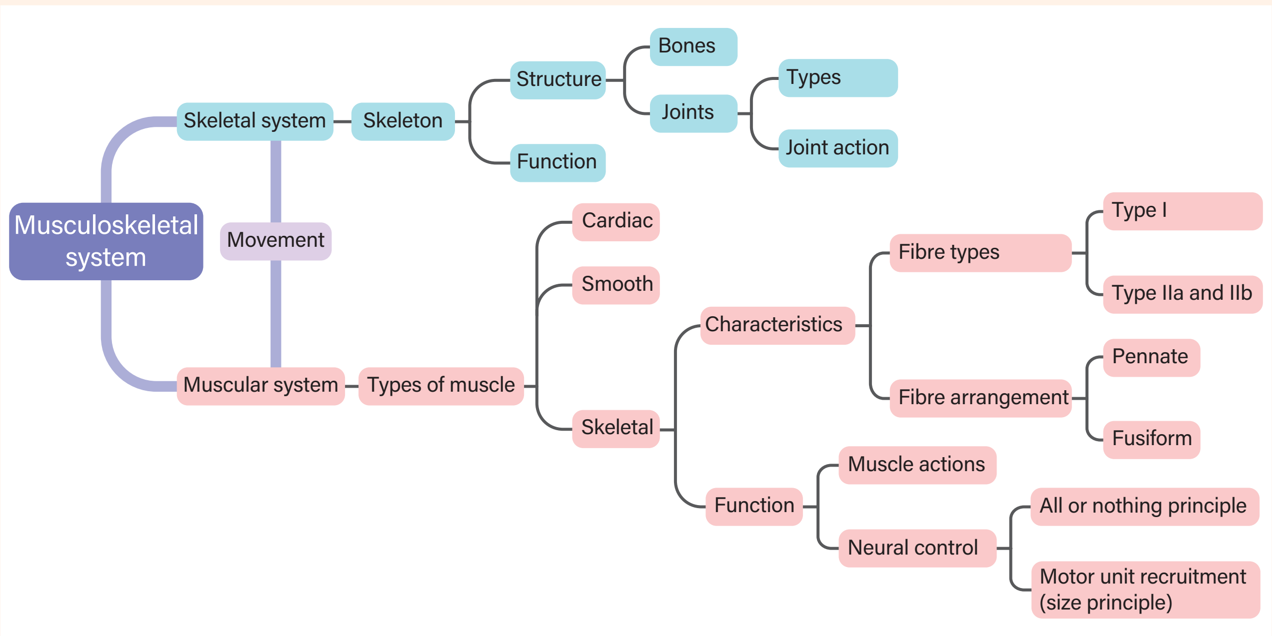
KEY KNOWLEDGE

- structure and function of the skeletal system:
  - bones of the human body
  - classification of joints
  - joint actions
- major muscles of the human body
- characteristics and functions of muscle fibres such as fibre arrangement and type (fast twitch and slow twitch)
- types of muscular contractions (concentric and eccentric and isometric)
- concept of reciprocal inhibition (the role of agonists, antagonists and stabilisers)
- neural control of muscles including the recruitment (size principle) and activation (all or nothing principle) of motor units in relation to force production
- interactions of muscles and bones to produce movement including the structure and examples of anatomical lever systems

KEY SKILLS

- apply and use anatomical terminology to identify the structures and functions of the muscular and skeletal systems in producing movement
- participate in and analyse a variety of movements used in physical activity, sport and/or exercise to explain the interaction between bones, muscles, joints and joint actions using examples of lever systems responsible for producing movement
- examine different types of muscle contractions and differentiate the role of agonists, antagonists and stabilisers in movement
- investigate and describe the relationship between motor unit recruitment, activation and force production in movement

Source: VCAA VCE Physical Education Study Design (2025–29)



Video
Masterclass: Chapter 1

Assessment
Pulse check

In this chapter we will look at the musculoskeletal system. This body system comprises the skeletal system (bones and joints) and the skeletal muscles. Muscles and bones work together to create movement. Understanding the anatomical and physiological basis of human movement is critical in the analysis of physical activity, sport and exercise. As well as looking at muscles and bones, we will also explore joints and joint actions, muscle actions and how they are controlled, and learn that the human body is a series of levers designed to enhance movement.

PULSE CHECK

Take the pulse check quiz to check your knowledge and prior understanding of the concepts covered in this chapter.

1 **Identify** the bones of the body that make up the appendicular skeleton.
2 What are the three parts of an anatomical lever?
3 Rewrite the following statements using correct anatomical terminology:
   Zachary's foot is further away from his knee.
   Stephanie felt pain on the inside of her knee.
   Chin could see the back of the runner in front of him when he came around the bend during the race.
4 What movements are possible at a hinge joint?
5 Based on the naming convention used for muscles, where would you find the tibialis anterior?
6 **Explain** what a concentric contraction is and provide an example of an exercise where the hamstring muscle contracts concentrically.
7 **Describe** how muscles and bones work together to create movement.

1.1 DESCRIBING THE HUMAN BODY IN MOTION

In this module you will learn about:
- anatomical terminology used to identify the structures, functions and movement of the muscular and skeletal systems

and learn to:
- apply and use anatomical terminology to identify the structures and functions of the muscular and skeletal systems in producing movement.

Anatomical terms

The primary function of the musculoskeletal system is to produce movement. We use anatomical terms to describe human movement. For example, you may have heard a commentator say 'That looks like medial ligament damage' after a player has taken a knock to the knee. The term 'medial' is an anatomical term used to describe a body part that is closer to the midline of the body. The medial ligament, therefore, is on the inside of the knee.

When describing the position of the body or the direction of movement, we need a reference position. We use the **anatomical position** to describe the location, position or movement of body parts. There are two other body positions that are commonly referred to when describing movement:

- prone: lying on the front with the face down
- supine: lying on the back with the face up.

Table 1.1 provides a summary of the key terms that are used to describe the relative location, position and movement of the body.

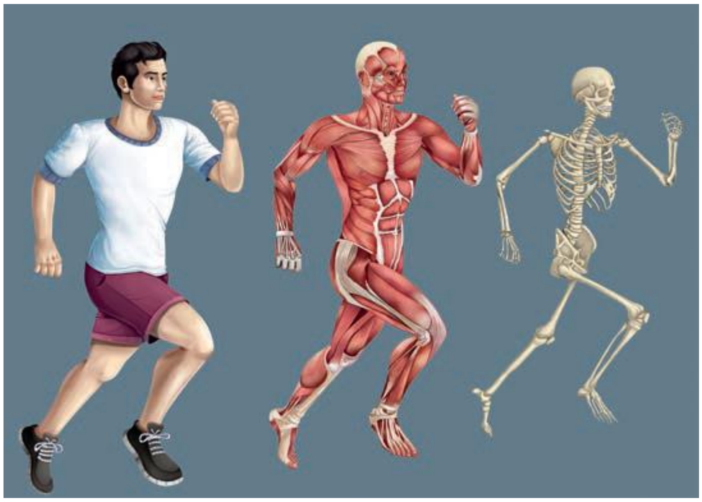


FIGURE 1.02 Understanding how the body moves relies on an understanding of the musculoskeletal system.

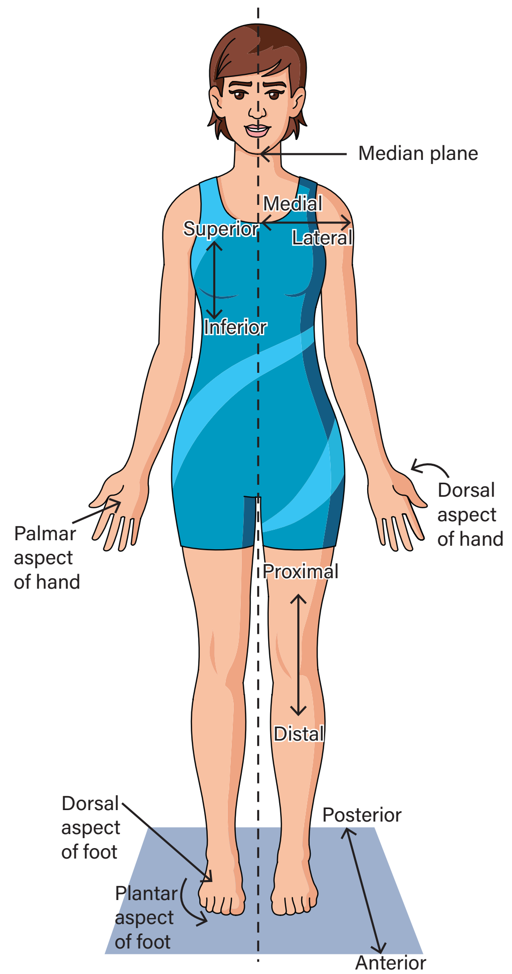


FIGURE 1.03 The anatomical position is used as a reference point for describing movement.

TABLE 1.1 Directional terms

Anatomical directional terms	Definition
Anterior	The front of the body
Posterior	The back of the body
Superior	A body part higher than another (closer to the head)
Inferior	A body part lower than another (further away from the head)
Medial	Closer to the midline of the body
Lateral	Further away from the midline of the body
Proximal	A body part closer to the trunk of the body
Distal	A body part further away from the trunk of the body
Superficial	Closer to the surface of the body
Deep	Away from the surface of the body
Palmer	The anterior surface of the hand
Dorsal	The posterior (back) of the body and top of the foot
Plantar	Bottom of the foot

anatomical position
Position of the body when a person is standing erect with feet facing forward, arms hanging beside the body and palms facing forward

Video
In focus: Planes and axes of motion

Planes and axes of motion

When describing the human body in motion, it is helpful to consider the body as being dissected by a series of planes (imaginary flat surfaces). These planes of movement divide the body in three directions:

- left and right: sagittal (median) plane
- anterior and posterior: frontal (coronal) plane
- superior and inferior: transverse (horizontal) plane.

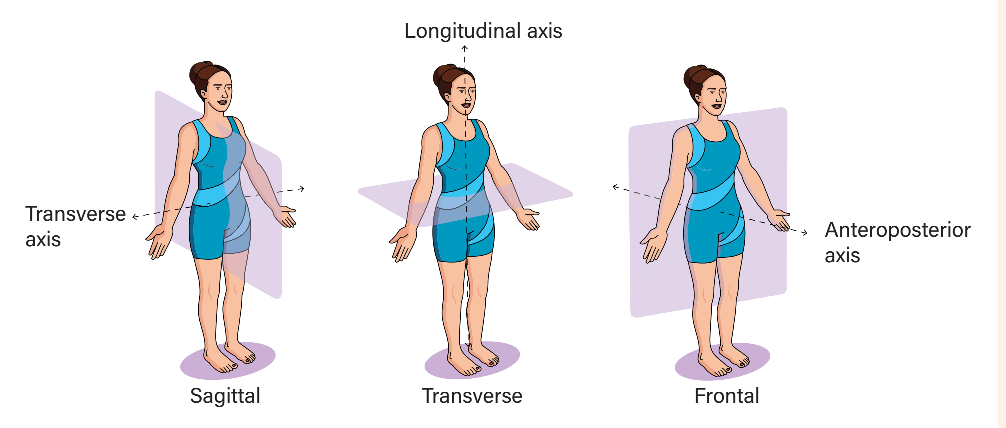


FIGURE 1.04 Anatomical planes and axes in the human body

perpendicular
At right angles (90 degrees) to another line or surface

transverse axis
an imaginary line running from left to eight and perpendicular to the sagittal plane

Movement occurs around an axis, and anatomical axes are **perpendicular** to the anatomical planes. There are three anatomical axes:

- sagittal (median) plane: **transverse axis**
- frontal (coronal) plane: anteroposterior axis
- transverse (horizontal) plane: longitudinal axis.

For each plane, motion can only occur around one axis. This means that if the plane of motion is known, then the corresponding axis of motion is also known.

For example, a bicep curl is performed in the sagittal plane; therefore, the axis of rotation is the transverse axis. We will revisit movements around the different axes when we look at joint actions more closely in Module 1.2.

Sergii Kumer/Shutterstock.com

FIGURE 1.05 A bicep curl is performed in the sagittal plane.

1.1 CHECK-IN QUESTIONS

1 When the body is in the anatomical position, the:
  A feet are facing outward.
  B head is turned to the right.
  C thumbs are brushing the thigh.
  D palms of the hands are facing forward.
2 Complete the following sentence using the correct anatomical terms:
  The knee is ________________ to the ankle, but ______________ to the hip joint.
3 Which of the following describes the transverse plane of the human body?
  A A vertical plane that divides the body into left and right parts
  B A vertical plane that divides the body into anterior and posterior parts
  C A horizontal plane that divides the body into superior and inferior parts
  D A horizontal plane that divides the body into anterior and posterior parts
4 A personal trainer instructs their client to move into the prone position prior to completing a 60-second plank. **Describe** the position the client should be in.
5 Provide the correct anatomical term to describe the location, position or movement of each of the following body parts/movements:
  a The location of the elbow in relation to the i. wrist and the ii. shoulder
  b The direction of movement of the arms when performing a dumbbell fly
  c The position of the hamstrings with respect to the quadriceps
6 In which plane and around which axis does the movement involved in touching your toes occur?

Assessment
1.1 Check-in questions

Command term

describe
Provide characteristics, features and qualities of a given concept, opinion, situation, event, process, effect, argument, narrative, text, experiment, artwork, performance piece or other artefact in an accurate way

1.2 THE SKELETAL SYSTEM

In this module you will learn about:
- structure and function of the skeletal system including the bones of the human body, classification of joints and joint actions

and learn to:
- participate in and analyse a variety of movements used in physical activity, sport and/or exercise to explain the interaction between bones, muscles, joints and joint actions using examples of lever systems responsible for producing movement.

Structure and function of the skeletal system

The skeletal system is made up of the bones of the skeleton, joints (where two or more bones meet) and the cartilage and ligaments that support the joint structures.
- **Ligaments** are tough bands of tissue that attach bone to bone, providing the joint with strength and stability.
- **Cartilage** is very strong, flexible tissue that is found throughout the body, such as in the nose and the rib cage. Cartilage covers the surface of bones that move against each other.

The bones of the skeleton are divided into two sections:
- axial skeleton (skull, vertebrae and ribs)
- appendicular skeleton (shoulder girdle, arms, legs, hands, feet and pelvis).

ligament
Connective tissues that connect bone to bone

cartilage
Flexible connective tissue that supports and protects bones

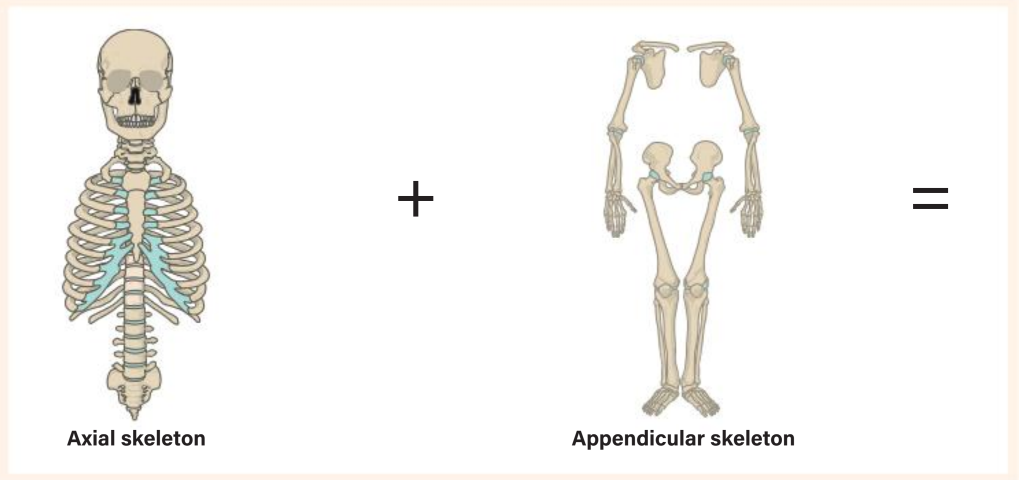


FIGURE 1.06 The skeletal system is divided into two parts: the axial and appendicular.

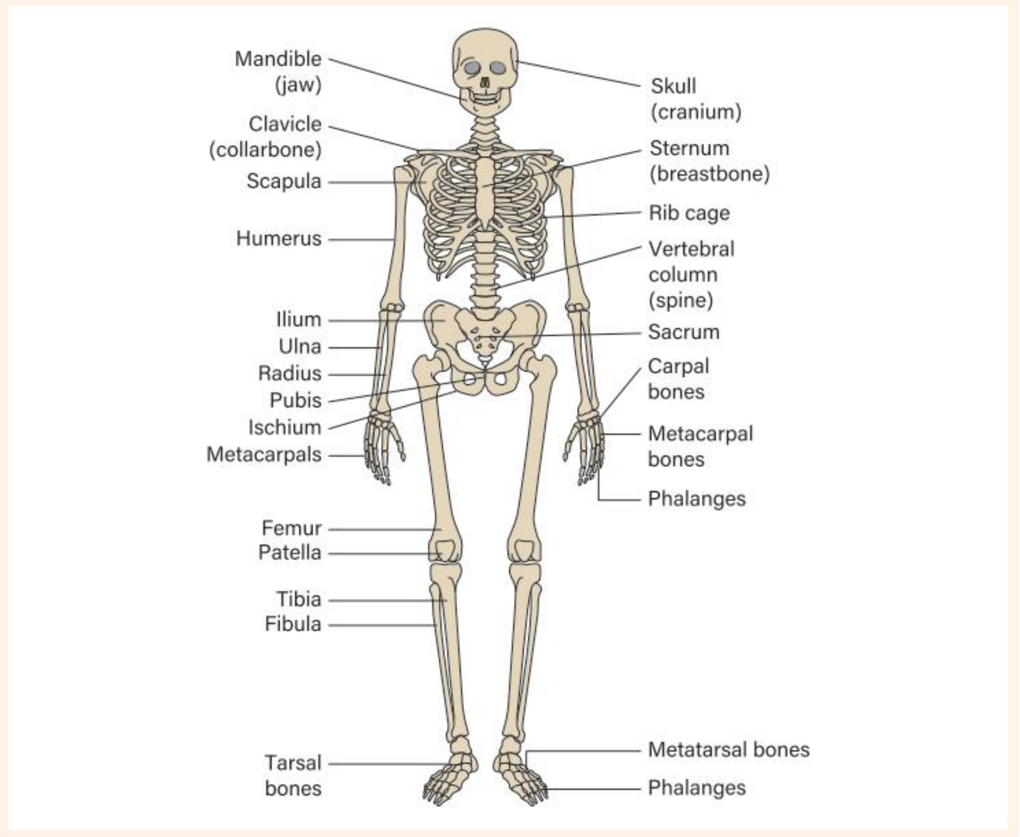


FIGURE 1.07 The adult human skeleton has 206 bones.

LOOKING FORWARD
Musculoskeletal injuries

Chapter 2

Cartilage doesn't have any blood vessels, so when damaged or injured, it takes a very long time to repair. We will look at injuries to the musculoskeletal system in detail in Chapter 2.

The primary function of the skeleton is to allow movement, but it has other functions that can be classified as either mechanical or physiological.

Mechanically, the skeleton is designed for movement through a series of anatomical levers (more about this in Module 1.4). The skeleton is the frame that supports the soft tissues and organs in the body and protects vital organs. Physiologically, the bones of the skeleton produce blood cells, and store and release minerals and fat as a fuel source when needed.

DID YOU KNOW?

At birth, a baby has approximately 300 bones, but as the baby grows, these bones grow and fuse together, forming the adult skeleton, which has 206 bones.

80 (axial) + 126 (appendicular) = 206

TABLE 1.2 Functions of the skeletal system

Mechanical functions	Physiological functions
Movement: muscles pull on bones to change their position	Blood cell production: platelets, red and white blood cells
Support: framework to give shape, maintain posture	Storage: minerals (calcium, phosphorus), fuels (fats)
Protection: skull (brain), rib cage (heart and lungs), vertebral column (spinal cord)	

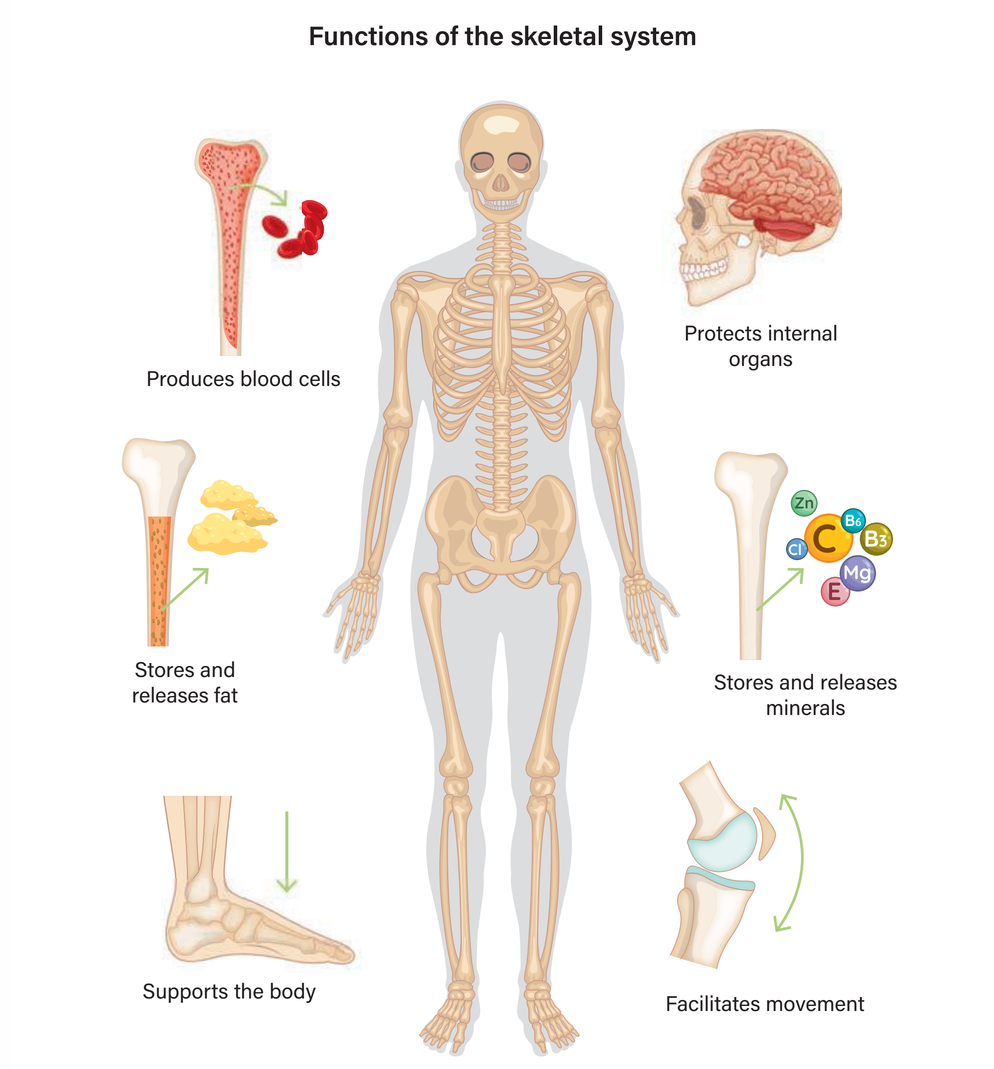
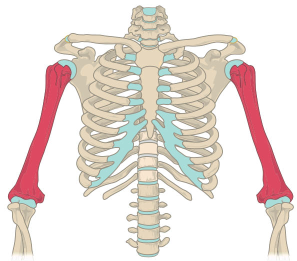
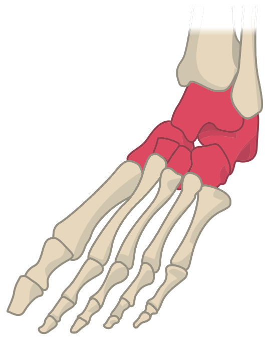
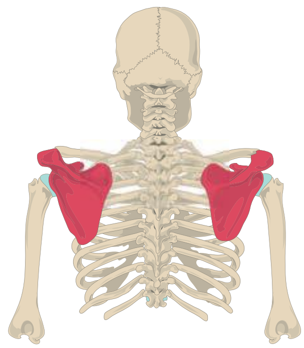
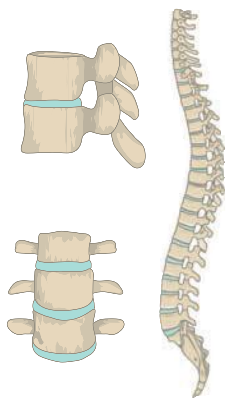


FIGURE 1.08 Functions of the skeletal system

Bones of the skeleton

The 206 bones in the human body are different shapes and sizes. The shape and size of each bone is determined by its function. Bones can be classified into four different types, depending on their shape.

TABLE 1.3 Types of bones

Type of bone	Description	Image	Example
Long	Long and thin		Humerus, radius, ulna, femur, tibia, fibula, phalanges
Short	Small, cube-shaped		Carpals, tarsals
Flat	Flattened, broad surface		Ribs, scapula, sternum, skull
Irregular	Vary in shape, complex shape		Vertebrae, facial bones

The vertebral column

The vertebral column protects the spinal cord and is made up of 33 vertebrae. It is divided into five sections.

The seven cervical vertebrae are small, designed to support the head and neck. The two top vertebrae, the atlas and axis, allow the head to move up and down (nod your head) and to rotate side to side (shake your head).

The 12 thoracic vertebrae are larger, and provide the anchor point for the ribs to attach and form the rib cage, which protects the heart and lungs. They allow some movement forwards, backwards and side to side.

The five lumbar vertebrae are the largest vertebrae and allow the greatest range of movement. They provide a frame for the powerful back muscles to attach to.

The five sacral vertebrae are fused together to form the sacrum, which is fused to the pelvis, creating a very strong base of support for the weight of the body.

The four coccyx vertebrae are also fused, and form the tailbone.

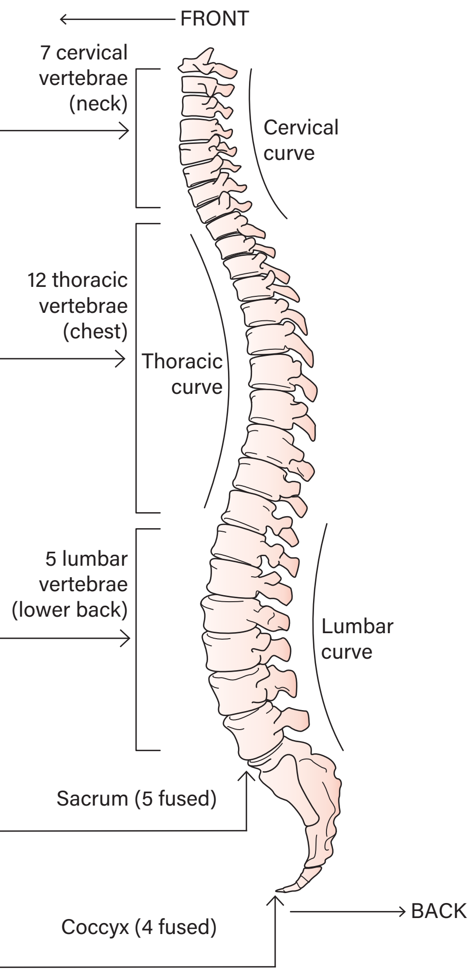


FIGURE 1.09 The vertebral column is made up of five sections.

Thoracic (rib) cage

The thoracic (rib) cage is made up of the thoracic vertebrae, ribs and sternum. Most people have 12 pairs of ribs, which all attach posteriorly to the thoracic vertebrae. The first seven pairs of 'true' ribs attach anteriorly to the costal cartilage and the sternum. The next three pairs ('false' ribs) are joined to a common cartilage that then attaches to the sternum. The last two pairs are called 'floating' ribs, and don't attach at all to the sternum. The flexibility of the cartilage allows the thoracic cage to expand during respiration.

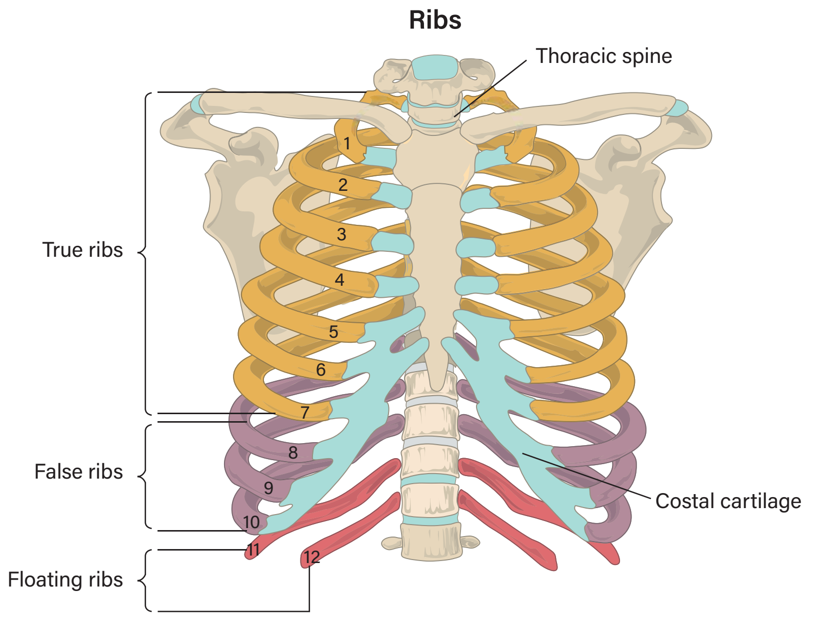


FIGURE 1.10 The rib cage is flexible enough to allow the lungs to expand as they fill with air.

SIGNPOST

Remembering the names of the bones in the human body is important for understanding movement, and analysing physical activity, sport and exercise. Go to Nelson MindTap to find an interactive skeleton. Label each of the bones, then compare your answers to the diagram in Figure 1.07.

Worksheet
Labelling the skeleton

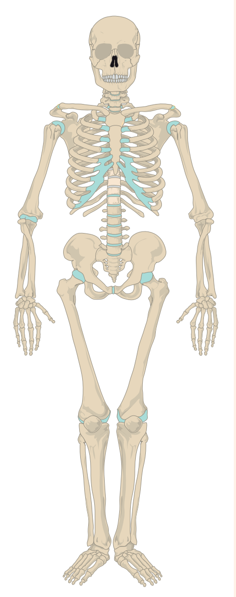
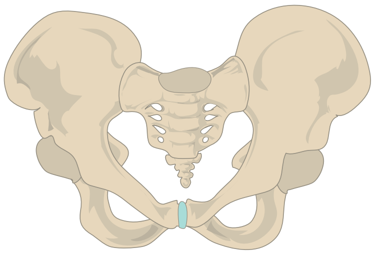
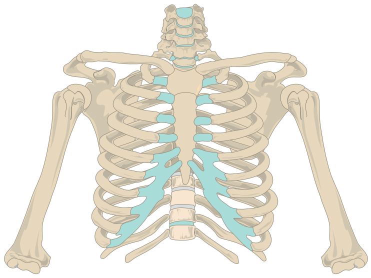
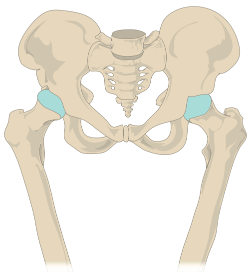


FIGURE 1.11 Can you name the bones of the skeleton?

Joints

A joint is any place where two or more bones meet. Joints are designed to hold our bones together, and to control the amount of movement allowed between the bones. Some joints, such as the skull, are rigid and allow very little movement. Other joints allow a small amount of movement, such as the vertebrae. However, most joints in the body allow a wide range of movement. Joints are classified by the amount of movement they allow.

TABLE 1.4 Classification of joints

Type of joint	Amount of movement	Image	Examples
Fixed or fibrous	Immovable		Skull, pelvis, radioulnar and tibiofibular joints
Cartilaginous	Slightly moveable		Ribs attaching to sternum, lumbar vertebrae
Synovial	Freely moveable		Hip and knee joints, cervical and thoracic vertebrae

Synovial joints

The purpose of a synovial joint is motion. As the human body is designed to move, most joints in the body are synovial joints. Synovial joints have the following characteristics:

- articular cartilage: covers the end of the bones to protect and reduce friction
- synovial membrane: a protective layer inside the joint capsule; produces synovial fluid
- synovial fluid: lubricates the joint, reduces friction
- articular (joint) capsule: fibrous tissues that holds the bones together and protects the joint.

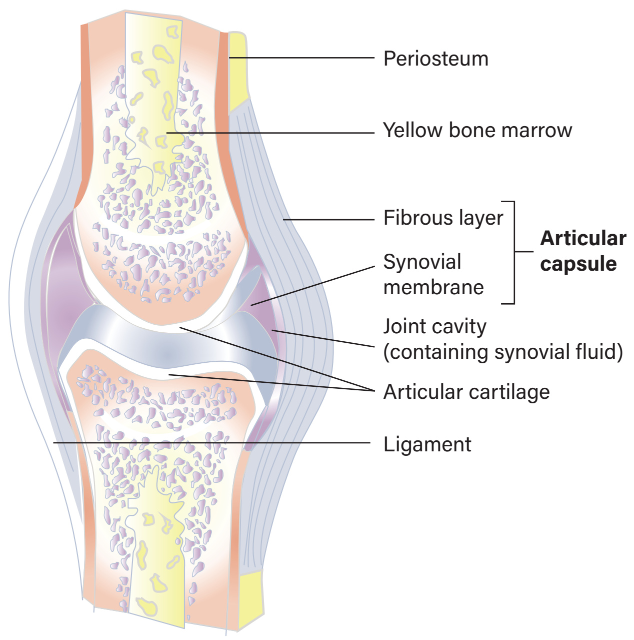
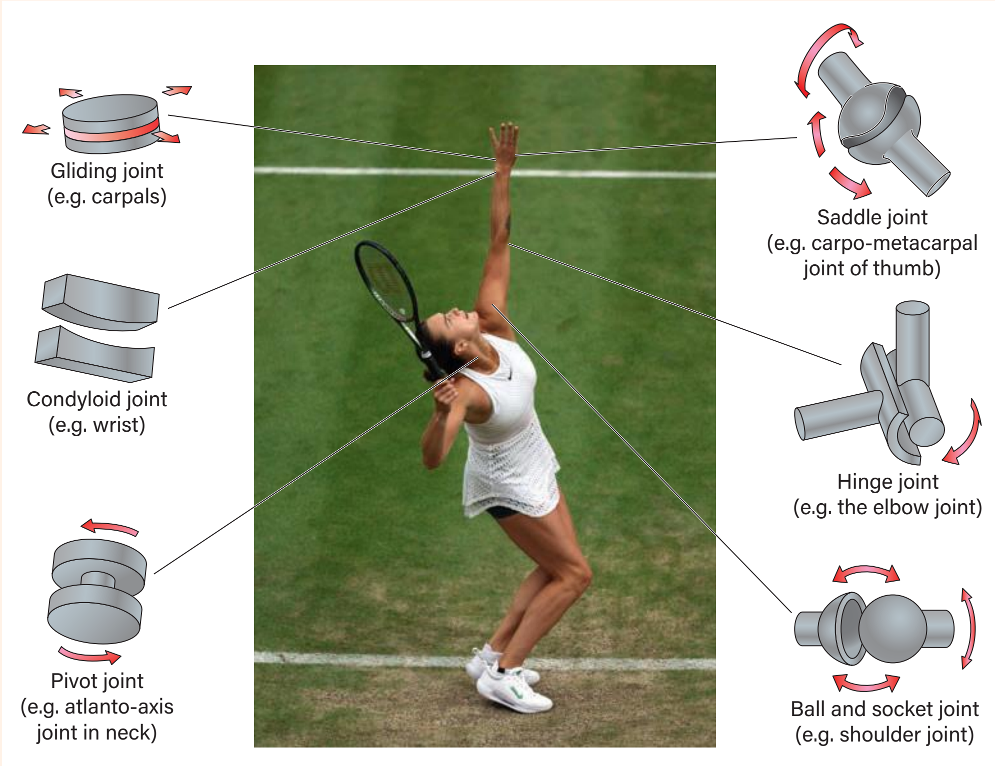


FIGURE 1.12 Structure of a synovial joint

articulating
Location where two or more bones meet to form a joint

There are six different types of synovial joints. These are classified by the shape of the two **articulating** surfaces and the movement they allow.



Clive Brunskill/Getty Images Sport/Getty Images

FIGURE 1.13 There are six types of synovial joints in the body.

TABLE 1.5 Synovial joints and the movement they allow

Type of joint	Description	Types of movement	Examples
Pivot	Only rotation of one bone around another	Rotation	Atlas and axis (top vertebrae)
Gliding	Gliding movements as one bone slides on top of another	Glide	Carpals/tarsals, vertebrae
Ball and socket	Wide range of movements in all directions	Flexion Extension Adduction Abduction Rotation (internal and external) Circumduction	Shoulder, hip
Hinge	Movement in one plane only	Flexion Extension	Knee, elbow
Saddle	Movement occurs in two planes	Flexion Extension Adduction Abduction Circumduction	Carpo-metacarpal joint of thumb
Condyloid	Movement limited to a hinge motion in two planes	Flexion Extension Adduction Abduction Circumduction	Wrist

Joint actions

Video
In focus: Joint actions

Table 1.5 (see p. 16) lists the types of movement that are possible at each of the six synovial joints. These joint actions are a result of the muscles pulling on the bones, causing movement. Understanding joint actions, and using the correct terminology to describe these actions, is important when analysing physical activity, sport or exercise. It is important to remember that when describing joint actions, it is assumed that the starting point is the anatomical position.

iStock.com/skynesher

FIGURE 1.14 Moving into this position involves abduction of the arms.

Abduction

Abduction is movement away from the midline of the body. Abduction occurs in the frontal plane For example, raising the arms outwards from the anatomical position to hold an iron cross position in gymnastics.

Adduction

Adduction is movement towards the midline of the body. Adduction occurs in the frontal plane. For example, bringing the arms back to the anatomical position from the iron cross position.

Circumduction

Circumduction is a combination of flexion, extension, abduction and adduction, where the movement is circular and results in the limb forming a cone shape from the joint. Circumduction occurs in the sagittal and frontal planes. For example, pitching the ball in softball.

Extension

Extension is a movement that results in an increase in the angle of the joint. For example, straightening the elbow from a bent position is extension. Extension movements occur in the sagittal plane.

DID YOU KNOW?

Hyperextension and **hyperflexion** refer to excessive extension or flexion of a joint beyond its normal range of motion. Hyperextension and hyperflexion often result in injury. Hyperextension injuries commonly occur at hinge joints, but when an individual experiences 'whiplash', their head has suddenly moved backwards and then forwards, causing both hyperextension and hyperflexion of the cervical spine. Injuries related to the musculoskeletal system will be covered in Chapter 2.

Michael Dodge/Getty Images Sport/Getty Images

FIGURE 1.15 The player's knee extends beyond the normal range of motion, resulting in hyperextension.

hyperextension
Excessive extension of joint, beyond the normal range of movement

hyperflexion
Excessive flexion of joint, beyond the normal range of movement

Flexion

Flexion involves movement that results in a decrease in the angle of the joint. For example, bending the elbow from a straight position is flexion. Flexion movements occur in the sagittal plane.

Rotation

Rotation occurs when a body part makes a turning movement while the rest of the body remains still. Turning your head or twisting your spine while your hips remain stationary are both examples of rotational movements.

Rotation in a ball and socket joint occurs when a limb or body part turns around its long axis. When this movement is towards the midline of the body it is called internal rotation. When it is away from the midline it is called external rotation.

All rotational movements occur in the transverse plane, as the movement is along the longitudinal axis.

Pronation

Pronation is the movement of the forearm that turns the palm towards the body, so the palm is posterior facing, and the ulna and radius are crossed. Remember that the movement is always described assuming the starting point is the anatomical position.

LEARNING HACK

Supination is the movement you use to scoop soup with a spoon – 'sup.'

'P'lantar flexion means to 'p'oint your toes.

Supination

Supination is the opposite to pronation. This movement results in the forearm rotating so the palm is anterior facing and the radius and ulna are uncrossed and parallel to each other.

Pronation and supination only occur at the radioulnar joint in the forearm. They occur through the longitudinal axis; therefore, through the transverse plane.

Inversion

Inversion is the movement where the sole of the foot is angled towards the midline of the body. This movement occurs in the frontal plane, along the anteroposterior axis.

Eversion

Eversion is the movement where the sole of the foot is turned away from the midline of the body. This movement occurs in the frontal plane, along the anteroposterior axis.

Dorsiflexion

Dorsiflexion occurs at the ankle joint when the front of the foot is lifted towards the shin. This movement occurs in the sagittal plane, along the transverse axis.

Plantar flexion

Plantar flexion occurs at the ankle joint when the heel is lifted from the ground and/or when the toes are pointed downwards. This movement occurs in the sagittal plane, along the transverse axis.

Inversion, eversion, dorsiflexion and plantar flexion only occur at the ankle joint.

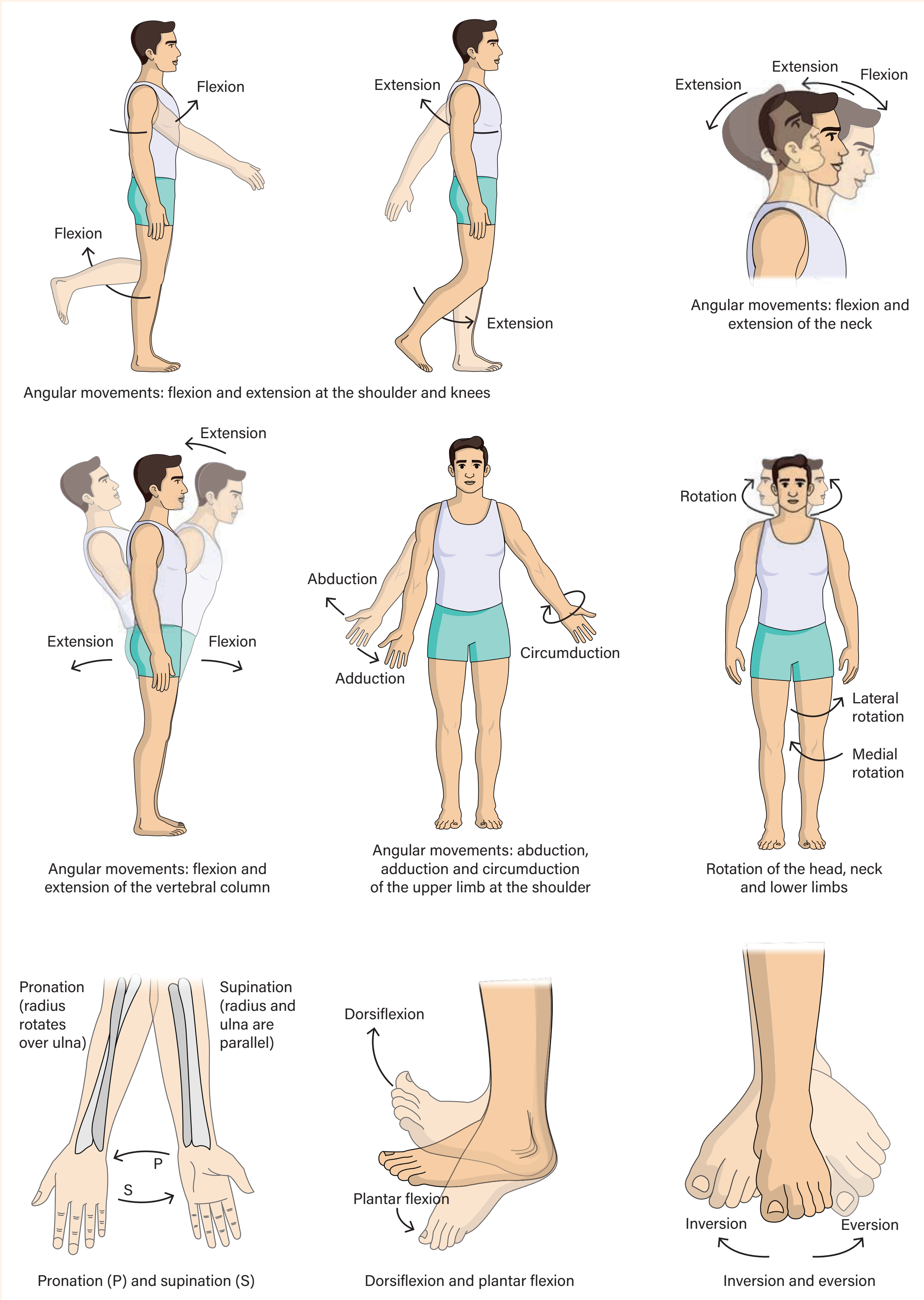


FIGURE 1.16 Anatomical terminology allows us to describe movement.

Assessment
1.2 Check-in questions

1.2 CHECK-IN QUESTIONS

1 The bones that make up the axial skeleton are the:
  A vertebral column, ribs and pelvis.
  B vertebral column, ribs, and skull.
  C shoulder girdle, ribs and pelvis.
  D skull, ribs and pelvis.

2 Which term refers to the movement that decreases the joint angle?
  A Flexion
  B Extension
  C Adduction
  D Abduction

3 What type of bones are mainly found in the appendicular skeleton? Why do you think this is the case?

4 What is the main function of flat bones? Provide a specific example.

5 **Identify** a pattern in joint actions. Provide three examples as evidence of the pattern you have identified. Which joint action does not fit into the pattern?

6 Complete the following table to show the relationship between planes of motion, axis of motion and joint action. The first one has been done for you.

Plane of motion	Axis of motion	Joint action
Frontal	*Anteroposterior*	*Adduction*
		Abduction
		Inversion
		Eversion

Command term

identify
Recognise and name and/or select an event, feature, ingredient, element, speaker and/or part from a list or extended narrative or argument, or within a diagram, structure, artwork or experiment

1.3 THE MUSCULAR SYSTEM

In this module you will learn about:

- major muscles of the human body
- characteristics and functions of muscle fibres such as fibre arrangement and type (fast twitch and slow twitch)
- types of muscular contractions (concentric, eccentric and isometric)
- concept of reciprocal inhibition (the role of agonists, antagonists and stabilisers)
- neural control of muscles, including the recruitment (size principle) and activation (all or nothing principle) of motor units in relation to force production

and learn to:

- apply and use anatomical terminology to identify the structures and functions of the muscular and skeletal systems in producing movement
- examine different types of muscle contractions and differentiate the role of agonists, antagonists and stabilisers in movement
- investigate and describe the relationship between motor unit recruitment, activation and force production in movement.

The musculoskeletal system is made up of the skeletal system (bones and joints), which, as discussed in Module 1.2, provides a framework for the body, and the muscular system. The muscles provide an active force that pulls on the bones to move or change the position of the body.

Every movement we make – walking, running, throwing, kicking, catching – all rely on the muscular system. The key characteristic of muscles, and the thing that makes movement possible, is their capacity to contract and relax.

Types of muscles

There are three types of muscles in the human body: cardiac, smooth and skeletal.

Cardiac muscles

Cardiac muscles are found in the heart. They are striped (striated), cylindrical and branched, and involuntary, meaning that they will contract and relax without the need for conscious control. In other words, you don't need to think about contracting your heart, and you can't consciously make your heart beat faster. The walls of the heart are made of cardiac muscle, and their function is to pump blood.

Smooth muscles

Smooth muscles are found in the walls of the blood vessels, and in the walls of hollow organs such as the intestines, uterus and bladder. Smooth muscles are spindle shaped, involuntary and play a role in many body functions, including moving food through the digestive tract, emptying the bladder, **vasoconstriction** and **vasodilation**.

vasoconstriction
A decrease in the diameter of a blood vessel, resulting in a decrease in blood flow to the area supplied by the blood vessel

vasodilation
An increase in the diameter of the blood vessel, resulting in an increase in blood flow to the area supplied by the blood vessel

Skeletal muscles

Skeletal muscles are attached to bones throughout the body. They are long and cylindrical, are striped (striated) and are voluntary, meaning that you can control their movement. The primary function of skeletal muscles is movement, however, they also play an important role in maintaining posture, protecting heat production and putting pressure on the blood vessels to aid circulation.

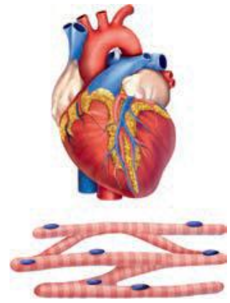
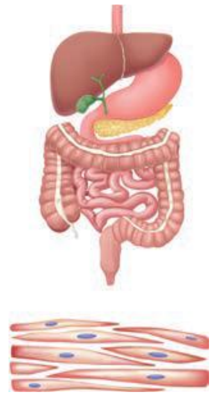
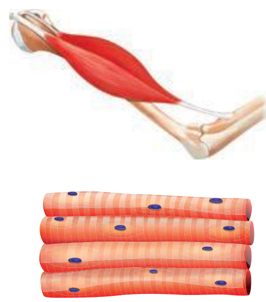
DID YOU KNOW?

Over 75 per cent of the energy that is used in muscular contractions is released as heat – muscles are our own personalised heating system!

BigBlueStudio/Shutterstock.com

FIGURE 1.17 Tendons attach skeletal muscles to bone.

TABLE 1.6 Types of muscles

Characteristic	Location	Shape	Striated*	Voluntary/involuntary	Function	Diagram
Cardiac	Heart	Cylindrical and branched	Yes	Involuntary	Pump blood	 Cardiac muscle
Smooth	Blood vessels, intestines, bladder, uterus, eyes, glands, skin	Spindle-shaped	No	Involuntary	Body functions	 Smooth muscle
Skeletal	Attached to bones	Very long and cylindrical	Yes	Voluntary	Body movement, posture, heat, facial expressions	 Skeletal muscle

* Striated muscles look striped when viewed under a microscope.

Skeletal muscles

There are approximately 600 skeletal muscles in the human body (don't worry, you don't need to know all of them!). Because skeletal muscles are attached to bone and control the movement that occurs at joints, these are the muscles that are of the most interest in physical education. Figure 1.18 provides an anterior and posterior view of the body and shows the major muscle groups, and Figure 1.19 shows the detail of the muscles in the arms and legs.

Worksheet
Labelling muscles

SIGNPOST

Remembering the names of the muscles of the body is important for understanding movement, and analysing physical activity, sport and exercise. Go to Nelson MindTap to find an interactive image for you to label each of the muscles. Compare your answers to the diagram in Figure 1.18.

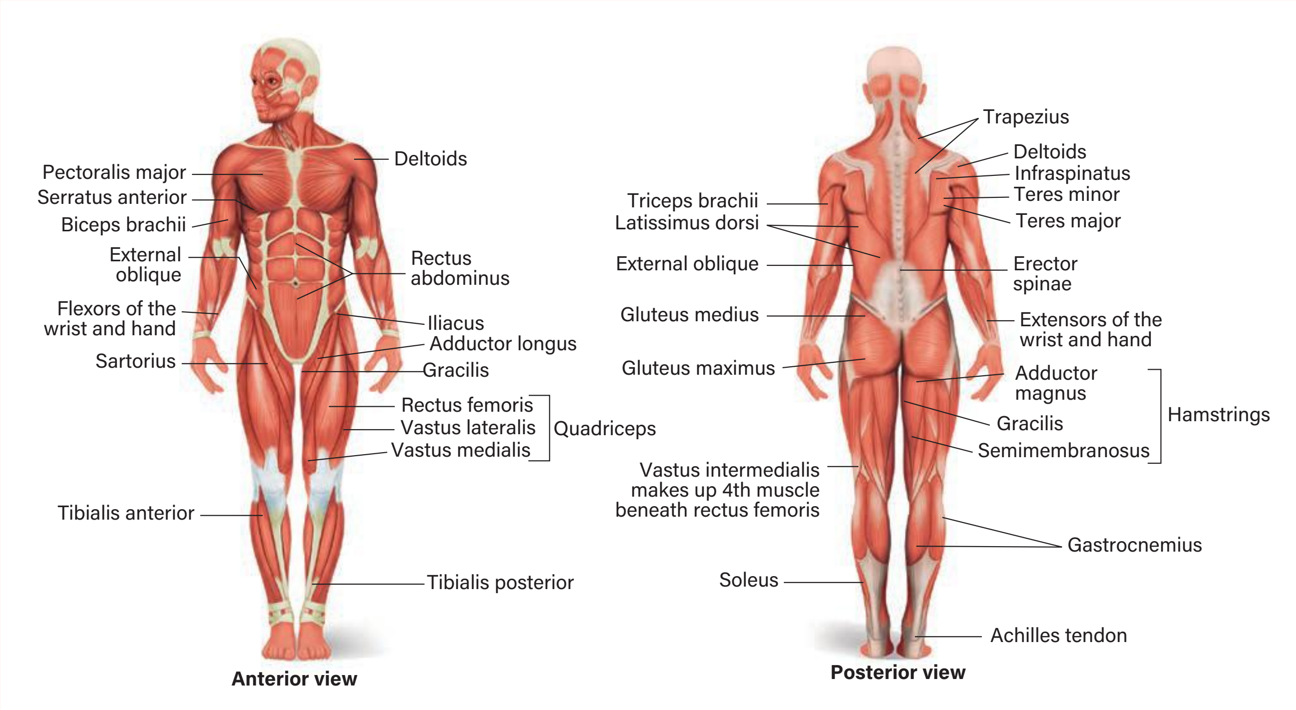


FIGURE 1.18 Major muscles of the human body

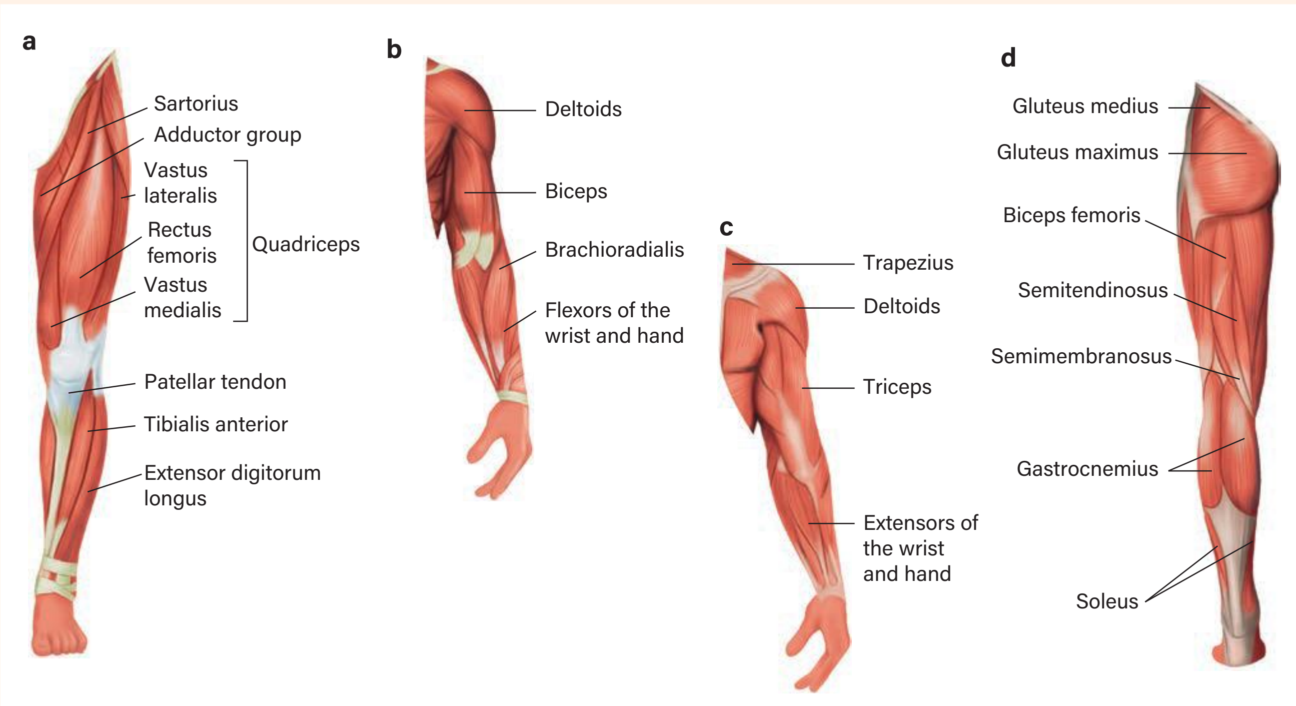


FIGURE 1.19 Muscles of the arms and legs

DID YOU KNOW?

There are seven different ways that a muscle can be named. The names can be based on their location in the body, muscle attachment points, size, shape, action, the number of divisions and muscle fibre direction.

Muscle attachment

tendon
Soft tissue that connects muscle to bone

origin
The point where the muscle attaches to the bone

insertion
The point where the muscle attaches to the bone that is pulled by the action of the muscle

Tendons attach skeletal muscle to bone. These strong connective tissues can withstand the stress that is generated by the muscle as it contracts. The role of the tendon is to transmit the force generated by the muscle to pull on the bone at the point of attachment, causing movement.

There are two points of attachment for each muscle: the origin and the insertion.

- The **origin** is the end where the muscle attaches to the fixed or stationary bone.
- The **insertion** is the end where the muscle attaches to the bone that is moving the most.

Some muscles will have multiple points of origin and one insertion point, such as the bicep muscle (see Figure 1.20). Muscles with more than one origin are said to have multiple heads. The largest part of the muscle between the origin and insertion points is called the muscle belly.

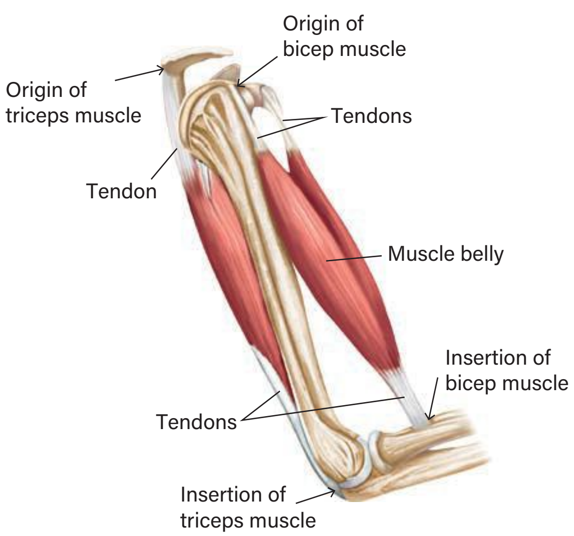


FIGURE 1.20 Origin and insertion points for the bicep and triceps muscles. Notice that the tendons cross the joint.

LEARNING HACK

The name of the muscle can provide a clue to the number of origin points (or heads). For example:

biceps: bi = two, ceps = head

triceps: tri = three, ceps = head

quadriceps: quad = four, ceps = head

Structure of skeletal muscle

sarcolemma
Thin cell membrane that covers the muscle fibre

fascicles
A bundle of muscle fibres

Skeletal muscle is made up of skeletal muscle cells, fibres, blood vessels, nerve fibres and connective tissue. Each individual muscle fibre is covered by the **sarcolemma**, a thin cell membrane. There are three layers of connective tissue that encase the bundles of muscle fibres (called **fascicles**), providing structure to the skeletal muscle. These three layers of connective tissue (from the outermost to the innermost layer) are:

- epimysium
- perimysium
- endomysium.

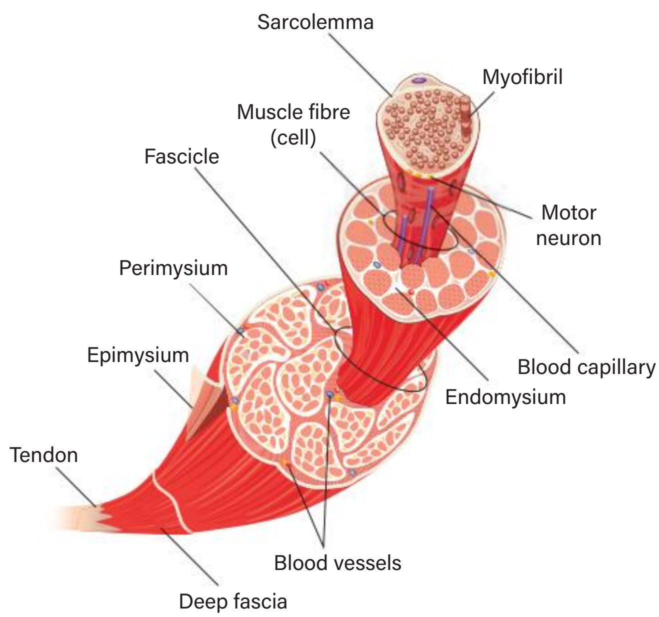


FIGURE 1.21 Skeletal muscle includes connective tissue that allows the muscle to remain intact while contracting powerfully.

The **epimysium** is the outer layer of the skeletal muscle. It is a dense connective tissue that covers the whole muscle. The **perimysium** is the middle layer of connective tissue that surrounds the bundles of muscle fibres (called fascicles). The **endomysium** encases each muscle fibre and helps transfer the force produced in the muscle fibres to the tendons.

epimysium
Connective tissue that encases the whole muscle

perimysium
Connective tissue that encases a bundle of muscle fibres

endomysium
Connective tissue that encases an individual muscle fibre

DID YOU KNOW?

The number of muscle fibres remains relatively constant from birth. Any increase in muscle size comes from an increase in the size of the individual muscle fibres.

Fibre arrangement

The arrangement of the bundles of muscle fibres (fascicules) is closely related to the force that can be generated in the muscle, and also the muscle's range of motion. There are five different fibre arrangements in the human body:

1. circular
2. convergent
3. parallel
4. pennate
5. fusiform.

Circular

The fascicles in circular muscles are arranged concentrically around an opening. When they contract, the opening decreases in size and when they relax, the opening increases in size. For example, the orbicularis oris muscle (the kissing muscle!) controls the puckering of the lips.

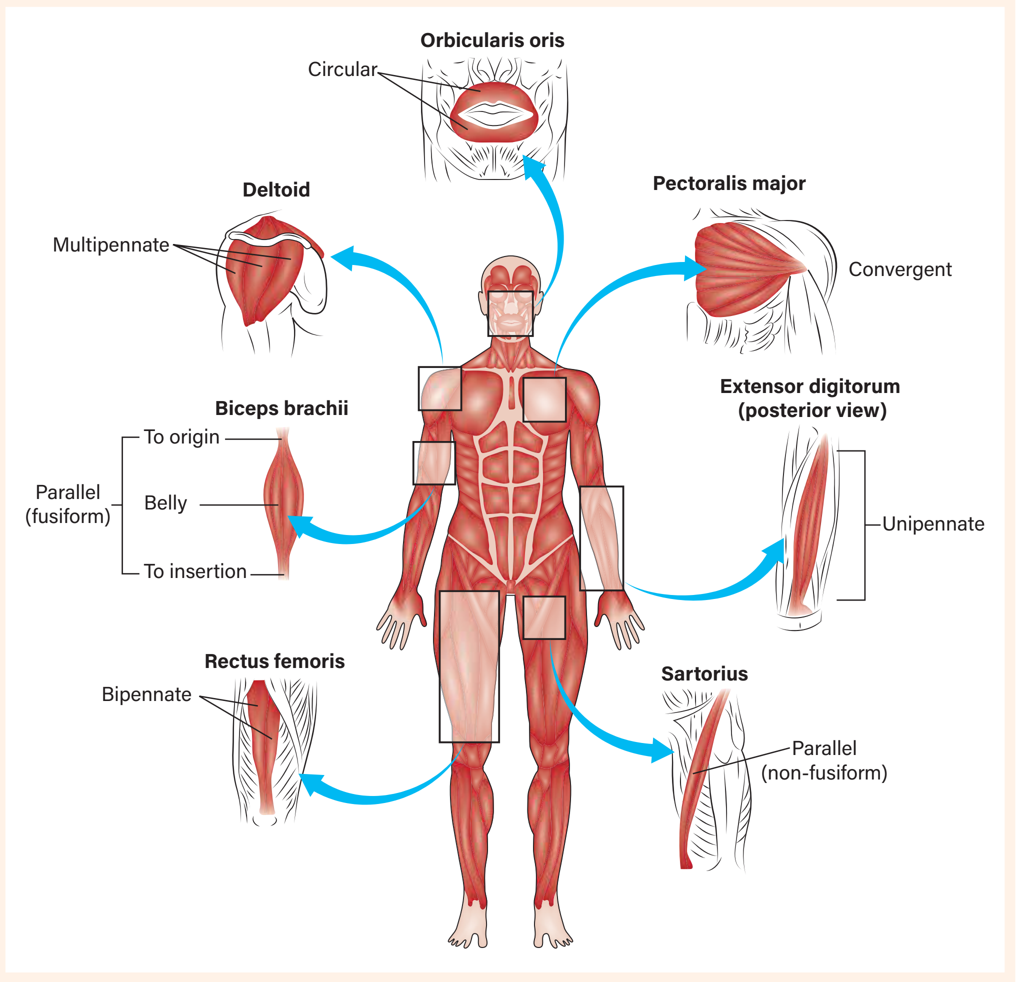


FIGURE 1.22 The five different muscle shapes and fibre arrangements in the human body

Convergent

Muscle fibres in convergent muscles have a broad base at the origin, but then come to a single attachment site. Convergent muscles have a triangular shape – for example, the deltoid muscle.

Parallel

In muscles where the fibres are arranged in a parallel pattern, the fibres run in the same direction as the long axis of the muscle. Parallel muscles can shorten more than muscles with other arrangements, but they contract with less force.

Pennate

The fibres in **pennate** arrangements lie at an angle to the long axis of the muscle. In pennate arrangements, more fibres can be 'packed' into the muscle. The complex arrangement of the fascicles, connective tissue and tendons in pennate muscles provide a greater cross-sectional area, and are designed for strong, forceful contractions.

pennate
Having a structure like that of a feather; in muscle, it is where the fibres extend obliquely from either side of a central tendon

The three forms of pennate fibre arrangements are:

- unipennate muscle: the fascicles are located on one side of the tendon; for example, the semimembranosus muscle of the hamstring muscles
- bipennate muscle: the fascicles insert into the tendon from both sides; for example, the rectus femoris of the quadricep muscles
- multipennate muscle: the fascicles insert on multiple tendons that then taper to a common tendon; for example, the deltoid muscle of the shoulder.

Fusiform

Fusiform muscles have fibres that align to the long axis, or the line of pull of the muscle. They are similar to parallel muscles, however, fusiform muscles are more spindle-shaped, with a larger central area called the muscle 'belly', and they taper at the point where they attach to the tendon. In fusiform muscles, the fibre length is equal to the length of the muscle. The force generated in the muscle is transferred directly to the tendon, which allows for the muscle to shorten rapidly. Muscles designed for speed of contraction have fibres arranged in a fusiform pattern.

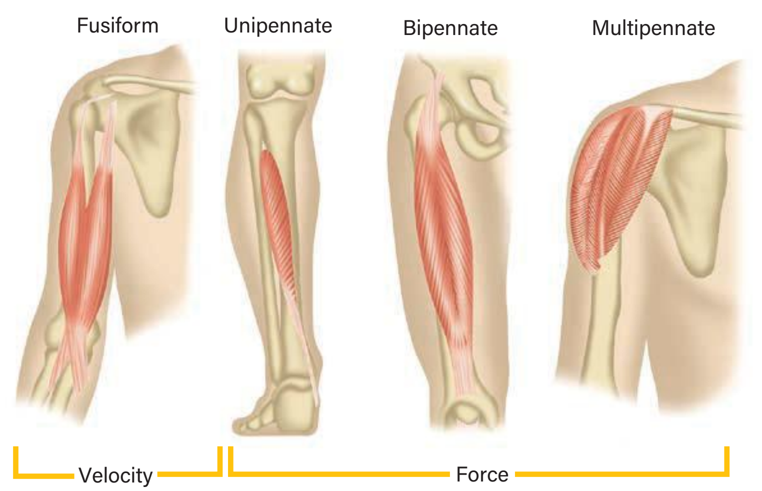


FIGURE 1.23 Muscle fibre arrangements affect the muscle's function.

When compared to fusiform muscles, pennate muscles have three main differences. Pennate muscles:

- contain shorter fibres
- possess more individual fibres
- have a smaller range of motion.

The force generated in the muscle is dependent on the ratio of the length of an individual fibre (FL) to the total length of the muscle (ML). A low FL:ML ratio produces high force (for example, the quadricep muscles) and a high FL:ML produces high contractile velocity (for example, the hamstring muscles).

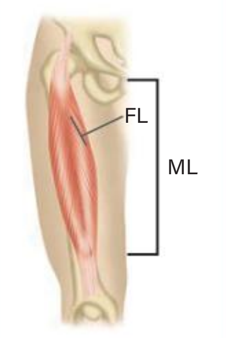


FIGURE 1.24 Muscle fibre length (FL) compared to muscle length (ML)

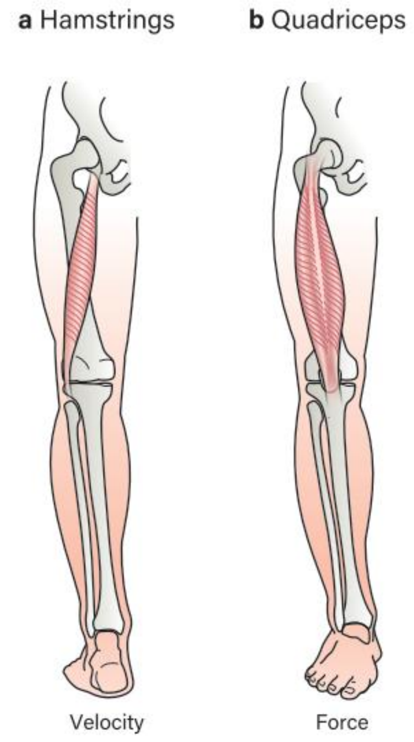


FIGURE 1.25 The ratio of fibre length to muscle length determines the force that can be generated in a muscle.

Muscle fibre type

Skeletal muscle consists of two main types of muscle fibres:

- slow-twitch (Type I)
- fast-twitch (Type IIa and Type IIb).

Skeletal muscles generally have an equal mix of Type I and Type IIa and Type IIb fibres. The proportion differs in individual muscles and from person to person, and is thought to be determined by both genetics and environmental factors (such as training, diet, coaching). Genetics is thought to account for 40–50 per cent of the variability in the proportion of Type I (slow-twitch) and Type II (fast-twitch) fibres. A greater percentage of one type of muscle fibre may be a factor in an individual's success in a specific event. For example, an athlete who has a higher percentage of Type II fibres will be able to generate greater force and power, which will aid in jumps and sprinting but would not be beneficial in events such as the 10 000 metres. While there is some evidence to suggest that the structure and capacity of muscle fibres can adapt to training, muscle fibres cannot be converted from one type to the other.

DID YOU KNOW?

To directly determine muscle fibre composition, a muscle biopsy test is used. A core sample of the muscle is taken and viewed under a microscope.

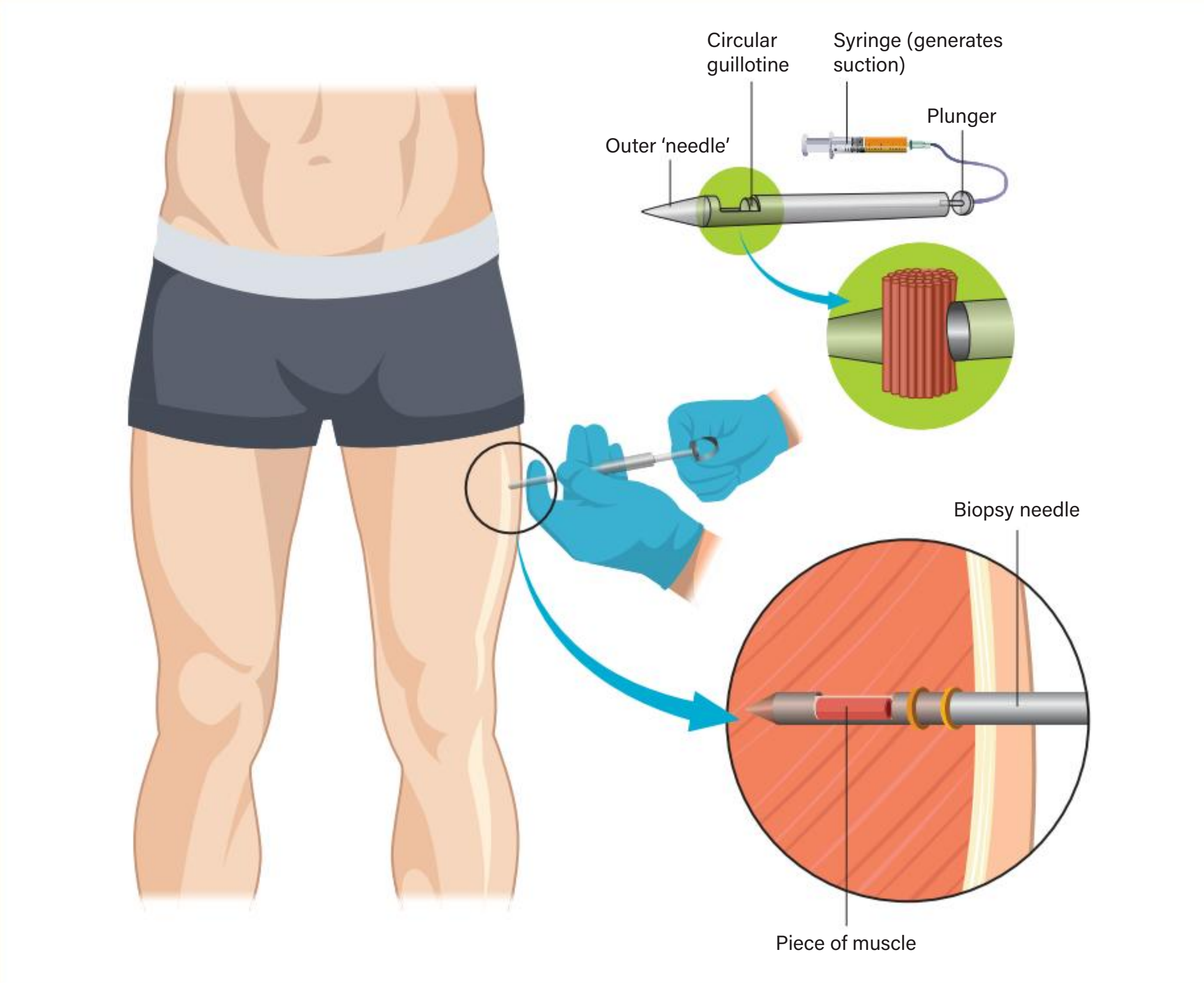


FIGURE 1.26 Muscle biopsy testing is used to determine muscle fibre composition.

Muscle fibres are classified by how fast they contract, and the energy system used to produce adenosine triphosphate (ATP). ATP is present in all living cells, including muscle cells, and provides the energy that is needed for muscular contraction.

Due to these properties, elite endurance athletes such as long-distance cyclists and runners have higher percentages of Type I, or slow-twitch, fibres, and elite power athletes, such as weightlifters and sprinters, have a higher proportion of Type II, fast-twitch fibres.

Slow-twitch fibres (Type I)

Type I fibres are called slow-twitch due to their relatively slow contraction time. These fibres are relatively small compared to Type II fibres, and are therefore unable to produce a large amount of force.

The characteristics of Type I fibres maximise their capacity to use aerobic respiration to produce ATP. Slow-twitch fibres have a high concentration of large mitochondria, high capillary density, which increases the oxygen supply from the blood, and high myoglobin levels. These characteristics give Type I fibres their distinctive dark red colouring and allow them to produce large amounts of ATP aerobically, making them fatigue resistant and able to contract for extended periods of time.

Slow-twitch fibres are suitable for continuous aerobic activities and are therefore preferentially recruited to endurance activities that are submaximal. **Submaximal exercise** is generally defined as physical activity that does not exceed 85 per cent of your maximum heart rate. Slow-twitch fibres appear in greater percentages in muscles that are used to maintain posture, due to their ability to contract for long periods without fatiguing.

submaximal exercise
Physical activity that does not exceed 85 per cent of your maximum heart rate

Slow-twitch fibres have:

- small diameter, reducing the amount of force that can be produced
- slow contraction time, meaning they are able to contract repeatedly, for extended periods of time
- low fatiguability, meaning they can work for extended periods of time
- high capillary density, supplying large amounts of blood and oxygen to working muscles
- high mitochondrial density and oxidative enzymes, releasing large amounts of energy under aerobic conditions
- high triglyceride stores, which is the preferred fuel under aerobic conditions (submaximal).

Fast-twitch fibres (Type II)

Type II fibres are called fast-twitch because of their ability to contract rapidly. Fast-twitch fibres can be further classified as:

- Type IIa: fast **oxidative**
- Type IIb: fast **glycolytic**.

oxidative
Oxidative fibres use aerobic respiration to generate ATP

glycolytic
Glycolytic fibres use anaerobic glycolysis to generate ATP

anaerobic glycolysis
The breaking down of glycogen with insufficient oxygen to produce ATP

Type IIa fibres are sometimes referred to as intermediate or partially aerobic fibres, because they have characteristics that sit somewhere between Type I and Type IIb fibres.

Type IIa fibres primarily use aerobic respiration to generate ATP, while Type IIb fibres primarily use **anaerobic glycolysis**, and are sometimes referred to as fully anaerobic fibres. Type IIa fibres produce ATP relatively quickly, can produce relatively high amounts of force, and do not fatigue as quickly. This makes them suitable for activities such as walking. The muscles used in these activities require more energy than those involved in maintaining posture but less energy than those involved in explosive movements.

Anaerobic glycolysis produces less ATP than aerobic respiration. As a result, fast-twitch fibres fatigue more quickly than slow-twitch fibres, and Type IIb fibres fatigue at the quickest rate. This means that fast-twitch fibres can only be used for short periods of time, for fast, powerful movements such as high jump, shot-put, or the 100-metre sprint.

Structurally, fast-twitch fibres have a larger diameter than slow-twitch fibres, allowing them to store greater volumes of glycogen, which is used to generate ATP quickly and produce high amounts of force. Type II fibres are white in colour due to their low levels of mitochondria, myoglobin and limited capillary density.

Fast-twitch fibres have:

- large diameter, increasing the amount of force that can be produced
- fast contraction time, meaning they can only contract at a high intensity for a short period of time
- high fatiguability, meaning they can only work for short periods of time
- high phosphocreatine stores, providing an immediate source of energy under anaerobic conditions
- high glycogen stores, which is the preferred fuel during near-maximal anaerobic efforts
- high glycolytic enzymes, which increase glycogen breakdown during high-intensity efforts lasting beyond 10 seconds.

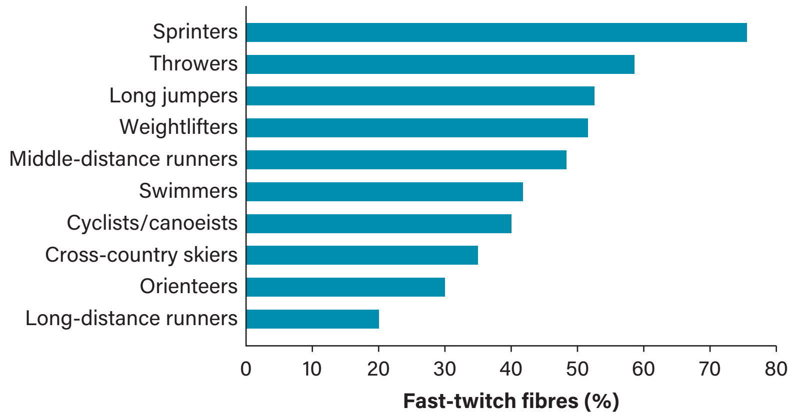


FIGURE 1.27 The percentage of fast-twitch fibres found in different athletes. Notice the prevalence of fast-twitch fibres in events that require power and speed.

COLLABORATIVE TASK

Prac activity

Estimating muscle fibre composition

AIM

To estimate the predominant muscle fibre type for a given muscle group

EQUIPMENT

Free weights (barbells, dumbbells) or gym equipment

METHOD

Choose an exercise (e.g. bicep curl, bench press, leg press) and determine your one repetition maximum (1RM*).

*1RM is a measure of the maximal weight a subject can lift with one repetition.

Rest for 15 minutes.

Using 80 per cent of your measured 1RM, perform as many repetitions (using correct technique) as possible in a single attempt.

OBSERVATIONS

Record the maximum number of times the weight is correctly lifted.

Using the scoring table below, determine the predicted percentage of muscle fibre types in the muscle tested.

Number of reps at 80%	Predicted proportion of muscle fibre type
<7	>50% fast-twitch
7–12	Equal proportion of fast- and slow-twitch fibres
>12	>50% slow-twitch fibres

DISCUSSION

1 What was your dominant muscle fibre type as determined by the activity?

2 Does this align to the activities and/or sports that you are more successful at?

3 **Compare** your results with a classmate and discuss how muscle fibre type can influence performance in physical activity, sport and exercise.

LEARNING SHORTCUT

1RM stands for one repetition maximum. 1RM is a measure of the maximal weight a subject can lift with one repetition.

TABLE 1.7 Characteristics of skeletal muscle fibre types

Characteristic	Slow-twitch	Fast-twitch	
	Type I (slow oxidative)	Type IIa (fast oxidative)	Type IIb (fast glycolytic)
Performance conditions	Aerobic	Partially aerobic	Purely anaerobic
Colour	Red	White/red	White
Oxidative enzymes	High	Medium	Low
Myoglobin content	High	Medium	Low
Glycolytic capacity	Low	High	High
Mitochondria density	High	Medium	Low
Capillary density	High	Medium	Low
Myosin-ATPase	Low	High	High
Phosphocreatine (PC) stores	Low	High	High
Triglyceride stores	High	Medium	Low
Fibre size	Small	Large	Large
Contraction speed	Slow	Moderate	Fast
Force capacity	Low	Medium	High
Fatigue resistance	High	Medium	Low

muscle typology
Muscle fibre type composition

CASE STUDY — MUSCLE FIBRE TYPES IN ELITE CYCLISTS

MUSCLE TYPOLOGY MAY BE KEY TO ELITE CYCLISTS' SUCCESS AT CHOSEN SPORT

19 NOVEMBER 2020

Thomas Wyness/Shutterstock.com

FIGURE 1.28 Muscle fibre type might be useful for talent identification for athletes in cycling events.

The differences in the **muscle typology** of world-class cyclists competing in different disciplines could help determine discipline selection and talent identification of young cyclists a new study has found.

Researchers from Griffith University's School of Allied Health Sciences and Ghent University, Belgium analysed the ratio of fast and slow-twitch muscle fibres of 80 cyclists (including BMX, track, cyclo-crossers, cross-country and mountain bikers) from Australia, UK, the Netherlands, New Zealand and Germany.

Using a non-invasive technique, they measured the carnosine (a molecule linked to improved cell performance), levels in the athletes' calves.

'The invasive nature of muscle biopsies, typically required to evaluate muscle typology, does not allow us to study the world's best athletes given this procedure is disruptive to their training and met with resistance,' said lead researcher Dr Phil Bellinger.

'We have been working with our colleagues at Ghent University to apply the non-invasive technique to improve talent identification and training individualisation with elite athletes.'

The researchers found BMX and sprint cyclists possess more fast-twitch muscles fibres while endurance cyclists and mountain bikers have more slow-twitch muscle fibres.

'A higher proportion of fast fibres is essential in sprint events such as BMX racing where a fast start is crucial, but also for road sprinters who produce a high intensity burst of speed at the end of a race.'

Physiological factors involved in successful endurance cycling include a high maximal aerobic power (VO_2 max), high lactate threshold and a high proportion of slow-twitch muscle fibres. Slow-twitch fibres are characterised by a high resistance to fatigue, enabling sustained high-power outputs for longer periods.

'While many track and field studies have shown that elite endurance athletes possess slow-twitch muscle fibres and elite sprint athletes with predominantly fast-twitch, Dr Belliger said it was the first study investigating the muscle typology in a large group of elite cyclists.

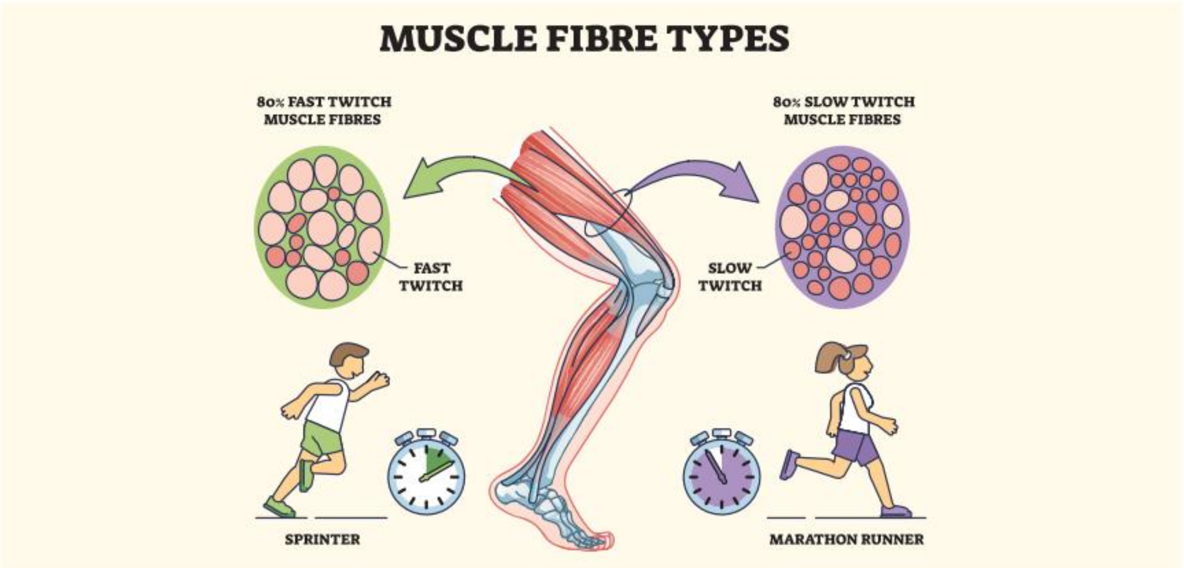
'While we found both slow and fast twitch muscle types in all the cyclists, when grouping them according to their main discipline, clear patterns emerged with both BMX and track cyclists possessing a faster typology when compared to cyclo-cross, road and mountain bike cyclists.

'BMX racing can be characterised as an all-out sprint discipline with race times not exceeding 45s [seconds] at the elite level. Track sprint cyclists also need fast fibres to produce a high pedalling frequency, but we found track cyclists excelling in track endurance events had an intermediate muscle typology as this event stresses both aerobic and anaerobic metabolism.'

The study found the individual pursuit, single-stage, cyclo-cross, mountain bike and multi-stage cyclists have a slow typology as these are mostly aerobically-based disciplines.

'As the muscle typology correlates well with the ideal discipline and event in both male and female cyclists of all professional levels, it may be a relevant factor for talent identification and talent transfer,' Dr Bellinger said.

Source: 'Muscle typology may be key to elite cyclists' success at chosen sport,' *Griffith News*, 19 November 2020. https://news.griffith.edu.au/2020/11/19/muscle-typology-key-to-elite-cyclists-success-at-chosen-sport
Reproduced with permission from Dr Phil Bellinger (Senior Lecturer and Sport Scientist, Griffith University).



VectorMine/Shutterstock.com

FIGURE 1.29 The importance of the skeletal muscle typology for training and recovery

QUESTIONS

1 **Identify** the key finding from the study.
2 **List** the characteristics of BMX racing that correlate with a need for a high percentage of fast-twitch fibres in the calf muscle.
3 **Identify** and **describe** the factors that contribute to success in endurance cycling events.
4 Based on your understanding of Type IIa and IIb fibres, **explain** why it is not surprising that the track cyclists had an intermediate muscle typology.
5 **Suggest** how the findings from the study could be used in talent identification programs.

Microstructure of skeletal muscles

mitochondria
Small structures found in the cytoplasm of a cell where ATP is produced

myoglobin
A protein that transfers oxygen from the blood to the muscle and stores and carries oxygen from the cell membrane to the mitochondria

sarcoplasmic reticulum
Endoplasmic reticulum in muscle cells that stores, releases and retrieves calcium ions

Skeletal muscle fibres are muscle cells, and within each cell there is a nucleus that produces the proteins and enzymes needed to maintain the function of the cell. Each individual muscle fibre is covered by a thin cell membrane called the sarcolemma, which contains the sarcoplasm, a gelatinous liquid that surrounds the cell.

The sarcoplasm contains:

- **mitochondria**, whose main role is to generate adenosine triphosphate (ATP), the primary energy source for movement
- **myoglobin**, which is responsible for transferring the oxygen from the haemoglobin in the blood to the muscle tissue, where it stores and carries oxygen from the cell membrane to the mitochondria
- **sarcoplasmic reticulum**, which stores, releases and retrieves calcium ions that are needed for muscle contraction and relaxation
- myofibrils, which are bundles of protein filaments (myosin and actin) that run the length of the muscle fibre.

Fuels (glycogen, triglycerides, creatine phosphate and ATP), other proteins and enzymes are all found in the muscle cell, and all have a role in muscle contraction.

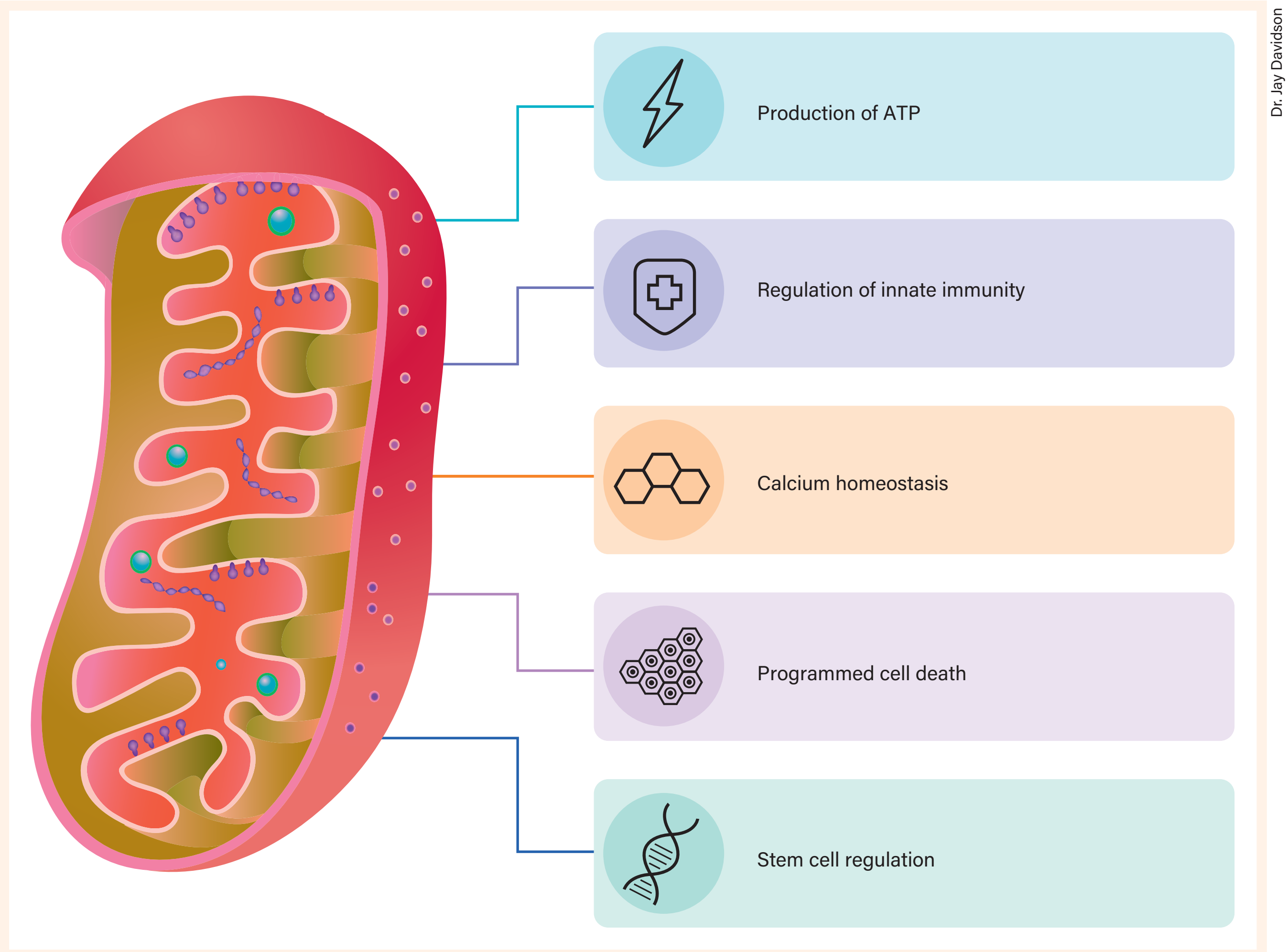


FIGURE 1.30 Role of the mitochondria

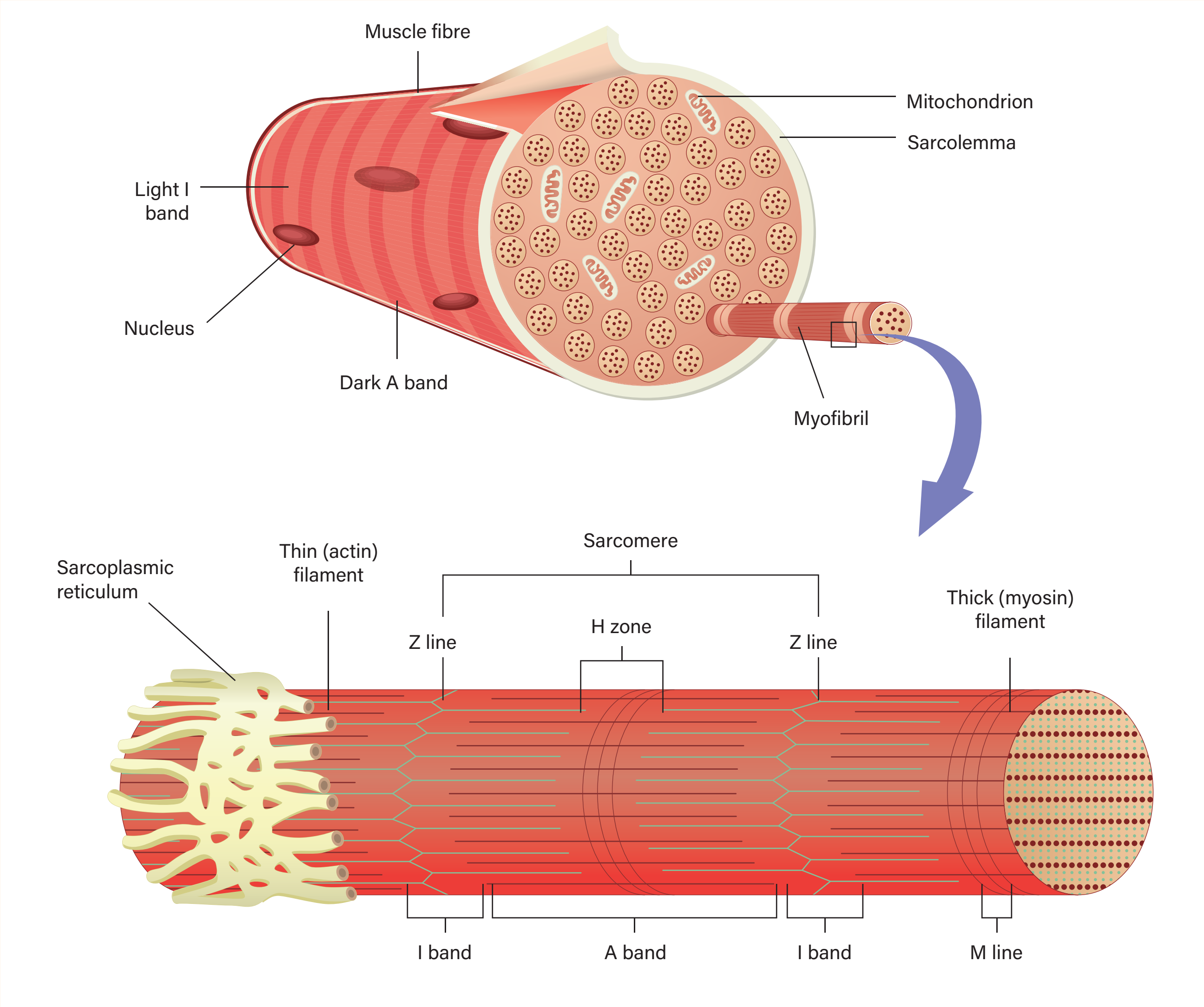


FIGURE 1.31 Microscopic structure of skeletal muscle

Within each muscle fibre are hundreds to thousands of **myofibrils**, and within each myofibril are sarcomeres, the smallest functional units in the muscle fibre.

The **sarcomere**, which is a contractile unit between two adjacent Z lines, contains the I band (light region) and the A band (dark region), which contain thick and thin protein myofilaments. These are then repeated along the length of the myofibril (see Figure 1.32). These light and dark regions repeat along the length of the fibre, giving the muscle its striated, or striped, appearance.

The A band is made up of thick **myosin** filaments and the I band is made up of thin **actin** filaments. Actin filaments extend into the A band and overlap with the myosin filaments, giving the A band its darker appearance. The H zone, the region in the middle of the A band, is lighter in colour because it only contains myosin.

Myosin filaments have oar-like projections called cross-bridges that link to the actin filaments and pull the filaments across each other, which is the most important factor for generating the contractile force. Troponin and tropomyosin are proteins that run along the actin filaments and control when the actin binding sites will be available to the myosin. Each myosin filament is surrounded by six actin filaments, but each actin filament is surrounded by three myosin filaments.

myofibrils
Bundles of protein filaments (myosin and actin) that run the length of the muscle fibre

sarcomere
Repeating contractile unit located between two adjacent Z lines within a myofibril

myosin
Thick protein filament found in the sarcomere

actin
Thin protein filament found in the sarcomere

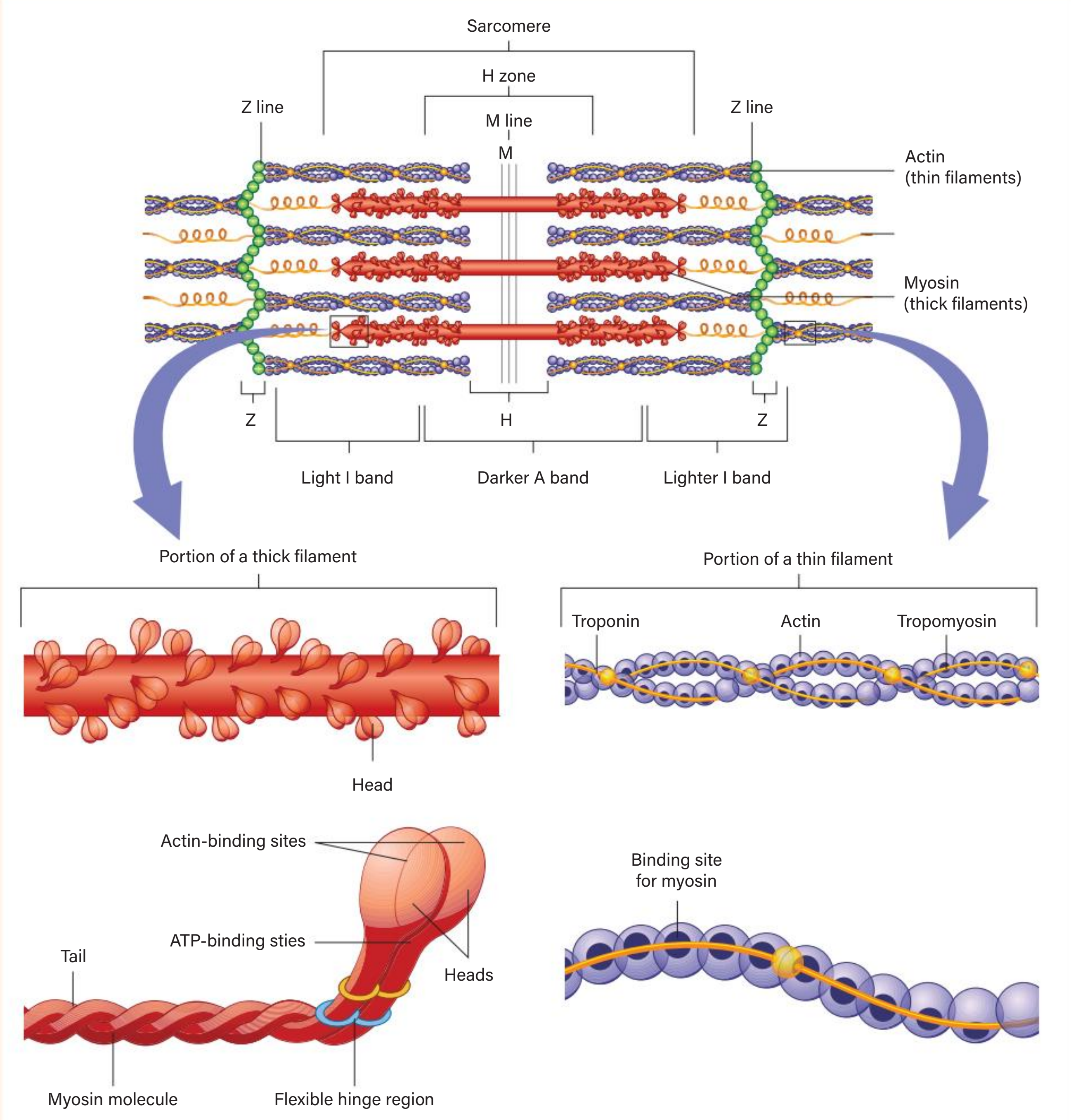


FIGURE 1.32 Myosin and actin filaments provide the structures that facilitate muscle contraction.

Video
In Focus: Sliding filament theory

The myosin cross-bridges attach to the actin filament, the head of the myosin flexes and bends to pull the actin filament towards the middle of the sarcomere (power stroke). The cross-bridge detaches and then the process is repeated, resulting in the overall shortening of the sarcomere. This is called the sliding filament theory, because the myofilaments do not change length but slide across each other.

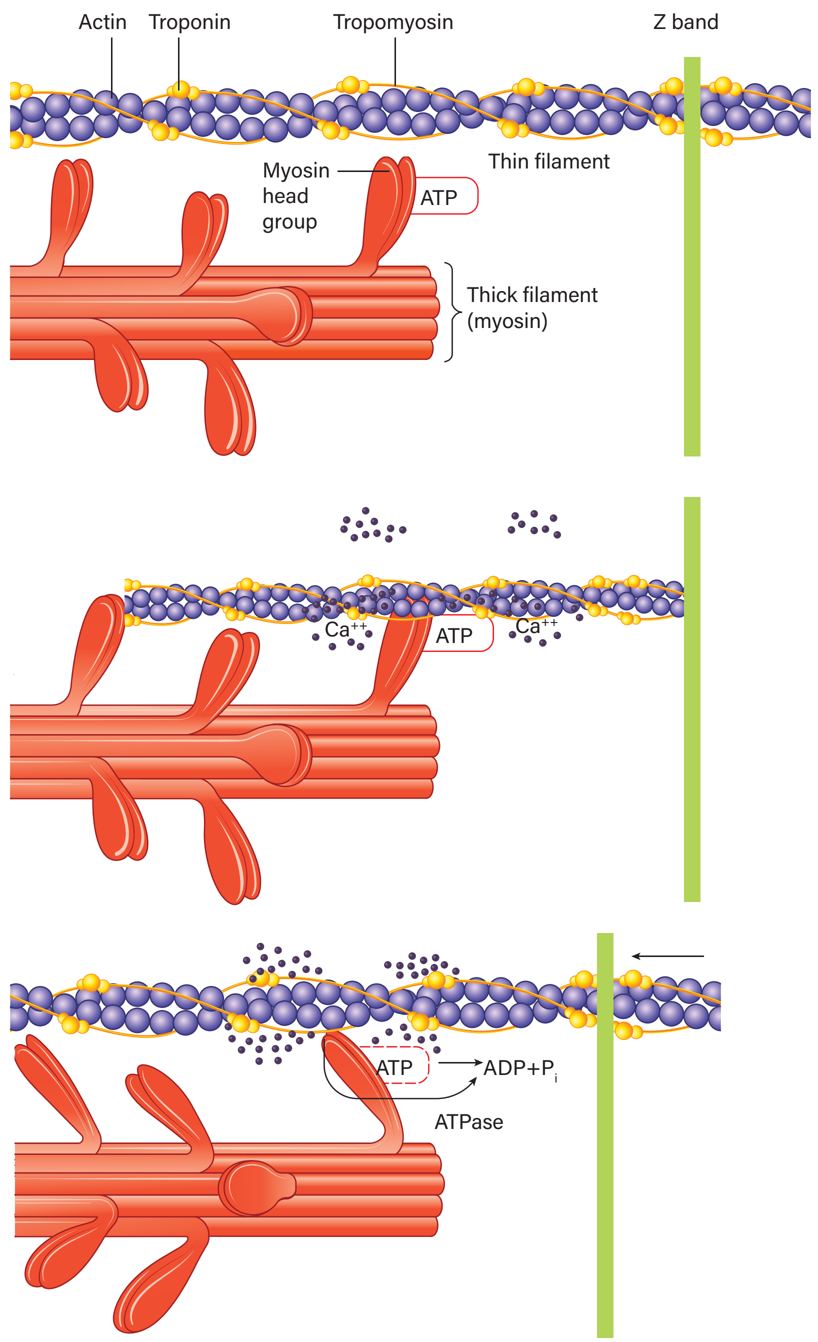


FIGURE 1.33 Myosin cross-bridge 'grabs' onto the actin, pulling it in towards the middle of the sarcomere, reducing the overall length of the sarcomere. This is repeated along the length of the muscle, resulting in muscle contraction.

Source: Manjarres-Triana, A., et al. (2023). Overview of processing techniques for surface electromyography signals. arXiv preprint arXiv:2304.04098

SIGNPOST

Watch the video 'Anatomy of a skeletal muscle fibre' on the Khan Academy website to see a detailed explanation on the anatomy of a skeletal muscle fibre.

Weblink
Anatomy of a skeletal muscle fibre

ABOVE AND BEYOND THE STUDY DESIGN
The sliding filament theory, p. 53

Muscle control

Controlling the force that is generated when movement occurs is important in many activities. For example, if an athlete was unable to control the force generated when playing tennis, it would not be possible to serve at different speeds, or to be able to control a forehand or drop shot. The muscle action is controlled by the **central nervous system (CNS)** and the **peripheral nervous system (PNS)**.

central nervous system (CNS)
Made up of the brain and the spinal cord

peripheral nervous system (PNS)
Made up of nerves that carry messages to and from the CNS

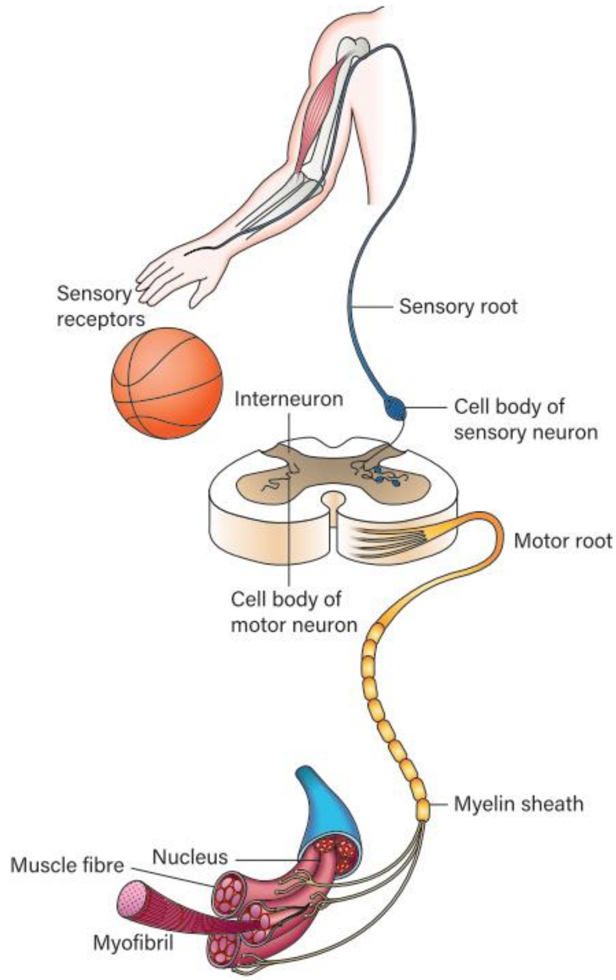


FIGURE 1.34 Nerve impulses are transmitted from the brain to the muscles via the spinal cord.

The muscle action is initiated by the brain, which sends a message via the spinal cord to the neuromuscular junction (NMJ), where the **motor neuron** meets the muscle fibre. A signal from the motor neuron is the only way to tell a muscle fibre to contract. Each individual muscle fibre is innervated by one motor neuron, but a single motor neuron can **innervate** a number of muscle fibres. The motor neuron and all of the muscle fibres it innervates is referred to as a **motor unit**.

motor neuron
A nerve cell that conveys nerve impulses from the spinal cord or brain away from the central nervous system and towards the muscle

innervate
To supply (a body part) with nerves

motor unit
A motor neuron and all of the muscle fibres it stimulates

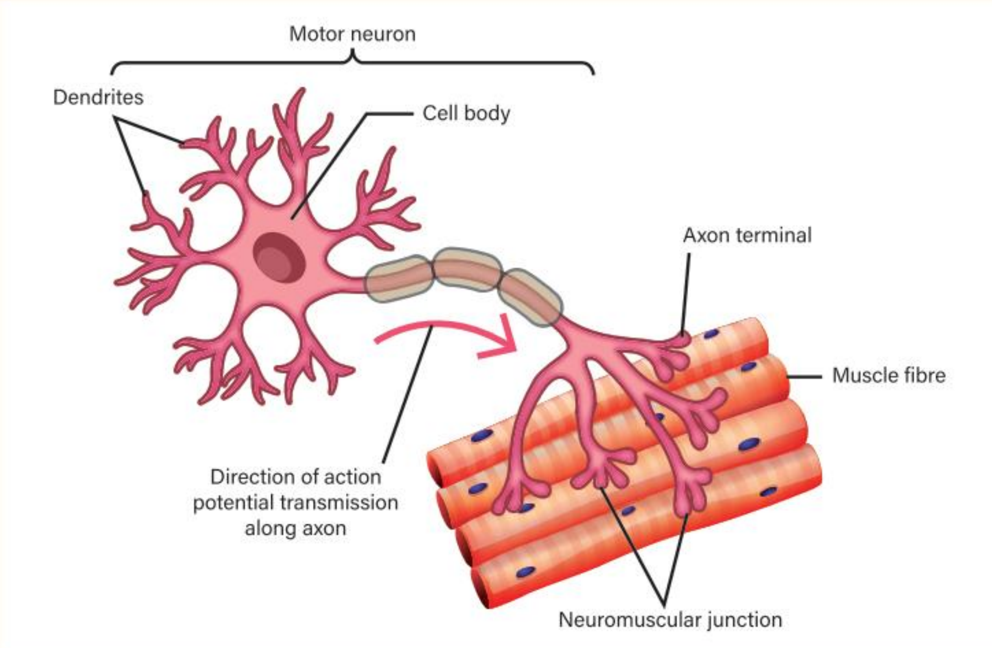


FIGURE 1.35 A motor unit comprises the motor neuron and all of the muscle fibres it innervates.

A motor unit contains *only* Type I or Type II fibres, and the characteristics of the fibre type correspond to the force capability of the motor unit.

TABLE 1.8 Motor unit characteristics

Muscle fibre type in motor unit	Force production	Contraction speed
Type IIb Fast glycolytic	High	Very fast
Type IIa Fast oxidative glycolytic	Moderate	Fast
Type I Slow oxidative	Low	Slow

The size of the motor unit determines the movements that it will control. For example, a motor unit that contains very few muscle fibres is more suited to fine motor movements such as the delicate eye movements needed to focus, and the movements of the fingers required to hold the bow string in archery. Other motor units have thousands of muscle fibres, and are more suited to gross movement skills such as kicking a football.

The sequence that leads to a muscle contracting starts with the generation of an action potential, which is a special type of electrical signal that travels along the cell membrane to the motor neuron in a wave-like manner. In skeletal muscles, this signalling of the action potential at the neuromuscular junction starts the excitation-contraction coupling process that results in a muscle action.

It is important to remember that muscle contraction cannot occur without enough ATP to fuel the cross-bridge cycle of attaching and detaching. The amount of ATP stored in muscle is very low – there is only enough for a few seconds of contractions, which means it needs to be replaced quickly to allow for sustained contractions. There are three energy systems that the body can call on to regenerate ATP: the creatine phosphate system, the anaerobic glycolysis system and the aerobic energy system.

FIGURE 1.36 Fine motor skills such as eye movements and finger movements have a smaller ratio of muscle fibres to motor units compared to gross movement skills.

LOOKING FORWARD

Energy for physical activity

Unit 3

The three energy systems are covered in VCE Physical Education Unit 3, when looking at the energy required for physical activity. In Unit 3 you will look at the different characteristics of each system and the relationship between energy system usage and the intensity and duration of the activity.

ABOVE AND BEYOND THE STUDY DESIGN

The excitation-contraction coupling process, p. 54

DID YOU KNOW?

Rigor mortis, which is the stiffening of the muscles and joints that is observed soon after someone dies, is due to the loss of ATP. When there is no ATP available for the myosin heads to detach from the actin-binding sites, the cross-bridges stay attached, which causes the rigidity in the skeletal muscles.

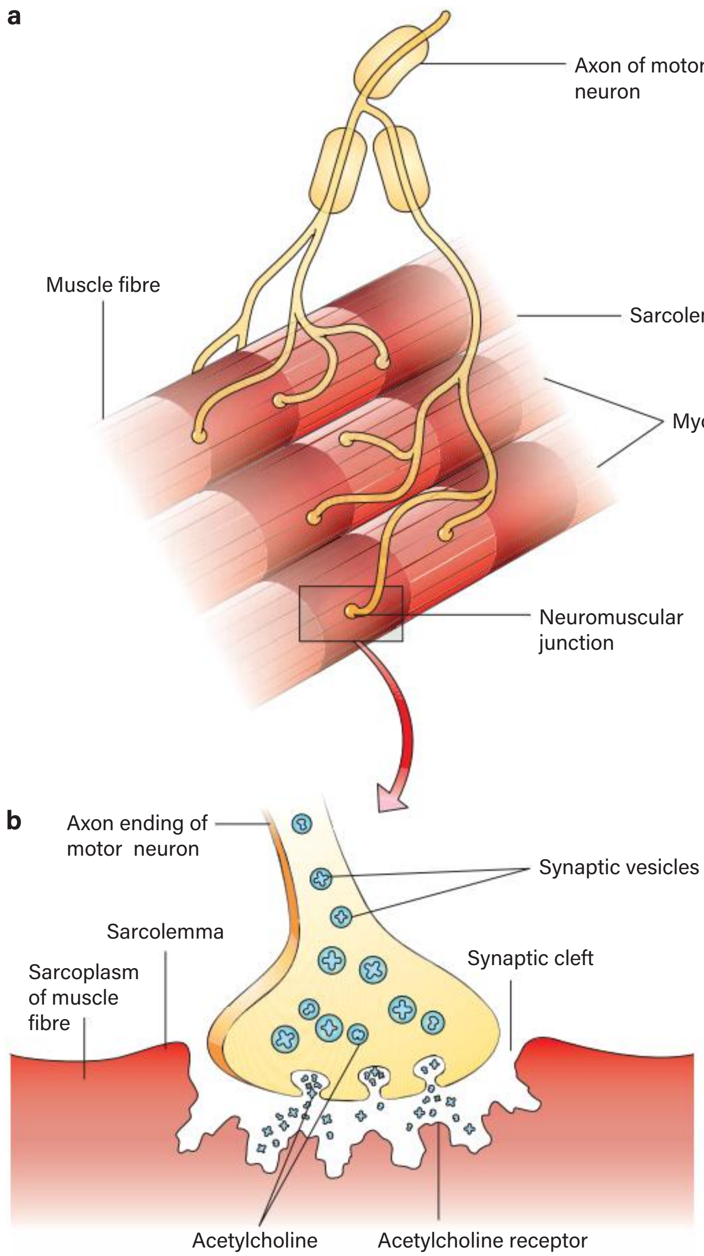


FIGURE 1.37 Enlarged detailed view of the neuromuscular junction

The all or nothing principle

When a motor unit is activated, it will either contract maximally or not at all. This is called the 'all or nothing principle'. The strength of the stimulus does not determine the strength of the response. As long as the stimulus exceeds the threshold, all of the muscle fibres within the motor unit will simultaneously contract maximally.

Therefore, if the intensity of the stimulus is:

- below the threshold = no action potential produced and no muscle contraction
- at threshold = action potential produced and muscle fibre contracts maximally
- above threshold = action potential produced and muscle fibre contracts maximally.

Increasing the strength of the stimulus above the threshold makes no difference to the strength of contraction of the muscle fibre. Therefore, the amount of force that a whole muscle contracts with is determined by the number of motor units recruited and the frequency of the messages that stimulate the motor neuron.

Video
In focus: Motor unit recruitment

Motor unit recruitment (size principle)

Motor unit recruitment is the process by which different motor units are activated to produce the required force for the specific activity. Consider how much force is needed to pick up a table tennis ball as you prepare to serve, compared to picking up a shot-put as you prepare to throw it. The nervous system controls the force required through the number of motor units that are stimulated. When a lower force is needed (such as when picking up the table tennis ball), very few motor units are activated, but when a larger force is needed (picking up the shot-put), more motor units are activated.

saintho/Adobe Stock

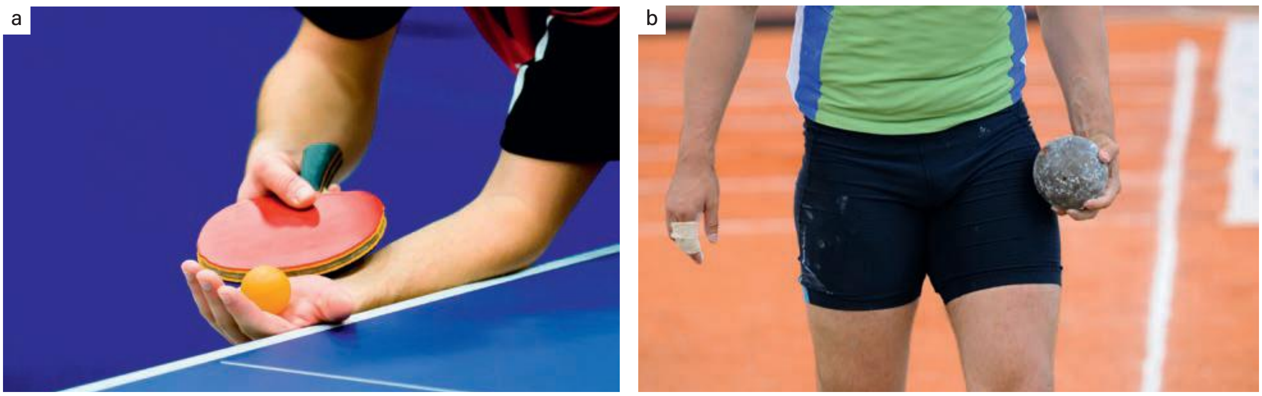


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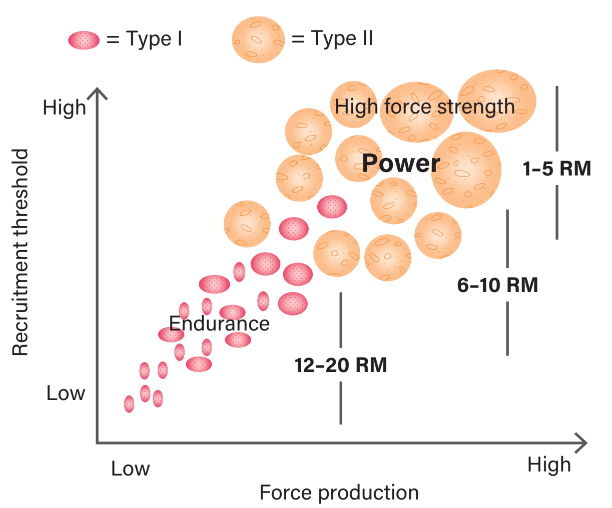
FIGURE 1.38 The force required to pick up a table tennis ball **(a)** is much less than the force needed to pick up a shot-put **(b)**.



Each circle (red are Type I and cream are Type II) represents a motor unit, with larger circles depicting larger motor units containing more fibres.

FIGURE 1.39 As the required force increases, the size and number of motor units increases.

Source: Kraemer, W.J. & Looney, D.P. (2012). Underlying mechanisms and physiology of muscular power. *Strength & Conditioning Journal*, 34(6), 13–19.

To control the amount of force generated by a muscle, the nervous system progressively enlists more, larger motor units. This is known as the size principle. The activation threshold of a motor unit is directly related to the size of the motor unit. The larger the motor unit, the greater the stimulation required. Smaller motor units have a lower threshold, so they are recruited first, followed by the larger motor units with a higher stimulus threshold. This orderly recruitment of smaller to larger motor units results in a smooth muscle action.

Type IIa and IIb muscle fibres are larger than Type I muscle fibres (see Table 1.7), so the size principle dictates that Type I (slow-twitch) muscle fibres are selectively recruited first. Not all Type I muscle fibres are activated simultaneously. Some of the motor units rest while others are active, to allow for longer muscle contractions in endurance activities. If a maximal force is needed, the maximum number of motor units in the muscle can be recruited simultaneously. For example, when cycling at a submaximal effort, Type I fibres will be activated, but if the cyclist needs to attack a hill, then the larger, more powerful Type II fibres will be activated.

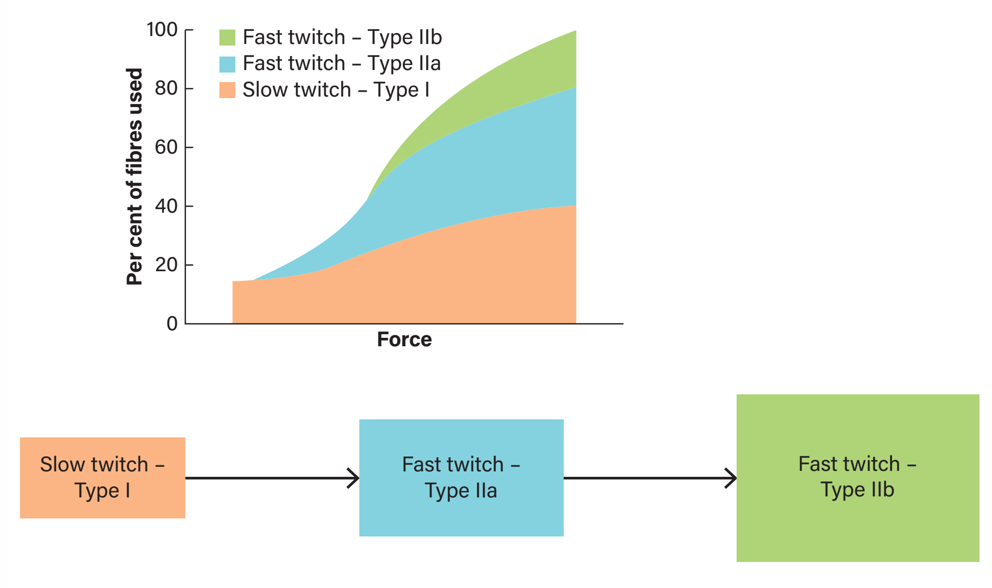


FIGURE 1.40 The recruitment of Type I (slow-twitch) and Type II and IIb (fast-twitch) muscle fibres as exercise intensity increases.

In summary, Type I (slow-twitch) muscle fibres are always recruited first, and as exercise intensity and/or duration increases, or fatigue becomes a factor, Type IIa and IIb are called upon to contribute to the development of force. In high-intensity efforts, the recruitment pattern occurs more rapidly, and in all-out maximal efforts, all fibres are recruited simultaneously.

DID YOU KNOW?

Muscles that are involved in maintaining posture, keeping the back straight, holding the head up and engaging the core need to be constantly producing tension. A small percentage of all motor units are constantly contracting, but not all at the same time, which means that the tension produced in the whole muscle remains constant.

Reciprocal inhibition and the role of agonists, antagonists and stabilisers

Muscles work together to produce movement. A group of muscles that work together are called **synergists**, and each of the muscles involved in the movement has a specific role to play. The key roles are:

- agonist
- antagonist
- stabilisers.

Muscles can only pull, not push, so they must work in pairs. The muscle that is contracting and plays the main role in producing movement is called the **agonist** (or prime mover).

synergists
Muscles that work together to create movement

agonist
The muscle primarily responsible for movement

antagonist
The muscle that relaxes as the agonist contracts

reciprocal inhibition
When muscles on one side of a bone or joint relax to accommodate the contraction of the muscle on the other side of the bone or joint

stabilisers
The muscles that stabilise one part of the body while another is moving

The muscle that produces the opposite action to the agonist is called the **antagonist**. The antagonist will relax and lengthen as the agonist contracts. This relaxation is essential to allow the agonist muscle to contract effectively and produce a smooth and controlled movement.

Reciprocal inhibition involves the coordination of agonist and antagonist muscles during movement. Muscles in the body typically work in pairs, with one muscle contracting to produce a specific movement (agonist), while its opposing muscle relaxes (antagonist). Reciprocal inhibition ensures that these muscle pairs work together efficiently. This mechanism helps prevent opposing muscles from contracting simultaneously and interfering with each other's actions.

Stabilisers are the muscles that stabilise the origin of the agonist to ensure that it remains fixed in position for the muscle to pull against. Stabilisers work isometrically, which means that they are contracting without any discernible change in length. They assist by stabilising the joint and the rest of the body.

An example of muscles working in pairs can be seen in forearm flexion (as seen in a bicep curl). The bicep brachii is the agonist, as it contracts and is responsible for the movement. The triceps muscle is the antagonist, as it must lengthen – the opposite action to the agonist. The muscles reverse roles when the forearm is extended.

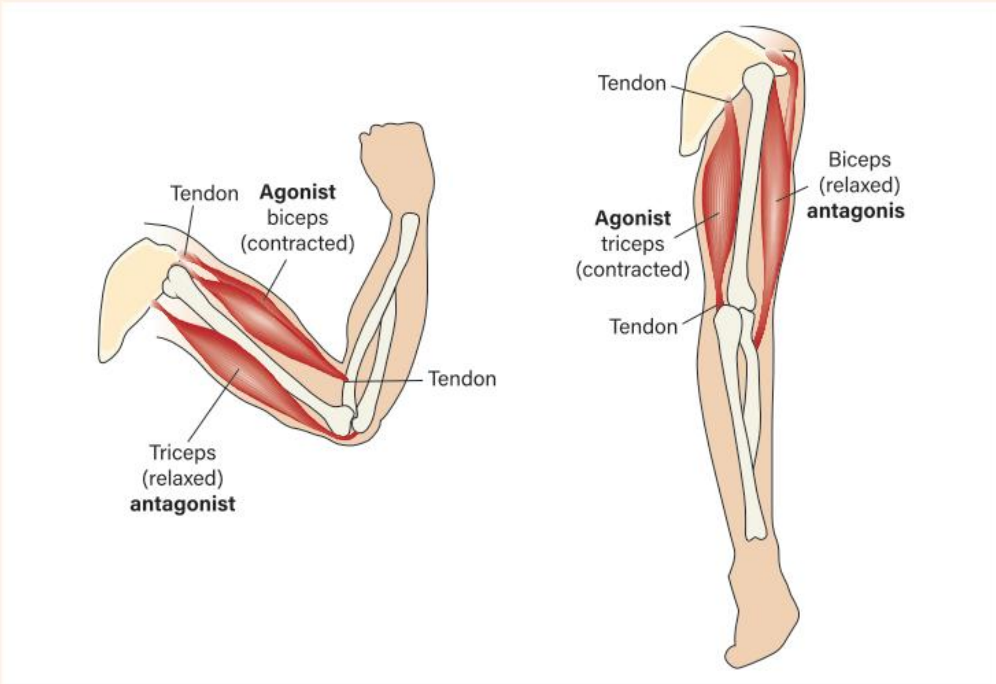


FIGURE 1.41 The agonist and antagonist relationship with elbow flexion (left) and extension (right)

TABLE 1.9 Sporting examples of agonist/antagonist relationships

Joint	Muscles	Movement	Example
Elbow	Biceps; triceps	Flexion; extension	Chest pass in netball; tennis smash
Knee	Hamstrings; quadriceps	Flexion; extension	Jumping to block in volleyball; depth jumps in plyometrics
Shoulder	Latissimus dorsi; deltoid	Adduction; abduction	Golf swing; breaststroke arms

COLLABORATIVE TASK
Prac activity

Musculoskeletal analysis of movement

AIM

To determine the joint motion and muscle groups involved in a vertical jump

EQUIPMENT

Nil/mobile phone

METHOD

This activity can be done through direct observation or through analysis of video footage.

In pairs, each student completes a vertical jump while their partner observes and/or films the action.

If using direct observation without recording, you may wish to perform more than one jump.

OBSERVATIONS

Draw a diagram to show the body position at the three phases of the motion: down phase, up phase and flight phase.

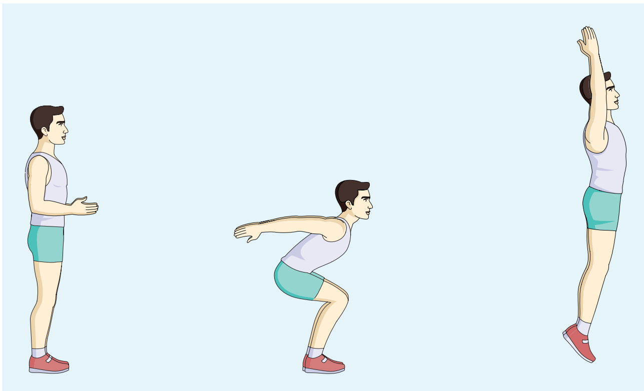


FIGURE 1.42 Perform and observe a vertical jump.

Complete the table below to analyse the movement (the first one has been done for you).

Joint	Phase of motion	Type of joint	Joint movement	Active muscle group
Ankle	Down	*Hinge*	*Dorsiflexion*	*Tibialis anterior*
	Up			
Knee	Down			
	Up			
Hip	Down			
	Up			
Shoulder	Down			
	Up			

DISCUSSION

1 **Identify** three different sports where having a good vertical jump is important.

2 What are the major muscle groups involved in the vertical jump?

3 How can athletes and coaches use the information you have collected to improve an athlete's performance in the vertical jump?

Template
Musculoskeletal analysis of movement

isoinertial
Muscle action where the resistance is constant throughout the movement

isometric
Muscle action where there is no change in muscle length and no joint movement occurs

Types of muscle actions

Skeletal muscles contract in response to a stimuli. When they contract they develop tension, which causes the muscle to pull on the bone it is attached to. The muscle may develop tension while shortening, lengthening or staying the same length. The terms used to describe these actions are **isoinertial** (concentric and eccentric) and **isometric**, respectively.

Isometric actions

When tension is developed in the muscle but there is no movement of the bones it is attached to, this is called an isometric muscle action. Isometric actions are static, meaning there is no change in muscle length and no limb or joint movement. The muscle length remains constant as the force is developed in the muscle. Isometric muscle actions are often used to 'fix' or stabilise the joints and limbs involved in the action (that is, to keep them from moving). Examples of isometric muscle actions include exercises such as a wall sit, plank or V-sit. In sport, isometric muscle actions are involved in gripping sporting apparatus such as bats, clubs and racquets.

New Africa/Adobe Stock

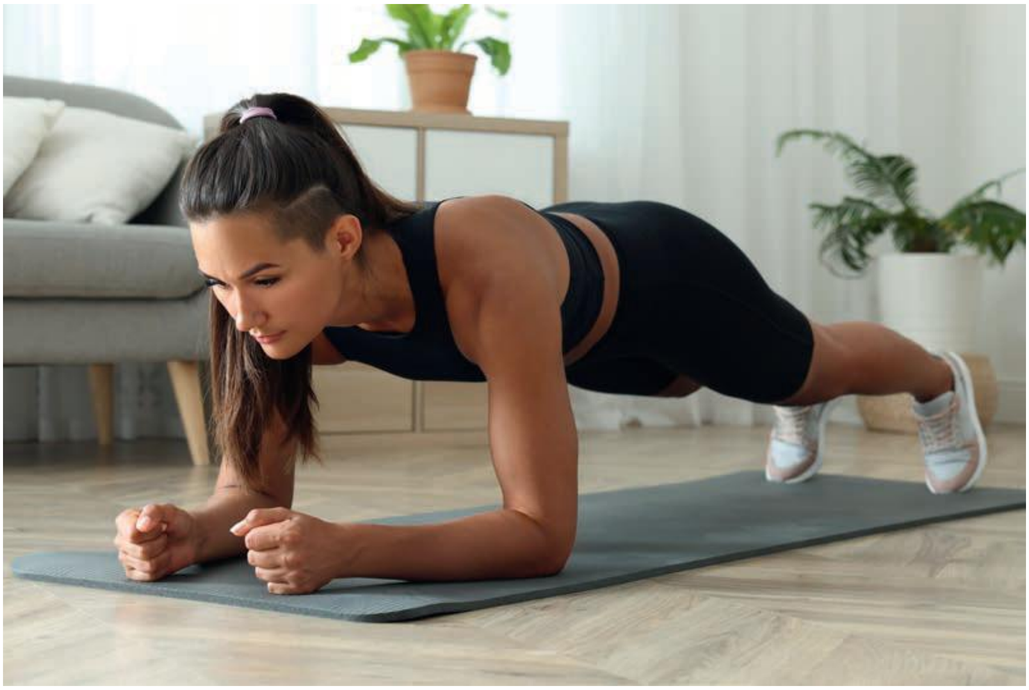


FIGURE 1.43 Isometric actions involve the muscle developing tension with no movement of the bones the muscle is attached to.

DID YOU KNOW?

Muscle actions have previously been described as muscular 'contractions.' However, this can be confusing, because to 'contract' means to shorten, and only one muscle action (a concentric action) involves shortening of the muscle.

Isoinertial actions

Isoinertial muscular actions are most common in physical activity, sport and exercise. When a muscle action produces movement of the skeleton, by either shortening or lengthening the muscle, tension is developed. This type of action is a dynamic muscle action, as it causes movement of the body part or limb.

There are two types of dynamic actions: concentric and eccentric.

- A **concentric action** of the muscle produces tension while shortening. In concentric actions, the points of attachment (origin and insertion) come closer together.
- An **eccentric action** of the muscle produces tension while lengthening. In eccentric actions, the points of attachment (origin and insertion) move further apart.

The term 'isoinertial' reflects the fact that the resistance (inertia) that is being moved is the same (iso) throughout the movement. For example, in a calf raise, the resistance being moved is the person's body weight, and in a bicep curl it is the weight of the dumbbell. The concentric action in a bicep curl is during the upward/lifting phase (elbow flexion), and the eccentric action is in the downward phase (elbow extension). Eccentric actions occur whenever an action opposes gravity.

concentric action
Muscle shortens as tension develops; joint movement occurs

eccentric action
Muscle lengthens as tension develops; joint movement occurs

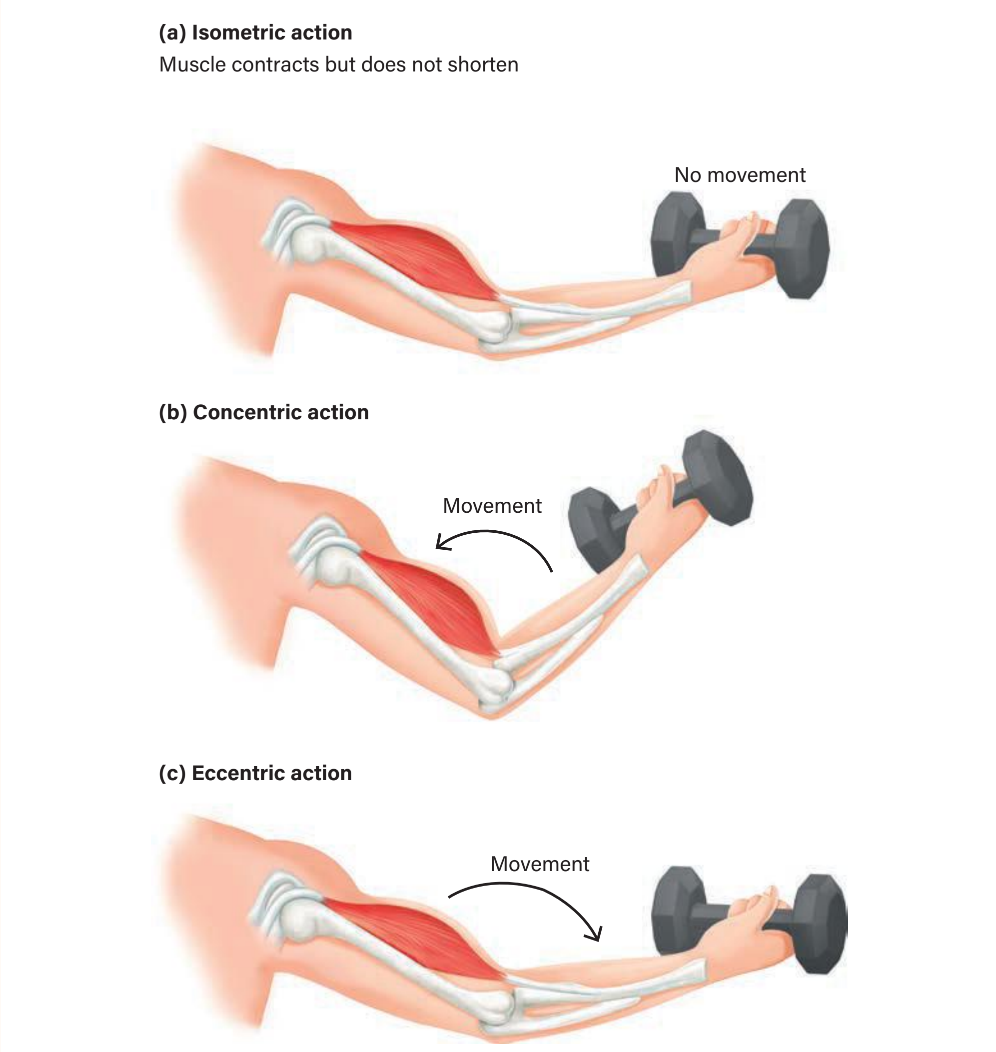


FIGURE 1.44 Isometric and isoinertial muscle actions

LEARNING HACK

The origins of words can help us to remember the types of muscle actions being described:

iso = equal or the same

metric = length

inertia = resistance

Therefore, muscle actions that are:

iso-metric = same length (muscle length does not change throughout the movement)

iso-inertial = same resistance (the resistance is constant throughout the movement).

COLLABORATIVE TASK
Classroom prac activity

Muscle actions

AIM

To identify examples of different muscle actions

EQUIPMENT

Nil

METHOD

Complete the following exercises and based on your experience, then reflect on the questions below.

Push-ups: Complete five push-ups and then on the sixth, hold the position, so that no movement is occurring. Hold for 5–10 seconds, then relax.

Sit-ups: Complete five sit-ups and on the sixth, hold the position so that no movement is occurring. Hold for 5–10 seconds, then relax.

DISCUSSION

1 In each phase of the push-up, what muscle action is occurring at the elbow joint?
2 In the up phase of the sit-up, which muscle is contracting concentrically, and which is contracting eccentrically?
3 What was occurring in the muscle when you were holding the static position in each exercise?
4 If the muscles were not active in the 'hold' position of each exercise, what would happen?

Assessment
1.3 Check-in questions

1.3 CHECK-IN QUESTIONS

1 The smallest to the largest unit of organisation in a skeletal muscle is:
   A muscle fibre, fascicle, filament, myofibril.
   B fascicle, filament, muscle fibre, myofibril.
   C myofibril, muscle fibre, filament, fascicle.
   D filament, myofibril, muscle fibre, fascicle.
2 Which arrangement best describes a unipennate muscle?
   A The muscle fibres feed in on an angle to a long tendon from one side.
   B The muscle fibres feed in on an angle to a long tendon from both sides.
   C The muscle fibres feed in on an angle to a long tendon from all directions.
   D The muscle fibres on one side of a tendon feed into it at a certain angle and the muscle fibres on the other side of the tendon feed into it at the opposite angle.
3 The muscles of a professional sprinter are most likely to have:
   A 20 per cent fast-twitch muscle fibres and 80 per cent slow-twitch muscle fibres.
   B 50 per cent fast-twitch muscle fibres and 50 per cent slow-twitch muscle fibres.
   C 80 per cent fast-twitch muscle fibres and 20 per cent slow-twitch muscle fibres.
   D 40 per cent fast-twitch muscle fibres and 60 per cent slow-twitch muscle fibres.
4 Using a specific example, **explain** reciprocal inhibition and why it is an important mechanism.
5 What are three factors that contribute to the amount of tension produced in an individual muscle fibre?
6 **Identify** the agonist, antagonist and stabiliser muscles involved in kicking a ball in soccer. How do the roles change after contact has been made with the ball?

Command term

explain
Give a detailed account of why and/or how with reference to causes, effects, continuity, change, reasons or mechanisms; make the relationships between things evident

1.4 THE MECHANICS OF MOVEMENT

In this module you will learn about:
- interactions of muscles and bones to produce movement, including the structure and examples of anatomical lever systems

and learn to:
- analyse a variety of movements used in physical activity, sport and/or exercise to explain the interaction between bones, muscles, joints and joint actions using examples of lever systems.

Interactions of the skeletal and muscular systems

The skeletal and muscular systems work together to produce movement in the body. Recall that skeletal muscles are voluntary, meaning that the movement can be controlled. For example, when hitting a golf ball, the force, velocity and range of motion of the swing are controlled by the player, to result in a coordinated movement pattern.


iStock.com/arsenik

FIGURE 1.45 When hitting a golf ball, the golfer controls the movements of the trunk, shoulders and arms, which are combined to hit the ball.

The tension developed in muscles as they contract is transferred through the tendon that is attached to the bone. The tendon then pulls on the bone at the points of attachment with equal force, pulling the bones towards each other. At the origin, the bone moves less, and at the insertion point the bones will move more. The movement generated is usually to shift a resistance – this may be the weight of the body or a body part, or it may be an external resistance, such as a bat, club, racquet or ball. To achieve this, the musculoskeletal system is functioning as a series of levers.

Anatomical lever systems

The bones, joints and muscles make up the lever systems in the body. A **lever** is a simple machine consisting of a rigid bar that rotates around an axis to exert a force on another object.

lever
A simple machine consisting of a rigid rod that is capable of rotating around an axis

All levers have three parts:
- an axis (or fulcrum or pivot point)
- a resistance (or weight or load to be moved)
- a force (or effort).

In the human body, the bones represent the rigid bars, the joints are the axes and the muscles contract to apply the force. The arrangement of these three components determines the type or class of lever. All three are found in the human body, however most levers in the human body are third-class levers, which are designed for speed and range of motion, not force production.

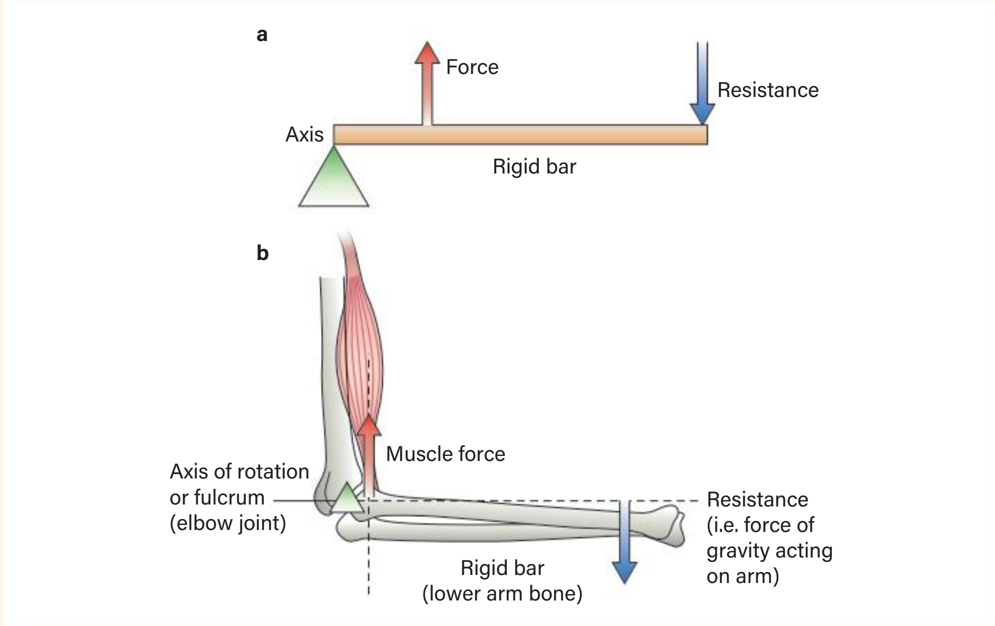


FIGURE 1.46 Components of a lever: **(a)** mechanical example, **(b)** human body example

Classification of levers

The arrangement of the three components of a lever determines the class of the lever and its functionality.

- First-class lever: the axis is between the resistance and the force.
- Second-class lever: the resistance is between the force and the axis.
- Third-class lever: the force is between the resistance and the axis.

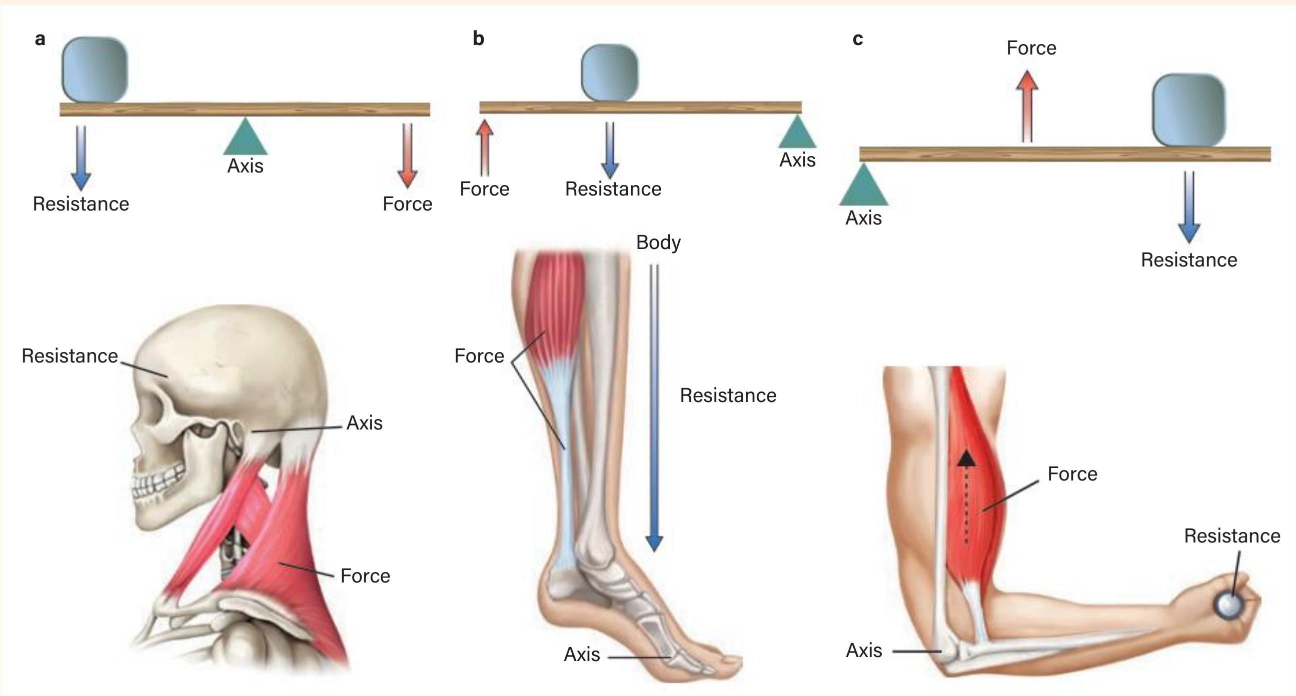


FIGURE 1.47 (a) First-class lever **(b)** Second-class lever **(c)** Third-class lever

First-class levers

In first-class levers, the axis is positioned between the resistance and the force. There are very few examples of first-class levers in the human body, but one is the nodding the head. In this movement, the joint between the head and the first vertebra is the axis, the weight of the head is the resistance and the posterior neck muscles provide the force. First-class levers are unique in that the resistance and the force act in the same direction. The relative position to the axis determines the function of the lever (range of motion or force output).

Second-class levers

In second-class levers the resistance is positioned between the axis and the force. There are very few examples of second-class levers in the human body, because it is not designed to apply great force through its system of levers. One example of a second-class lever is performing calf raises (or standing on the tips of your toes). The ball of the foot is the axis and the weight of the body is the resistance to be moved. The gastrocnemius and soleus provide the force that results in the movement; that force is applied to the heel bone (see Figure 1.47(b)). Second-class levers are useful when a large resistance needs to be moved by a relatively small force. They are sometimes called force multipliers.

Third-class levers

In third-class levers, the force is applied between the axis and the resistance. Third-class levers are the most common type of lever in the human body, as they are designed to increase the speed and range of motion of the lever, which is usually a limb (arm or leg). The resistance (often a bat, club or ball held in the hand) is further from the axis than the force being applied, as the resistance is generally at the end of the lever. One example is a bicep curl. The elbow joint is the axis, the resistance is the weight being lifted, and the force is generated by the biceps muscle as the elbow is flexed (see Figure 1.47(c)).

Third-class levers require greater force to move a given resistance than other types of levers, but gain a greater range of motion and angular speed, which is why they are sometimes called speed multipliers. This is beneficial for actions such as kicking, hitting and throwing, which all involve third-class levers.

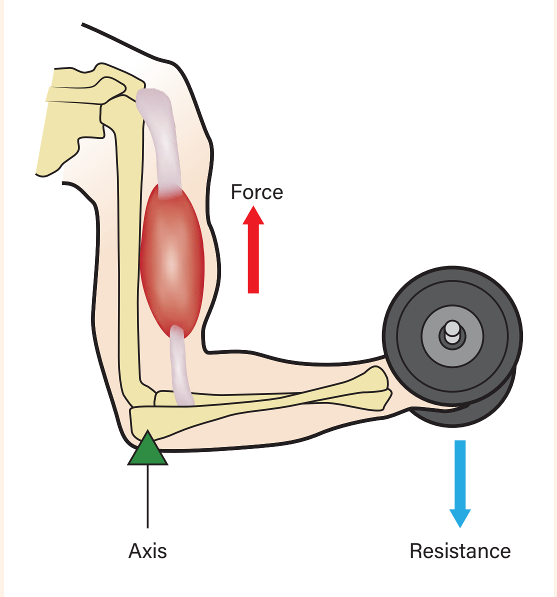


FIGURE 1.48 Third-class levers require a relatively large force to move a relatively small resistance through a large range of motion.

LOOKING FORWARD
Analysis of human movement

Units 3&4 – Chapter 3

Unit 3 of VCE Physical Education looks at the biomechanical principles associated with analysing human movement, and how the components of anatomical levers can be manipulated to enhance performance in physical activity, sport and exercise. Chapter 3 of the *Nelson Physical Education VCE Units 3&4* takes a deep dive into the mechanical advantage of third-class levers.

Assessment
1.4 Check-in questions

Command terms

list
Provide a series of related words, names, numbers or items that are arranged consecutively

justify
Show, prove or defend, with reasoning and evidence, an argument, decision and/or point of view using given data and/or other information

1.4 CHECK-IN QUESTIONS

1 **List** the three components of an anatomical lever.
2 The advantage of a second-class lever is:
  A an increase in the angular velocity of the lever.
  B an increase in the range of motion of the lever.
  C a decrease in the force required to move a mass.
  D a decrease in the mechanical advantage of the lever.
3 The baseball bat shown in the image below is an example of which class of lever? **Justify** your response.

Joe/Adobe Stock

4 **Describe** the interaction of the musculoskeletal system when throwing a ball.
5 Select a movement skill and **explain** the interaction of the musculoskeletal system (bones, muscles, joints, joint actions) and the lever system involved in the movement.

MODULE 1.3, p. 38

The sliding filament theory

ABOVE AND BEYOND THE STUDY DESIGN

The sliding filament theory was developed over 60 years ago, and proposes that muscles shorten or lengthen because the thick myosin and thin actin filaments slide over each other without actually changing length. This model helps to explain muscle actions. There are five key stages involved:

- Resting stage: This is the resting state of muscle. No tension is developed in the muscle, as tropomyosin blocks the binding sites and the actin and myosin are detached.
- Excitation-contraction stage: A message from the motor nerve generates an action potential that triggers the release of calcium from the sarcoplasmic reticulum. Calcium (Ca^{2+}) binds to the troponin, which causes the tropomyosin to move, resulting in the exposure of the active binding sites on the actin. This allows the myosin head to attach to the actin, forming the cross-bridges (see step 2 in Figure 1.49).
- Contraction stage: Actin combines with myosin ATPase, which splits the ATP molecule into ADP and Pi, releasing energy. This energy is used by the myosin head to move, pulling the actin filament towards the middle of the sarcomere (power stroke), creating tension (see step 3 in Figure 1.49). This movement occurs from both sides, shortening the sarcomere and resulting in muscle contraction.
- Recharge stage: The cross-bridges continue to be activated, and will form and reform, with the myosin attaching to a new position on the actin filament while Ca^{2+} is present and ATP and myosin ATPase are available (see step 4 in Figure 1.49).
- Relaxation stage: When the message is no longer arriving at the muscle, the Ca^{2+} moves back into the sarcoplasmic reticulum, which turns off the active sites. The actin and myosin filaments no longer bind to each other.

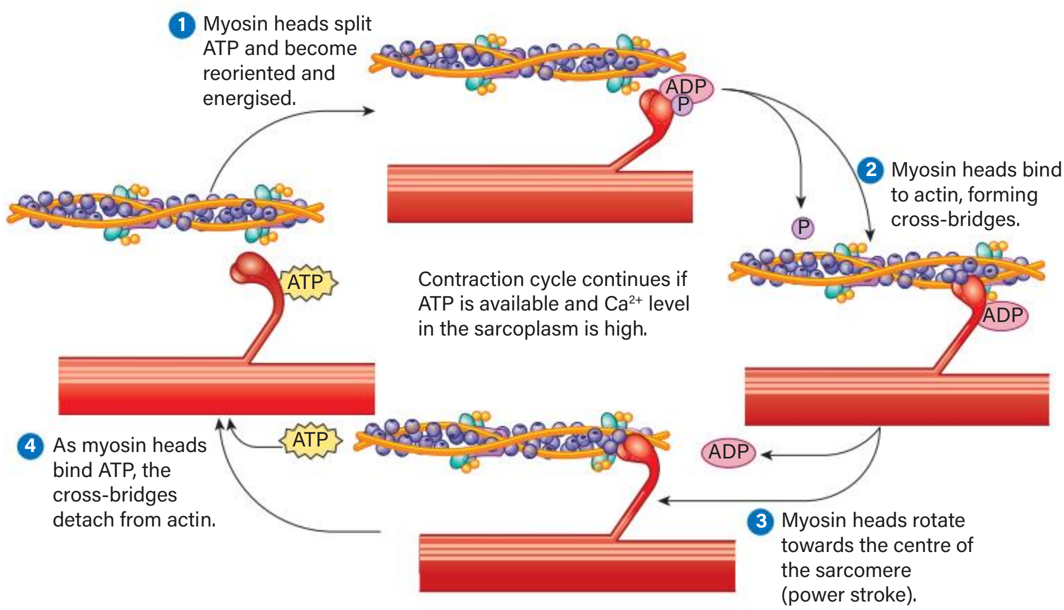


FIGURE 1.49 There are five stages in the sliding filament theory.

Source: Tortora, G.J. & Grabowski, S.R. (2003). *Principles of Anatomy of Physiology*. New York: John Wiley & Sons.

During a muscle contraction, the distance between the Z lines is reduced, which results in the shortening of the sarcomere. While the sarcomere can shorten by 30–60 per cent during the contraction, the length of the A band does not change. The H zone can disappear, however, and the I band regions shrink.

ABOVE AND BEYOND THE STUDY DESIGN

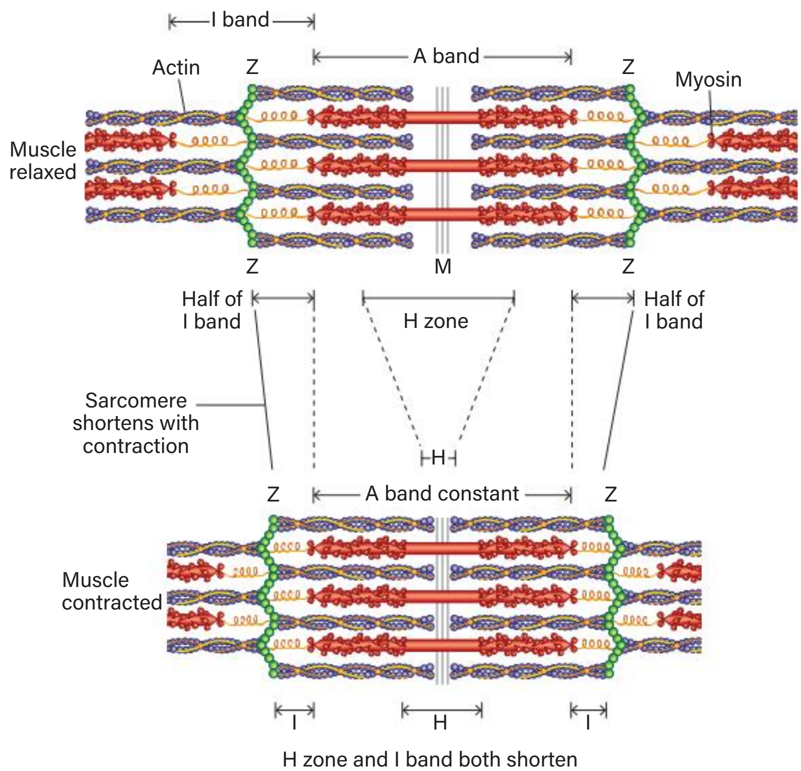


FIGURE 1.50 The actin and myosin filaments overlap, resulting in the shortening of each individual sarcomere.

MODULE 1.3, p.40

The excitation-contraction coupling process

The excitation-contraction coupling process is outlined below:

- Nerve impulse arrives at the neuromuscular junction (NMJ).
- Acetylcholine (ACh), which is a **neurotransmitter**, is released and diffuses across the **synaptic cleft**.
- ACh binds with ACh receptors on the other side of the synapse in the muscle fibre sarcolemma.
- The chemically 'gated' channel is opened, and sodium ions enter the muscle fibre, depolarising the membrane. This allows the action potential to rapidly 'fire' along the length of the muscle fibre.
- Immediately following depolarisation, repolarisation occurs as potassium leaves the cell. This returns the cell membrane to a negative membrane potential.
- The action potential in the muscle fibre causes electrical changes that make the membrane of the sarcoplasmic reticulum permeable to calcium ions.
- Calcium (Ca^{2+}) ions are released and diffuse into the sarcoplasm, resulting in muscular contraction.
- ACh in the synaptic cleft is degraded so that it cannot rebind to a receptor and reopen its channel, resulting in one presynaptic action potential producing one postsynaptic action potential in the muscle fibres.
- The muscle relaxes.

neurotransmitter
A substance released by the presynaptic terminal that stimulates the production of an action potential

synaptic cleft
Space between the pre-synaptic and the post-synaptic membranes

CHAPTER SUMMARY

1.1 Describing the human body in motion

- Anatomical terms provide a 'language' to describe human movement.
- There are three anatomical planes that dissect the body. Each has an associated axis of movement:
  - sagittal (median) plane – transverse axis
  - frontal (coronal) plane – anteroposterior axis
  - transverse (horizontal) plane – longitudinal axis.

Resource
Self-assessment checklist

Video
Masterclass: Chapter 1

1.2 The skeletal system

- The musculoskeletal system comprises the skeletal system (bones and joints) and the skeletal muscles.
- The skeletal system has five key functions: movement, support/posture, protection, storage and blood cell production.
- Bones can be classified as long, short, flat or irregular.
- The vertebral column consists of the seven cervical vertebrae, 12 thoracic vertebrae, five lumbar vertebrae, five sacrum and four coccyx.
- Joints (where two or more bones meet) hold bones together and are classified according to the amount of movement they allow: fixed (immoveable), cartilaginous (slightly moveable) and synovial (freely moveable).
- There are six types of synovial joints, which are classified according to their shape and the type of movement they allow: pivot, gliding, ball and socket, hinge, saddle and condyloid.
- Joint actions include flexion, extension, abduction, adduction, rotation, circumduction, pronation, supination, dorsiflexion, plantarflexion, inversion and eversion.

1.3 The muscular system

- There are three types of muscle in the human body: cardiac, smooth and skeletal.
- Skeletal muscles are attached to bones via tendons. When muscles contract, they produce forces that pull on the bones, resulting in movement.
- Muscles attach to bones at two points: the origin and the insertion. The origin is the end where the muscle attaches to the fixed or stationary bone, and the insertion is the end where the muscle attaches to the bone that is moving the most.
- Muscles work together (often in pairs) to produce coordinated movement. Reciprocal inhibition describes the relationship between muscles. As one muscle contracts (agonist) the opposite muscle relaxes (antagonist).
- Skeletal muscle is made up of skeletal muscle cells, fibres, blood vessels, nerve fibres and connective tissue.
- Skeletal muscles can be classified according to their shape (fusiform or pennate).
- Muscles designed for speed of contraction have fibres arranged in a fusiform pattern, while those designed for force have a pennate pattern.

- Muscle fibres are classified by how fast they contract, and the energy system used to produce ATP.
- The characteristics of Type I, or slow-twitch fibres, make them suitable for continuous aerobic activities, and they are therefore preferentially recruited to endurance activities that are sub-maximal.
- Type IIa fibres are partially aerobic, as they primarily use aerobic respiration to generate ATP relatively quickly. They can produce relatively high amounts of force, but do not fatigue as quickly as Type IIb fibres.
- Type IIb, or fast-twitch fibres, have characteristics that make them suitable for high-intensity, short-duration activities, and are therefore preferentially recruited for fast, powerful and explosive activities.
- Mitochondria, found in the muscle cell, generate adenosine triphosphate (ATP), the primary energy source for movement.
- Myofibrils contain sarcomeres, the smallest functional units in the muscle fibre. Within each sarcomere are thick (myosin) and thin (actin) protein myofilaments.
- Myosin filaments have oar-like projections called cross-bridges that link to the actin filaments and pull the filaments across each other, generating the contractile force responsible for muscle contraction.
- A motor unit consists of a motor neuron and all of the fibres it stimulates, and can only contain Type I or Type II fibres.
- The size of the motor unit determines the movements that it will control. Fine motor skills are controlled by a motor unit that contains very few muscle fibres. Gross movement skills are controlled by motor units that have thousands of muscle fibres.
- The all or nothing principle states that when a motor unit is activated, it will contract either maximally or not at all.
- The size principle states that to control the amount of force generated by a muscle, the nervous system progressively enlists more, larger motor units.
- Muscles can contract quickly or slowly, depending on the number of motor units stimulated and the rate of motor unit recruitment.
- Muscles may develop tension while shortening (concentric action), lengthening (eccentric action) or staying the same length (isometric action).

1.4 The mechanics of movement

- The bones, joints and muscles make up the lever systems in the body. Anatomical levers have three parts: an axis (joint), resistance (weight of limb to be moved) and force (produced by the muscles).
- There are three classes of levers, but third-class levers are the most common type of lever in the body.

CHAPTER REVIEW

1 Which statement best describes the body when it is in the anatomical position?

A The person is prone, with upper limbs and lower limbs touching at their sides.

B The person is supine, with upper limbs and lower limbs touching at their sides.

C The person is standing upright facing the observer. Upper limbs are extended at ninety degrees from the torso and lower limbs are shoulder width apart, feet pointing forward.

D The person is standing upright facing the observer. Feet are shoulder-width apart and parallel, toes forward. The upper limbs are held out to each side, and the palms of the hands face forward.

2 During an isoinertial (concentric) muscle action, the length of the H-zone:

A doubles.

B increases.

C decreases.

D remains unchanged.

3 Flat bones are generally found in the:

A axial skeleton, protecting vital organs.

B axial skeleton, enabling movement of the limbs.

C appendicular skeleton, enabling movement of the limbs.

D appendicular skeleton, providing points of attachment for muscles.

4 **List** and **explain** two characteristics of Type I muscle fibres that make them suitable for endurance activities.

5 Using a sporting example, **describe** the concept of reciprocal inhibition.

6 **Outline** the function of the mitochondria and myoglobin in muscle contraction.

7 **Describe** the pathway that a message from the brain takes to prompt a muscular contraction, from when the stimuli is received (i.e. see the ball on the ground), to when the foot makes contact with the ball.

8 The proportion of Type I and Type II fibres in a muscle has been suggested as a suitable talent identification tool. **Discuss** the physiological reasons why this may be an appropriate strategy to identify talented athletes.

9 Complete an analysis of the bench press by completing the table below.

Joint	Phase of motion	Joint type	Joint motion	Muscle group	Type of action
Elbow	Down				
	Up				
Shoulder	Down				
	Up				

Assessment
Chapter 1 Review

Command terms

list
Provide a series of related words, names, numbers or items that are arranged consecutively

outline
Provide an overview or the main features of an argument, point of view, text, narrative, diagram or image

discuss
Present a clear, considered and balanced argument or prose that identifies issues and shows the strengths and weaknesses of, or points for and against, one or more arguments, concepts, factors, hypotheses, narratives and/or opinions

CHAPTER

2

MUSCULOSKELETAL INJURIES

UNIT 1 – AREA OF STUDY 1

Joe/Adobe Stock

FIGURE 2.01 Protective equipment can help reduce the risk of injury.

Quizzes

Chapter 2 Pulse check

2.1 Check-in questions

2.2 Check-in questions

2.3 Check-in questions

Chapter 2 Review

Videos

Masterclass: Chapter 2

2.1 In focus: Injury treatment

Resources

Chapter 2 Self-assessment checklist

Nelson MindTap

To access resources above, visit **cengage.com.au/nelsonmindtap**

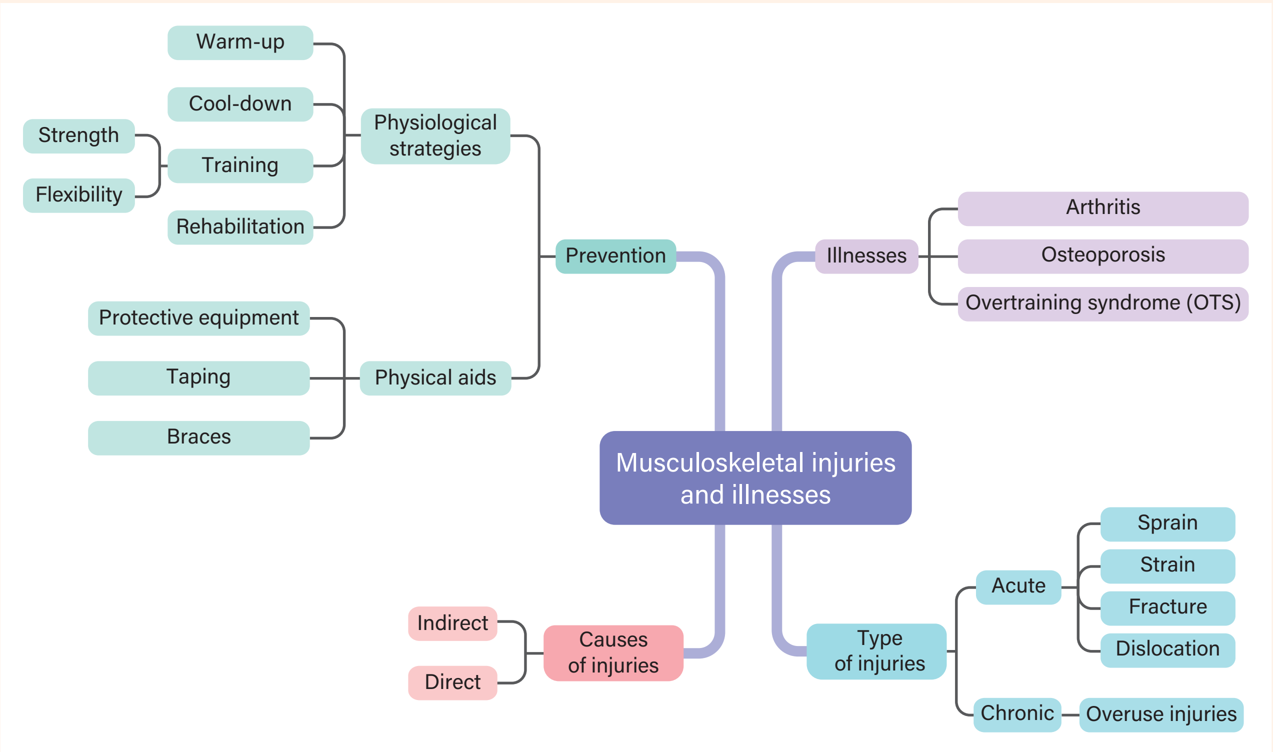
- causes of potential acute and chronic injuries and illness associated with the musculoskeletal system such as overtraining, arthritis, osteoporosis
- physiological strategies to prevent musculoskeletal injuries such as warm-up, cool-down and rehabilitation
- the role of physical aids that support the musculoskeletal system such as protective equipment, taping and braces

KEY KNOWLEDGE

- explore a variety of causes of musculoskeletal injuries
- implement and describe the correct application of physical aids and physiological strategies in a variety of sporting activities to maintain optimal functioning of the musculoskeletal system

Source: VCAA VCE Physical Education Study Design (2025–29)

KEY SKILLS



Video
Masterclass: Chapter 2

In this chapter we will look at common injuries and illness associated with the musculoskeletal system. Participation in any physical activity, sport or exercise carries a risk of injury, and as well as looking at the different types of injuries that may occur, we will also look at preventative strategies. A recent report by the Australian Institute of Health and Welfare (AIHW, 2023) estimates that participation in physical activity, including sport, can save Australians billions of dollars every year through reduced healthcare costs. At the same time, $1.2 billion was spent on injuries incurred while undertaking physical activity, and $149 million was spent on osteoarthritis due to previous injury from physical activity. Despite this, participation in sport and physical activity had an overall positive impact on the health system.

Assessment
Chapter 2 Pulse check

PULSE CHECK

Take the pulse check quiz to check your prior knowledge and understanding of the concepts covered in this chapter.

1 **Identify** three causes of injuries that may occur in a game of netball. Classify these causes as intrinsic or extrinsic.
2 **Explain** the difference between an acute injury and a chronic injury.
3 What strategies could be used to reduce the risk of the injuries identified in question 1?
4 **Describe** a rehabilitation strategy you are familiar with that could be used to help a player return to training or competition after injury.
5 **Identify** the signs and symptoms of overtraining syndrome.

Weblink
Sports injuries and rehabilitation

SIGNPOST

Watch the video 'Sports Injuries and Rehabilitation' by Sport Science Hub. The video summarises types of injuries, causes and rehabilitation strategies.

Watch the video at the start of the unit as a part of a 'pulse check' activity.

What did you already know? What was new information? What do you want to learn more about? The video can also be used at the end of the unit as a revision tool.

2.1 CAUSES OF MUSCULOSKELETAL INJURIES

In this module you will learn about:
- the causes of potential acute and chronic injuries and illness associated with the musculoskeletal system such as overtraining, arthritis and osteoporosis

and learn to:
- explore a variety of causes of musculoskeletal injuries.

intrinsic factors
Related to the individual's ability to cope with the forces imposed on the body, including alignment of the musculoskeletal system, fitness level and previous history of injury

extrinsic factors
Related to the characteristics of the task and the environment, including intensity and frequency of the task, playing surface and equipment

Musculoskeletal injuries are caused by forces acting on the body that are greater than the body part can withstand. There are many factors that may contribute to an injury. These may be related to the individual, or to the task and the environment in which it is performed. **Intrinsic factors** are related to the individual, and **extrinsic factors** are related to the environment.

TABLE 2.1 Factors that may have an influence on injury occurrence

Intrinsic factors	Extrinsic factors
Fitness level (muscle strength, endurance)	Playing surface
Joint flexibility	Workload (intensity and frequency)
Body composition	Equipment
Muscle imbalance	Movement patterns
Previous injury history	Level of participation (recreational vs elite)
Balance	Rules of the sport
Skeletal alignment	Environmental conditions (weather)

Injuries can be classified by *how* they occur, *when* the injury occurs, and *what* the injury is.

Sports injury classification

If you turn up to school using a pair of crutches, or with a cast on your arm, someone is sure to ask you, 'What have you done to yourself?', often followed by 'How did you do that?'. Injuries sustained while playing sport are often the result of a collision with another player or a hard surface, but they can also occur when there is a sudden change in direction or speed.

Injuries are caused by forces, which can be either internal or external.

- **Indirect injuries** are caused by an internal force; for example, a sudden change in intensity of activity can place an excessive load on the musculoskeletal system, resulting in a muscle strain.
- **Direct injuries** are caused by an external force on the body – for example, a collision with another player, resulting in a bone fracture.

indirect injuries
Injuries caused by a sudden change in the demands of the activity

direct injuries
Injuries caused by an external force to the body

Daniel Pockett/Getty Images Sport/Getty Images

FIGURE 2.02 Collisions that cause injury are not always with the opposition. 'Friendly fire' can cause just as much damage.

Mark Witte/Getty Images Sport/Getty Images

FIGURE 2.03 This netball player crashed into the goal post as she attempted to intercept the ball.

Acute injuries

An **acute injury** is one that occurs suddenly; for example, a netball player landing awkwardly, resulting in a sprained ankle. Acute injuries can be direct, and can result from contact with a player, a piece of equipment or a hard surface. Examples of direct acute injuries include being struck with a hockey stick, hit with a ball in cricket, running into the goal post in AFL or kicked in soccer. The collision may cause minor damage to the musculoskeletal system, resulting in injuries ranging from bruising (**haematoma**) and swelling to more serious damage, such as dislocation or a broken bone.

Acute injuries can also be caused by internal forces on the muscles, tendons and/or ligaments. When the force is more than the tissue can withstand, this will result in the muscle or joint moving beyond its physiological capability, resulting in hyperextension, **subluxation** or dislocation. Joints are susceptible to injury due to the demands placed on them during physical activity, sport and exercise. Joints need to be able to provide stability and flexibility. There is a balance between ensuring the muscles surrounding the joint are strong enough to withstand excessive forces while also being flexible enough to move through a full range of motion.

acute injury
An injury that occurs suddenly, without warning

haematoma
Abnormal collection of clotted blood outside of a blood vessel, usually caused by injury

subluxation
Partial dislocation of a joint

LOOKING BACK
Joints and joint actions

Chapter 1

In Chapter 1 we looked at the different joints and the actions they are capable of. Revisit this content when looking at the types of injuries that are common in each joint.

Muscles are usually injured when contracting eccentrically (lengthening) and the muscle is stretched beyond its limit or range of motion. You will recall from Chapter 1 that muscles work in pairs, and when an imbalance occurs there is greater risk of injury. For example, the quadriceps muscle has a much greater capacity to generate force than the hamstring muscles, which are designed to contract rapidly. When an athlete moves to sprint quickly, the force output imbalance can result in a hamstring tear. A muscle tear is referred to as a muscle strain, and can be categorised as a Grade 1, 2 or 3 strain, according to its severity.

TABLE 2.2 Signs and symptoms of Grade 1, 2 and 3 hamstring strains

Grade	Description
1 (mild)	Overstretching without tearing of muscle or tendon fibres. Symptoms may not present until activity is over. Usually no loss of muscular strength or flexibility. Increased tightness in the muscle during stretch or through a full range of motion. A feeling of pain may be reported with sitting or while walking uphill or ascending stairs. Depending on the severity, weight bearing activities may or may not be possible, walking properly may be possible and there will be minimal swelling.

>

Grade	Description
2 (moderate)	Partial tear in the muscle. Muscular strength and flexibility is reduced. Pain is more immediate and more severe than the pain of a Grade 1 strain. Pain on stretch and contraction of the muscle, and is usually sore to touch. Limping is likely during walking, and occasional sudden twinges of pain during activity may occur. Bending the knee against resistance will cause pain and there may be some difficulty in fully straightening the knee.
3 (severe)	Severe or complete **rupture** of the muscle. May be a large lump (of muscle tissue) above a depression where the tear is. Sudden, sharp pain in the back of the thigh. Walking is not possible without pain. After a few days with Grade 2 and 3 injuries, a large bruise may appear below the injury site caused by bleeding within the tissues. May require surgical repair.

Source: Sports Medicine Australia, 2024

rupture
A break or tear of the soft tissue

When a ligament is damaged from an excessive force, it is referred to as a sprain. A common sprain occurs in the ankle joint, and you will often hear individuals say they 'rolled' their ankle. This term refers to the excessive **inversion** of the ankle, beyond the normal range of motion, resulting in damage to the ligaments that stabilise the ankle joint.

inversion
Movement where the sole of the foot is turned towards the midline of the body

Ligament damage can be categorised as a Grade 1, 2 or 3 sprain:

- Grade 1: slight tearing of the ligaments with mild swelling
- Grade 2: incomplete tearing of the ligaments with moderate pain and swelling
- Grade 3: complete tearing of the ligaments with severe swelling, pain and bruising.

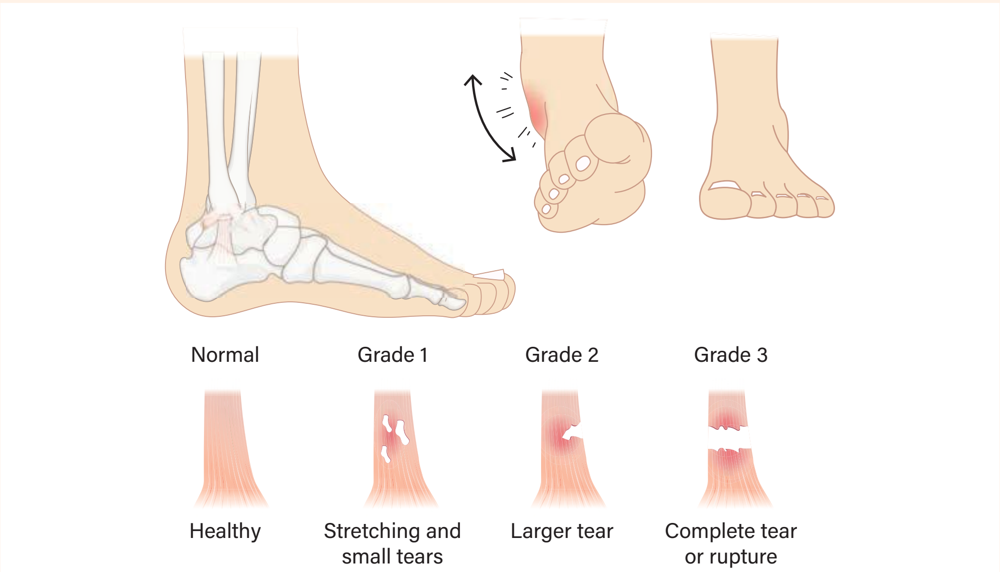


FIGURE 2.04 Grades of ligament damage

Both muscle strains and ligament sprains should be treated with rest, ice, compression and elevation, followed by a referral to a specialist if required. Treatment of soft tissue injuries using the RICER protocol (see Figure 2.06) should continue for 48–72 hours.

Video
In focus: Injury treatment

Mark Dadswell/Getty Images

FIGURE 2.05 A sprained ankle is often the result of an indirect injury.

The aim is to reduce the bleeding and damage to the muscle or joint, so the No HARM protocol should also be applied: no **h**eat, no **a**lcohol, no **r**unning or activity and no **m**assage. Avoiding HARM aims to decrease bleeding and swelling in the injured area.

Untreated soft tissue injuries result in greater formation of scar tissue, which can be painful and limit movement. Scar tissue is tough, fibrous and inflexible. When left untreated it can cause reinjury, meaning what was originally a Grade 1 strain can become a far more serious injury.

Scar tissue causes:

- loss of flexibility
- weak spot in the soft tissue
- loss of strength and power.

The RICER method can significantly reduce bleeding and swelling and the amount of scar tissue formed.

LEARNING HACK

To help remember the difference between a sprain and a strain, think about how we describe the injury. A 'sprained' ankle or a 'strained' hamstring – the ankle is a joint, and therefore the damage is to the ligaments, while the hamstring is a muscle, so the damage is to the muscle itself. And then if you 'tear' your Achilles tendon – remember 't' for tear and tendon.

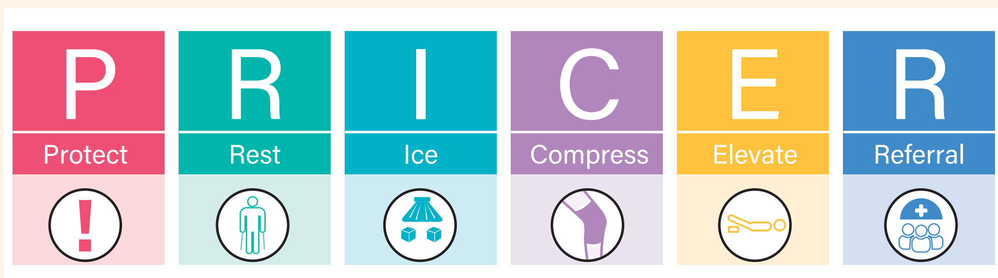


FIGURE 2.06 Adding a 'P' to the RICER method reminds us that avoiding injury is better than needing to treat an injury. We will look at protective equipment in Module 2.3.

Chronic injuries

A **chronic injury** is a long-term injury that is caused by repeated overuse of bones, muscle groups or joints. Chronic injuries develop over time as the muscle, tendon, ligament or bone is repeatedly stressed without sufficient rest to heal or adapt, resulting in inflammation and pain. For example, 'tennis elbow' is caused by increased force on the elbow joint through poor technique.

chronic injury
Long-term, overuse injury

Overuse injuries

Overuse injuries are defined as micro-traumatic damage to bone, muscle or tendon caused by repetitive stress without adequate time for recovery and reparation (Brenner, 2007). An overuse injury may result from the repetition of a lower stress activity. While the activity would not cause an acute injury. the repeated application of that stress injures the muscle or bone. There is usually little indication of a problem in the early stages of an overuse injury, as there is little or no pain. The athlete unknowingly continues to stress the injured area and as a result, does not give the body time to heal or adapt. For example, osteitis pubis, which is often caused by the repetitive use of your hips, pelvis and groin, is common in people who walk or run long distances on hard or uneven surfaces.

There are a number of factors that can contribute to overuse injuries, including:

- poor technique
- the repetitive nature of the activity
- insufficient recovery
- inadequate or incorrect footwear
- inappropriate training surface.

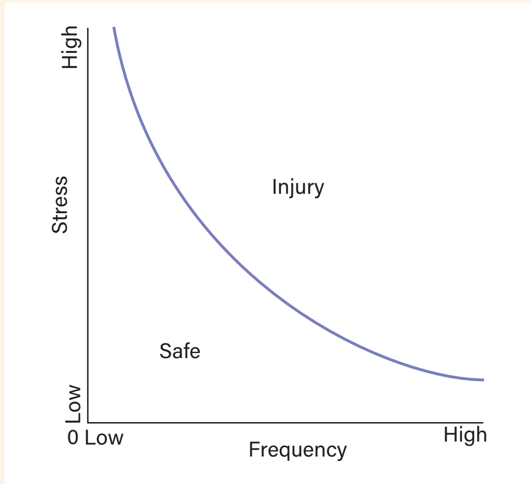


FIGURE 2.07 Overuse injuries are more common when the level of stress on the bone or muscle and the frequency of application are both high.

SIGNPOST

Shin splints are a common overuse injury. Watch the video 'Shin splints' on the Hopkins Medicine website for an explanation of what shin splints are, the causes and how to treat them.

Weblink
Shin splints

DID YOU KNOW?

Up to 70 per cent of recreational and competitive runners sustain overuse injuries as a result of training errors (running frequency, duration, distance, speed and lack of leg strength and flexibility) and inappropriate surfaces, terrain and footwear.

Types of sports injuries

Fractures

A fracture is a break in a bone. Fractures may be acute or chronic injuries. An acute fracture is sustained from a collision with another person or a hard surface, or from being hit with a ball, bat, stick, racquet etc. The impact causes the bone to crack, snap or break through the skin (which is known as compound fracture). Fractures are common in the bones of the wrist (ulna and radius), ankle (tarsals) and hip (pelvis). Most fractures are treated by immobilisation, whereby a cast or metal rods/plates are inserted into the bone to hold it in place. Stress fractures are chronic injuries that generally occur in the bones of the lower body as a result of repeated impact.

FIGURE 2.08 A broken or fractured wrist is a common injury among skaters, as most will put their hand out to break their fall.

Dislocations

A dislocation is the separation of two bones where they meet at a joint. Dislocations most commonly occur in shoulders and fingers. In a shoulder dislocation, the head (ball) of the humerus bone is forced out of the socket. Dislocations are common in contact sports, such as football and basketball.

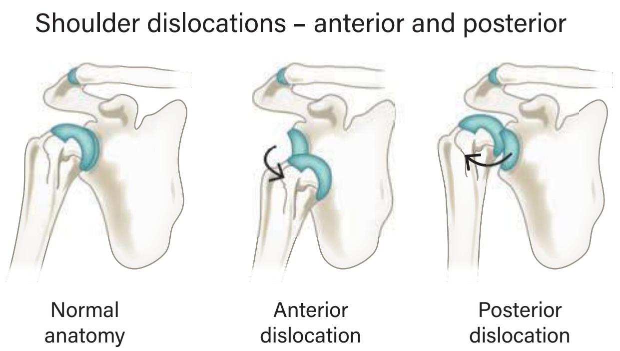


FIGURE 2.09 NBA basketballer Steph Curry suffered a partial dislocation after an opposition player ran into him while playing basketball.

Soft tissue injuries

Sprains

Sprains are stretches or tears of ligaments, and are caused by acute trauma such as a fall or knock that forces the joint beyond its normal range of motion. As discussed earlier, sprains can range from Grade 1 (minimally stretched ligament) to Grade 3 (a complete tear). Ankles, knees and wrists are all susceptible to sprains.

Strains

Strains are caused by muscles or tendons overstretching or contracting too quickly, as discussed on page 62. A muscle strain may result in a partial or complete tear of the muscle and/or tendon fibres. Muscles that cross more than one joint (such as the hamstrings, quadriceps and gastrocnemius) are more likely to suffer a strain than single joint muscles.

Other soft tissue injuries

Tendinitis is inflammation of a tendon, often in the shoulder, elbow, wrist, hip, knee or ankle. Tendinitis can be caused by a sudden injury, but it usually results from overuse.

Bursitis is inflammation of the bursae (plural of 'bursa'), small, fluid-filled sacs that act as cushions between a bone and other moving parts, such as muscles, tendons or skin. Bursitis can result from a direct impact, but can also develop over time as a result of repeating the same motion over and over.

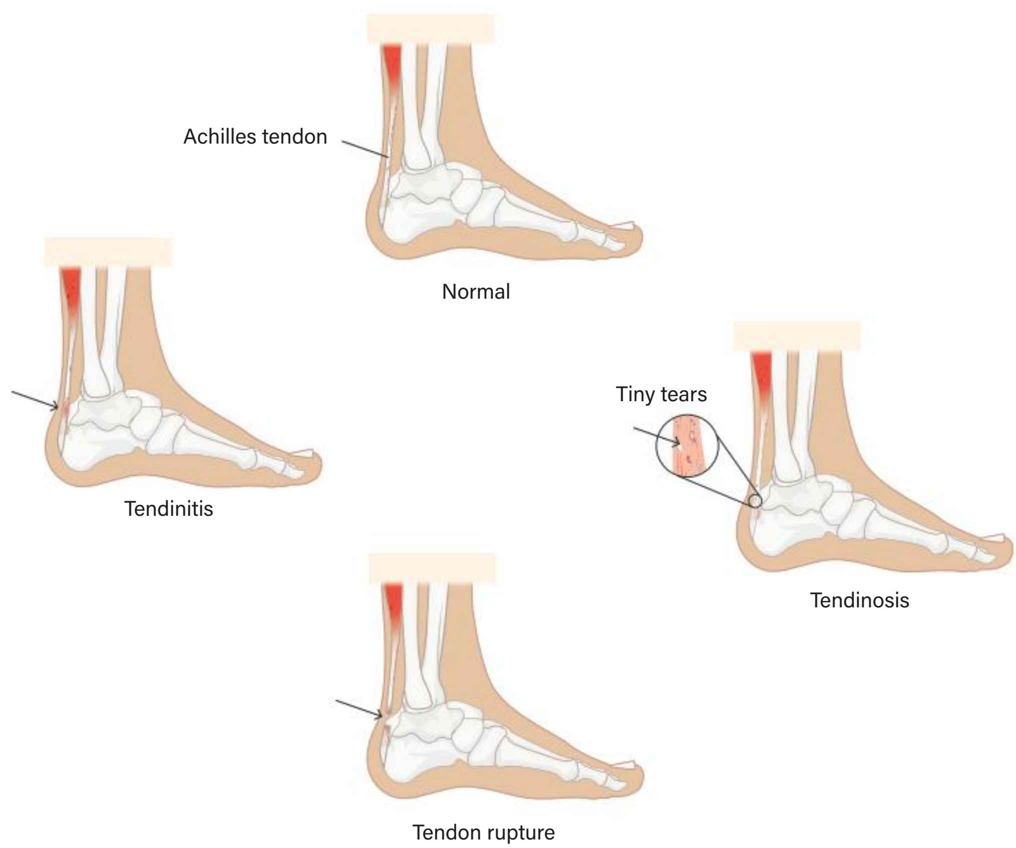
tendinitis
Inflammation of a tendon

bursitis
Inflammation of the bursae

DID YOU KNOW?

An Achilles tendon rupture is an acute injury that is common in people aged 30–50. A complete or partial tear of the Achilles occurs when the tendon is stretched beyond its functional capacity. Explosive activities such as jumping, pivoting or sudden accelerations can overstretch the tendon and cause a tear. They often occur in 'weekend warriors', a term used to describe individuals who engage in irregular physical activity, sport or exercise.

Achilles tendinopathy (tendinitis or tendinosis) is a chronic injury that causes weakness in the Achilles tendon due to a series of very small tears (tendinosis).



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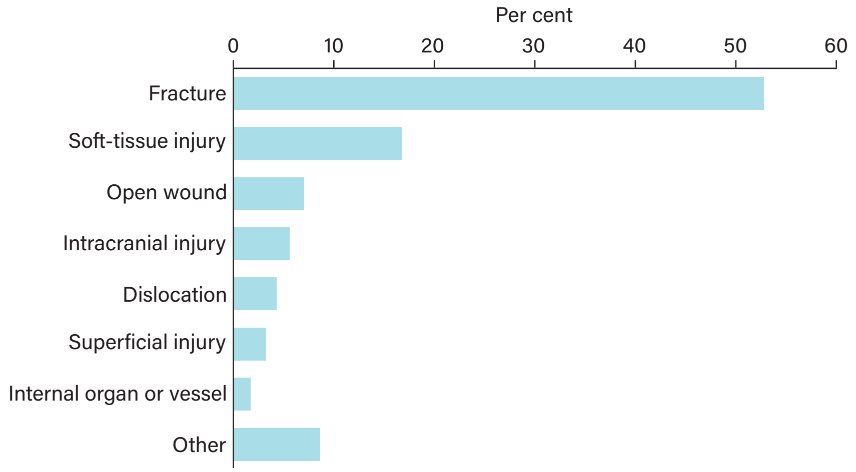
Sports injury – AIHW

REAL WORLD APPLICATIONS

Sport injuries resulting in hospital admissions

Over half of all hospitalisations for sporting injuries in 2020–21 were for fractures, most commonly a fractured arm or shoulder. Cycling had the highest number of hospitalisations for any sport; however, when this was compared to the number of participants, rugby had the highest rate of hospitalisations due to injury.

For a further breakdown of the data, head to the 'Sports injury' page on the Australian Institute of Health and Welfare website.



Note: Type of injury is derived from the principal diagnosis.

FIGURE 2.10 Some sports injuries, particularly fractures, result in the individual needing to be admitted to hospital.

The characteristics of the most common injuries are:

- fracture: a partial or complete break in a bone
- soft-tissue injury: sprain or strain of muscles, ligaments or joints
- open wound: a break in the skin such as a cut, puncture or bite
- intracranial injury: injury inside the skull (often a concussion)
- dislocation: a separation of different bones where they join
- superficial injury: an injury to the skin surface such as abrasion, bruising or blistering.

Discussion

The report does not include information on sports injuries that did not result in a hospital admission.

1 **Explain** what you think this means for the number of injuries represented in the data.
2 Reflect on an injury that you sustained while exercising or playing sport. If you haven't had a sports injury, **discuss** this with a classmate who has. What did you do? How was the injury sustained? What treatment did you get? How long did it take to fully recover?
3 Other than hospital, where might people go for treatment of a sports injury?

COLLABORATIVE TASK
Data analysis

Sports injuries

AIM

To compare the prevalence and types of sports injuries in two different sports

EQUIPMENT

Nil

METHOD

1 Working in pairs, each person will need to select a different sport from the list below:
   - Australian Rules football
   - basketball
   - cricket
   - cycling
   - equestrian activities
   - netball
   - roller sports
   - rugby
   - soccer
   - wheeled motor sports.
2 Research the incidence of sports injuries for your selected sport on the Australian Institute of Health and Welfare website.
3 Analyse the data to identify trends in the type and cause of injury, age and gender.

DISCUSSION

Compare your findings with your partner.

1 What are the similarities and differences?
2 What surprised you?
3 Hypothesise reasons for the differences in the data between sports.

Weblink
Australian Institute of Health and Welfare

Musculoskeletal conditions

A number of conditions affect the musculoskeletal system and can impact on movement and limit participation in physical activity, sport and exercise. In this section we will look at three of these conditions in detail:

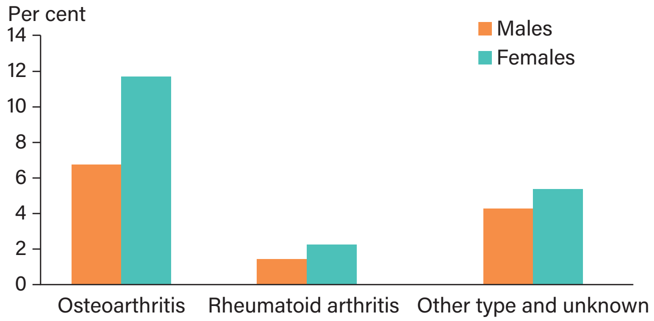
- arthritis
- osteoporosis
- overtraining syndrome.

Arthritis

Arthritis occurs when joints become inflamed, painful, stiff and swollen. There are over 100 different forms of arthritis. The two most common forms are:

- osteoarthritis
- rheumatoid arthritis.

Between 2017 and 2018, osteoarthritis and rheumatoid arthritis affected over 3.6 million Australians (AIHW, 2023).



Note: Refers to people who self-reported that they were diagnosed by a doctor or nurse as having arthritis (current and long term) and people who self-reported having arthritis.

FIGURE 2.11 Prevalence of self-reported arthritis in Australia, by arthritis type and sex, 2017–18

Osteoarthritis

Osteoarthritis is a chronic, **degenerative** joint disease where the cartilage that covers the ends of bones in joints deteriorates. Over time the cartilage wears away completely, and the articulating surfaces of the joint become bone on bone. This results in pain, swelling, reduced range of motion and stiffness of the joint.

There is some debate over the impact of physical activity in developing osteoarthritis, however, current literature suggests exercise does not significantly increase the likelihood of arthritis in normal, healthy joints. What is clear from the research is that joint injury increases the risk of developing osteoarthritis. Conversely, exercise can also benefit people with osteoarthritis by reducing some of the symptoms and improving joint mobility and strength.

degenerative
Progressive deterioration and loss of function in the organs or tissues

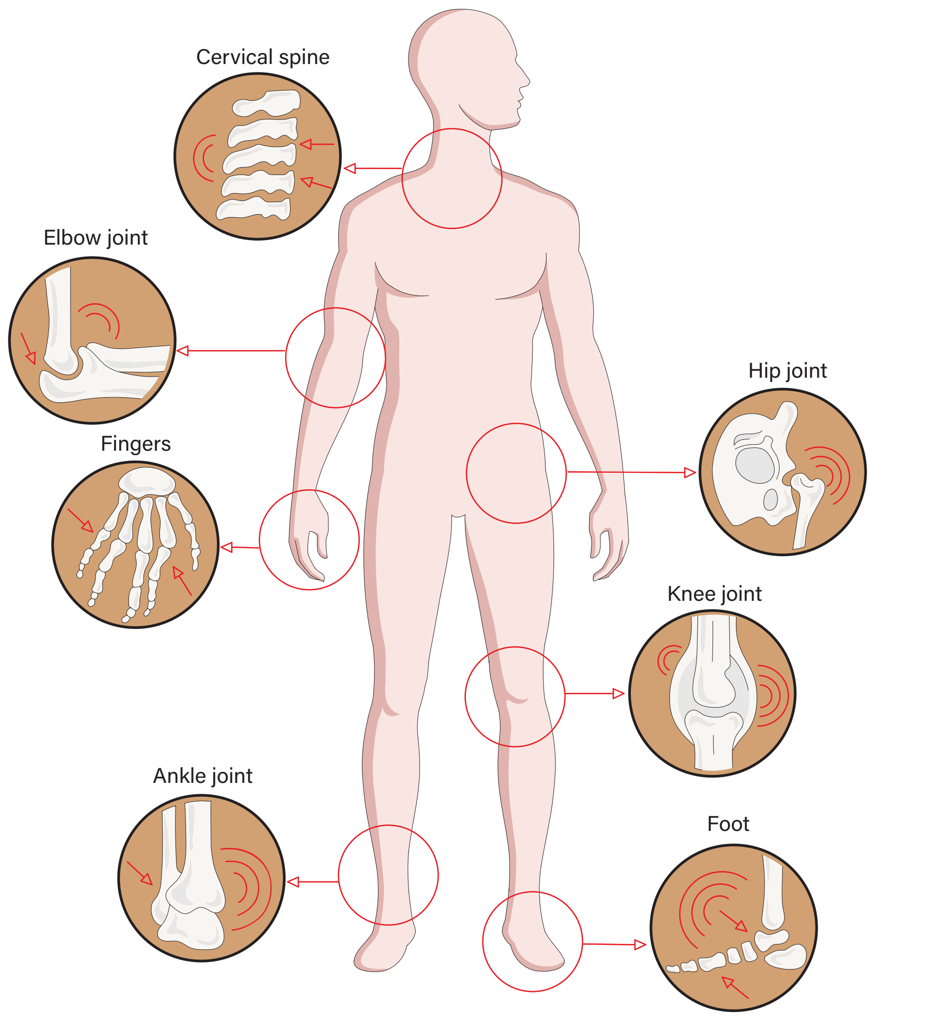


FIGURE 2.12 Arthritis can affect any joint in the body, making movement difficult and painful.

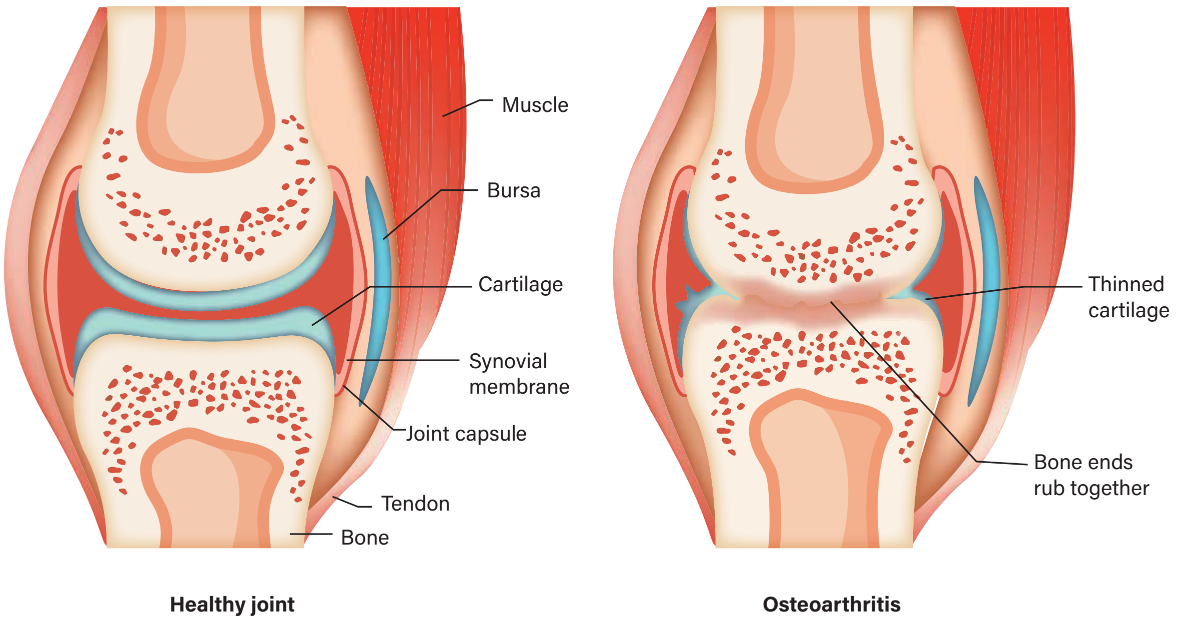


FIGURE 2.13 Differences between a healthy joint and a joint with osteoarthritis

Rheumatoid arthritis

Rheumatoid arthritis is an **autoimmune** disease where the body's immune system attacks the joint tissues. Inflammation results in pain, swelling, reduced range of motion and stiffness of the joint.

autoimmune
Autoimmune disease occurs when a person's immune system mistakenly attacks their own body

CASE STUDY DOES PARTICIPATION IN SPORT AT THE HIGHEST LEVEL INCREASE THE RISK OF OSTEOARTHRITIS?

ELITE SPORT LINKED WITH OSTEOARTHRITIS RISK

24 NOVEMBER 2022

PeopleImages.com - Yuri A/Shutterstock.com

FIGURE 2.14 Osteoarthritis can result in painful and swollen joints.

Competing at elite level in sport is linked with an increased risk of developing osteoarthritis and joint pain in later life, a study suggests.

One in four retired Olympians reported a diagnosis of osteoarthritis, the form of arthritis that causes changes in the joint and can lead to discomfort, pain and disability, the research found.

Competing at elite level in sport is linked with an increased risk of developing osteoarthritis and joint pain in later life, a study suggests. Elite retired sportspeople who had experienced a sports-related injury had a higher chance of knee and hip osteoarthritis when compared with the general population.

>

Retired Olympians

The athletes – who had competed at an Olympic level in 57 sports including athletics, rowing and skiing – also had an increased risk of lower back pain overall, and shoulder osteoarthritis after a shoulder injury.

Researchers hope the findings will help develop new approaches in injury prevention for the benefit of athletes now and in retirement.

The study is the largest international survey of its kind, and the first to observe the consequences of osteoarthritis and pain in different joints from retired elite athletes across different summer and winter Olympic sports.

Researchers quizzed 3357 retired Olympians aged around 45 on injuries and the health of their bones, joints, muscles and spine. They were also asked if they were currently experiencing joint pain, and if they had an osteoarthritis diagnosis.

Population comparisons

For comparison, 1735 people aged around 41 from the general population completed the same survey.

Researchers used statistical models to compare the prevalence of spine, upper limb and lower limb osteoarthritis and pain in retired Olympians with the general population.

The team considered factors that could influence the risk of pain and osteoarthritis such as injury, recurrent injury, age, sex and obesity.

They found that the knee, lumbar spine and shoulder were the most injury prone areas for Olympians. These were also among the most common locations for osteoarthritis and pain.

After a joint injury the Olympians were more likely to develop osteoarthritis than someone sustaining a similar injury in the general population, the research found.

The sportspeople also had an increased risk of shoulder, knee, hip and ankle and upper and lower spine pain after injury, although this did not differ with the general population.

'High performance sport is associated with an increased risk of sport-related injury and there is emerging evidence suggesting retired elite athletes have high rates of post-traumatic osteoarthritis. This study provides new evidence for specific factors associated with pain and osteoarthritis in retired elite athletes across the knee, hip, ankle, lumbar and cervical spine, and shoulder, and identifies differences in their occurrence that are specific to Olympians.' (Dr Debbie Palmer, Moray House School of Education and Sport)

Researchers say the study may help people make decisions about recovery and rehabilitation from injuries in order to prevent recurrences, and to inform prevention strategies to reduce the risk and progression of pain and osteoarthritis in retirement.

QUESTIONS

1 **Identify** the key finding of this study.
2 What percentage of retired Olympians had been diagnosed with osteoarthritis?
3 What does the article suggest is the reason that elite athletes are more susceptible to developing osteoarthritis later in life?
4 **Hypothesise** why after a joint injury the Olympians were more likely to develop osteoarthritis compared to someone in the general population who had sustained a similar injury.
5 How might the findings of this study be used?

hypothesise
Suggest or put forward a point of view, idea, argument, diagram and/or plan based on given data or stimulus material for consideration or action

Osteoporosis

Osteoporosis is a bone disease where bone mineral density and bone mass decreases, resulting in a change in the structure and strength of the bone. The decrease in bone strength increases the risk of a fracture. Many people with osteoporosis do not have symptoms, and so are unaware that they have the disease until they break a bone. Osteoporosis is more common in postmenopausal women and older men. The hip, vertebrae and wrist are the most commonly broken bones as a result of osteoporosis.

There are a number of risk factors associated with osteoporosis, including increasing age, being female, family history of the condition, low vitamin D levels, low intake of calcium, low body weight, smoking, excess alcohol consumption, physical inactivity, long-term **corticosteroid** use and reduced oestrogen level (Ebeling et al., 2013). However, osteoporosis is largely preventable. Bone mass peaks at about age 30. After that, gains in bone mass can still be made, but you lose slightly more than you gain, resulting in an overall decline.

Bone density can be maintained through regular weight-bearing exercise and resistance training, as well as maintaining a diet rich in vitamin D and calcium, a healthy weight, not smoking and limiting alcohol intake.

Maintaining good bone health starts in childhood and continues throughout the lifespan. Regular exercise slows the rate of skeletal aging. Physically active children and adults (both male and female) have greater bone mass than those who are sedentary, and a key preventative measure is to maximise bone mass during childhood and early adulthood. The focus of physical activity for bone health should reflect the stage of life of the individual.

FIGURE 2.15 Osteoporosis causes a decrease in the mineral density of the bone.

corticosteroid
Synthetic cortisol-like compound used to treat cortisol (hormone)-related disorders

LOOKING FORWARD

Health benefits of physical activity

Chapter 7

In Chapter 7, we will explore the health benefits associated with physical activity, such as high-impact activities for bone health.

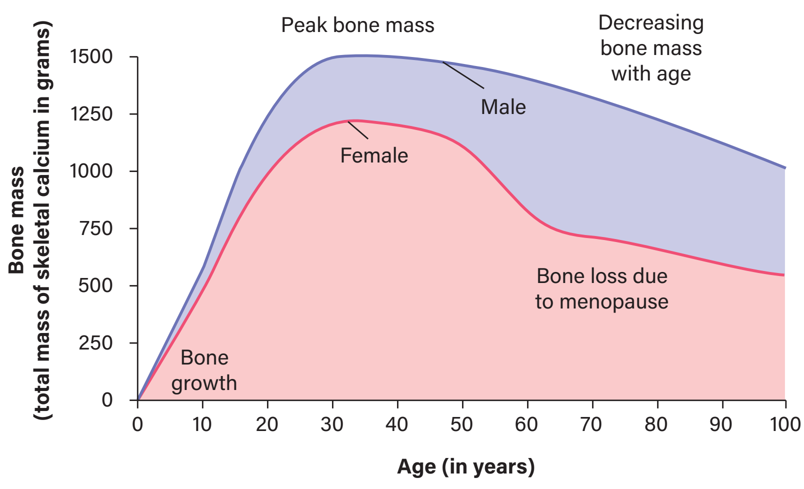


FIGURE 2.16 Bone mass decreases from about 30 years of age but the loss is more pronounced in females.

Source: Betts G., et al. (2013). *Anatomy and Physiology*. Houston, TX: OpenStax. https://openstax.org/books/anatomy-and-physiology/pages/6-6-exercise-nutrition-hormones-and-bone-tissue

FIGURE 2.17 Maintaining good bone health is a lifelong activity.

Source: Healthy Bones Australia, 'Exercise & Bone Health', https://healthybonesaustralia.org.au/your-bone-health/exercise-bone-health/

LEARNING HACK

Word origins can help us remember which part of the musculoskeletal system a disease impacts. Osteo, meaning bone, appears in the words osteoarthritis and osteopetrosis, two diseases that affect the bones of the skeletal system.

Weblink
Osteopenia and bone health – Healthy Bones Australia

It is important to consider the following factors when considering the effects of exercise in reducing the risk of osteoporosis:

- Bone adaptations are specific to the bone involved in the exercise (i.e. running doesn't impact bone density of the arm bones).
- Bone growth occurs when the bone is overloaded (weight-bearing exercise).
- Bone adaptations are reversible.
- Bone mass increases are the greatest for individuals starting from a very low base.
- Bone mass will plateau as an individual reaches their genetic limit.

SIGNPOST

To learn more about low bone density (osteopenia), go to the 'Osteopenia and Bone Health' page on the Healthy Bones Australia website.

Overtraining syndrome (OTS)

It is estimated that 10–20 per cent of all athletes will experience overtraining at some point in their careers, but overtraining syndrome (OTS) is more than a plateau or a decrease in performance, or an inability to train at the required level. OTS is the body's response to excessive exercise without adequate rest. It results in changes to a number of body systems, including the musculoskeletal system.

OTS can occur with prolonged, excessive training (high volume or high intensity) or a dramatic or sudden increase in training that occurs without sufficient recovery, often resulting in an overuse injury. The use of a training diary to monitor and record training loads, energy levels, sleep and other factors is important for athletes to reduce the risk of OTS. Athletes with OTS are more susceptible to illness, infections, muscle soreness and injury.

Signs and symptoms of overtraining syndrome

The signs and symptoms of OTS include:

- unexplained and persistently poor performance and high fatigue ratings
- prolonged recovery from training sessions or competitive events
- disturbed mood states characterised by general fatigue, apathy, depression, irritability and loss of competitive drive
- persistent feelings of soreness and stiffness in muscles and joints
- elevated resting pulse and increased susceptibility to upper respiratory infections (altered immune function) and gastrointestinal disturbances
- insomnia
- loss of appetite, weight loss, and inability to maintain proper body weight for competition
- overuse injuries.

FIGURE 2.18 Strategies to combat OTS

Source: The National Sports Medicine Institute, 'What is overtraining?', 23 February 2021, https://www.nationalsportsmed.com/what-is-overtraining

2.1 CHECK-IN QUESTIONS

Assessment
2.1 Check-in questions

1 Injuries that are caused by an internal force are classified as:
  A acute.
  B direct.
  C chronic.
  D indirect.
2 A soft tissue injury of the musculoskeletal system would involve which of the following?
  A Bone, muscle, tendons and ligaments
  B Muscle, tendons and ligaments
  C Tendons, ligaments and joints
  D Bone, joints and muscles
3 **Identify** the difference between a sprain and a strain.
4 **Identify** three factors that may contribute to overuse injuries.
5 **Compare** and contrast osteoarthritis and osteoporosis by listing the similarities and differences.
6 As a coach, what signs of OTS should you be looking for that are related to the musculoskeletal system?
7 **Explain** why swimmers might have lower bone density when compared to runners or weightlifters.
8 **Suggest** three reasons why the shoulder is more likely to be dislocated than the hip, even though they are both ball and socket joints.
9 During a school match, you suddenly feel a sharp pain in your calf muscle while attempting to kick the ball. You are unable to continue playing. **Identify** and classify the injury. Discuss the potential causes, and list the immediate steps you should take in the first 24–48 hours.
10 Select one of the following overuse injuries to investigate further: 'tennis elbow', plantar fasciitis, 'Little League's elbow', shin splints or 'runner's knee'. Through your investigation, **identify** the aspects of the musculoskeletal system impacted, and possible causes, signs and symptoms.

2.2 INJURY PREVENTION

In this module you will learn about:
- physiological strategies to prevent musculoskeletal injuries such as warm-up, cool-down and rehabilitation

and learn to:
- implement and describe the correct application of physical aids and physiological strategies in a variety of sporting activities to maintain optimal functioning of the musculoskeletal system.

'Prevention is better than cure' is a statement that can be applied to injuries and illnesses associated with the musculoskeletal system. Preventing an injury is better for both the individual and for our health system, and ultimately better for the wider population, too. A key factor in sports injury rehabilitation protocols is injury prevention.

The benefits of increasing the level of physical activity of all Australians through participation in physical activity, sport and exercise are substantial. However, participation will always carry a risk of injury. Broadly, we can address and manage this risk through:
- education regarding what is 'safe practice'
- relevant data collection and research to more accurately assess risks and develop mediating strategies
- implementation of strategies and programs at all levels of organised sport
- public awareness of the benefits and risks of physical activity, particularly during unsupervised activities (Clearinghouse for Sport, 2024).

In this module we will look at physiological strategies such as warm-up and cool-down and how these strategies can help to reduce the risk of injury. We will also look at strategies used in the rehabilitation of an injury.

Warm-up

The main purpose of a warm-up is to prepare the athlete or individual both physiologically and psychologically for physical activity. An effective warm-up will improve performance, making sure the player is ready mentally and physically, but the warm-up also plays a key role in injury prevention.

Physiologically, the warm-up is designed to increase the body and muscle temperature. Increases in muscle temperature boost blood flow to the working muscles, increasing the elasticity of the muscles and the range of motion of the joints. This then reduces the risk of damage to the muscles, tendons or ligaments.

The physiological benefits of a warm-up include increases in:
- core body temperature
- muscle temperature
- range of motion of joints/muscles
- blood flow to active muscles
- muscle contraction and relaxation.

DID YOU KNOW?

The FIFA 11+ program is an injury prevention program that has been shown to reduce major injuries, particularly in female soccer players aged 13–18, who have a high risk of knee and ACL injury, by 50 per cent, as well as reducing overall injury incidence in recreational/sub-elite football by 39 per cent. To reduce the risk of injury, players need to perform the warm-up exercises regularly (at least twice a week).

Netball Australia has produced a similar program to prevent knee and ankle injuries. The **K**nee injury prevention for **N**etballers to **E**nhance performance and **E**xtend play (KNEE) program aims to reduce injuries such as anterior cruciate ligament (ACL) injuries, which account for 25 per cent of all serious injuries in netball. The KNEE program is an on-court warm-up program designed to enhance movement efficiency and prevent injury. The program targets three specific player groups – junior, recreational and elite level athletes, with different exercises tailored to match the predicted capabilities of each group.

Weblink
FIFA 11+ program

David Ramos/Getty Images Sport/Getty Images

FIGURE 2.19 Warm-up exercises in the KNEE program aim to decrease injuries in netball players.

SIGNPOST

Visit the KNEE Netball website to learn more about the program.

Weblink
KNEE Netball

Structure of the warm-up

Mark Dadswell/Getty Images

FIGURE 2.20 What similarities can you see in the exercises conducted for netball in Figure 2.19 and football in Figure 2.20?

A well-designed, effective warm-up can reduce the risk of injury. The warm-up should be done before any physical activity, sport or exercise and should last between 10 and 30 minutes.

The warm-up will include activities that:

- increase the body temperature
- activate and mobilise the main muscles and joints that will be used in the game
- gradually increase in intensity.

The RAMP warm-up protocol (Jeffreys, 2007) provides a framework to construct an effective warm-up through three key phases:

1 Raise
2 Activate and Mobilise
3 Potentiate/prepare.

Raise

Raise relates to raising the body and muscle temperature through whole-body activities such as running/line drills/change of direction drills (sport-specific movements), small-sided games, cycling and skipping. These activities will increase the heart rate, respiration rate, blood flow to working muscles and joint viscosity, which is beneficial in reducing the risk of injury.

After about 5–8 minutes the player should be sweating lightly, but not out of breath, as this would indicate that the warm-up activity was too intense.

COLLABORATIVE TASK
Classroom prac activity

Warm-up – 'raise'

AIM

To develop a fun, engaging 'raise' activity for a warm-up

EQUIPMENT

As required by student activities

METHOD

Do you sometimes find warm-ups boring? Does the 'raise' aspect of your warm-up involve running laps of the gym or oval? The method of raising the body temperature in the warm-up is limited only by the imagination of the person running the activity.

In this activity you will use games and competitive tasks to design a warm-up activity, making the 'Raise' component of the warm-up more fun and interesting.

1 Working with a partner, design an activity that lasts 5–8 minutes and will raise the temperature of the body.
2 Have each group present and conduct their activity with the class.

REFLECTION

1 Which activity did you enjoy the most?
2 What were the features of the activity that you liked?
3 Did the activity achieve the purpose of the 'raise' component of the warm-up?
4 Would you make any changes to further improve the activity?

SIGNPOST

Access the series of videos from World Rugby, the international rugby federation, that demonstrate each phase of the RAMP protocol on the World Rugby website.

Weblink
World Rugby

Activate

Activate is the aspect of the warm-up designed to target and wake up the muscle that will be used in the activity. Activation exercises need to involve actions that contract the muscles in order to excite and stimulate them. If the muscles are not activated, performance may be affected, and the risk of injury could rise.

Mobilise

The mobilise aspect of the warm-up is often combined with the activate activities in order to take the key joints involved in the movement pattern through the full range of motion. This will help reduce any restrictions in the movement that could lead to poor or inefficient movement patterns. The focus is on specific movements used in the activity, rather than on individual muscle groups.

Dynamic stretching is often part of the 'Mobilise' aspect of the warm-up. Dynamic stretching involves stretching with movements that are like the movement patterns used in the game. Dynamic stretching will allow players to enhance their joint range of motion in the warm-up and maintain an elevated muscle temperature, as the activity involves movement and contraction of the muscle.

Maridav/Shutterstock.com

FIGURE 2.21 Dynamic stretching forms part of the warm-up, helping to reduce the risk of injury by moving the joint through its full range of motion.

potentiation
Activities that make the warm-up effective or will improve the effectiveness of the performance

Potentiate/prepare

The **potentiate**/prepare component of the warm-up aims to improve performance through sport-specific activities that increase in intensity to match the upcoming activity/game. This is the final stage of the warm-up, and it needs to help players transition into competition smoothly so they are fully prepared to play. Activities are generally high-intensity drills and actions that will occur in the activity to be undertaken.

DID YOU KNOW?

Static stretching is not recommended as an activity for the warm-up because it has been shown to have little to no effect on performance or on injury prevention. More recently, static stretching has been shown to reduce the muscles' ability to produce force, which is detrimental to performance in activities that require high force production. It is not appropriate to include static stretching in a warm-up, however, it is an effective training method for increasing flexibility.

COLLABORATIVE TASK
Prac activity

Australian Football League (AFL) group warm-up

AIM

To participate in an AFL-specific warm-up designed to prevent leg injuries in community-level Australian Rules football

EQUIPMENT

- 20 m × 6 m wide area
- 4 cones
- 2 footballs

METHOD

1 Line players up in groups of four (e.g. the five groups of four shown in Figure 2.22).
2 The activities for this formation are listed below.
3 Each group will cover the 20 metres and return a total of nine times.
4 At the end cones, players in lanes 1 and 2 turn left around the cone and jog back to the beginning. Players in lanes 3 and 4 turn right around the other cone and jog back.
5 As the players jog back, a coach (one on each side) handballs a ball to players one at a time. The player handballs the ball back and continues the return trip. Do this fast enough to avoid a bottleneck of players waiting for a handball.
6 Groups should follow each other with a gap of about 3 metres to avoid time standing still.
7 Carry out all activities at jogging pace.

>

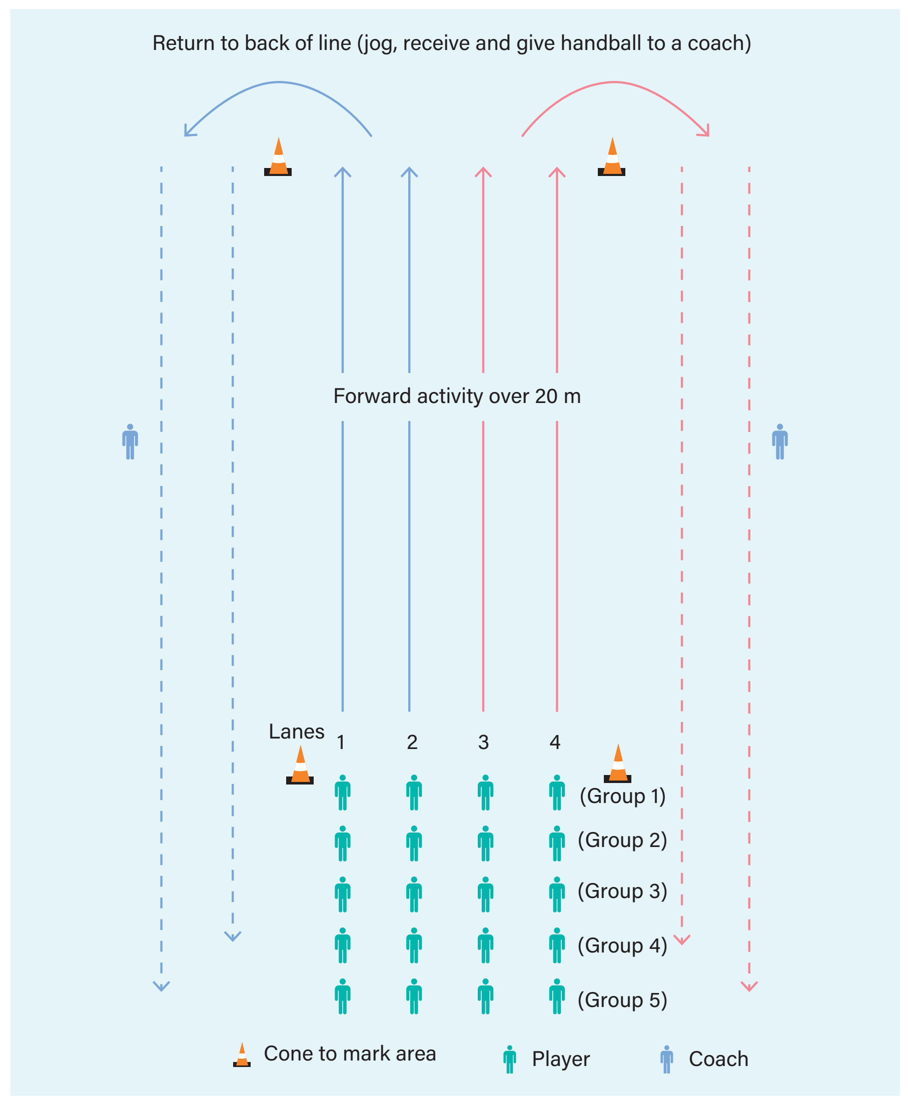


FIGURE 2.22 How to structure the space to conduct the warm-up exercises

Source: 'Footy First: A training program to prevent leg injuries in community Australian Football', https://coastsport.com.au/wp-content/uploads/2018/02/FootyFirst_-_Manual.pdf

ACTIVITIES

1 Jog.
2 Side-to-side run – facing side-on to the direction of travel, bring the feet together but do not cross them over. Repeat, facing opposite side.
3 Grapevine with high knees – facing side-on to the direction of travel, bring the back leg in front and then behind the body in an alternating fashion. Repeat, facing opposite side.
4 Backwards running with high feet – jogging backwards, bring the feet up so they get close to the buttocks before planting them on the ground behind the body.
5 Butt kicks – jogging forward with an arm action like normal running, keep the thighs vertical (no knee lifts) and bring the heels up towards the buttocks, but not touching. In the second repetition, bend the knee forcefully enough so that the heels make contact with the buttocks.

>

6 Hands to ground – while jogging, touch both hands on the ground as if picking up a ball. Immediately straighten up to a normal running posture. Jog a few metres and repeat. Do this four times over the 20 metres.

7 This is followed by a series of dynamic stretches that focus on the lower body.

8 Participate in a modified game of Australian Rules football (9 v 9) or similar.

OBSERVATIONS

Record your heart rate before and after the warm-up activities.

DISCUSSION

1 What was the purpose of the six locomotion activities in the warm-up?

2 How does dynamic stretching help reduce the risk of injury?

3 What are the advantages of having a set warm-up routine for community level players?

Cool-down

Physiologically, the cool-down aims to aid recovery and return the body to a pre-exercise state. Throughout the cool-down, your respiratory rate and heart rate should decrease back to resting levels. This is achieved gradually, by completing low to moderate intensity exercises that use the same muscle groups and movement patterns that were used during the exercise session. For example, a swimmer may do 5–10 minutes of slower paced laps, using a combination of strokes.

The cool-down is completed at the conclusion of the physical activity, sport or exercise session and usually lasts 5–15 minutes.

A cool-down with gentle movements and stretches can help to prevent the muscle stiffness and tightness that can occur after exercise by lengthening the muscles and promoting flexibility, and reduces the risk of delayed onset muscle soreness (DOMS).

Delayed onset muscle soreness

DOMS is usually felt 12–24 hours after unaccustomed strenuous exercise, usually peaking around 24–72 hours after exercise. DOMS is caused by microscopic damage to the muscle fibres and the surrounding connective tissue, particularly during eccentric (lengthening) muscle contractions. Activities such as running downhill, lowering weights, or performing squats or lunges cause the muscles to lengthen while under tension. This stress on the muscles can lead to small tears in the muscle fibres and inflammation in the surrounding tissue, leading to soreness.

Symptoms of DOMS include muscle soreness, stiffness, tenderness to touch, and reduced range of motion in the affected muscles. The pain is localised to the muscles that were worked during the exercise session, and the severity of the soreness will depend on the intensity and duration of the activity, the individual's fitness level and previous exposure to similar activities.

The pain associated with DOMS will usually disappear in a few days. The pain can be relieved with activities that can be included in the cool-down. Gentle stretching, low-impact activity (such as walking or cycling), massage, foam rolling and applying ice or heat can all help relieve the symptoms of DOMS.

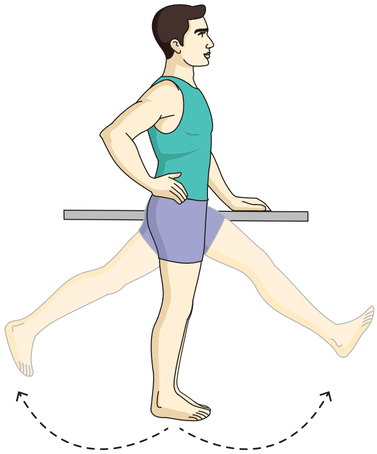
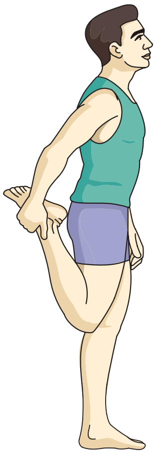
Stretching

Incorporating static stretching exercises into the cool-down routine can help improve flexibility and range of motion in the joints. It is appropriate to include static stretching at the end of the exercise or training session, while the muscles are warm. Stretching can lead to improved flexibility, which may reduce the risk of injury by allowing the muscles and joints to move through their full range of motion smoothly and efficiently in subsequent workouts or activities.

oksix/Adobe Stock

FIGURE 2.23 Foam rolling has been shown to be effective in reducing the symptoms associated with DOMS.

TABLE 2.3 Characteristics of dynamic and static stretching

Dynamic stretching	Static stretching
	
Best BEFORE training or exercise (warm-up)	Best AFTER training or exercise (cool-down)
Increases heart rate	Decreases heart rate
Improves flexibility	Improves flexibility
Targets several muscle groups	Targets a single muscle group
Stretch involves controlled movement of the joint through its full range of motion	Stretch is held for 10 seconds or more in a stationary position

Other physiological strategies

There is strong evidence to suggest that a sport-specific strength and conditioning program, proprioception and neuromuscular training are likely to reduce the risk of both acute and overuse injuries. The correct application of training principles, particularly intensity, frequency and progression, is important in minimising the risk of musculoskeletal injuries. The design and structure of a training program must ensure adequate rest and recovery time to allow the muscles to adapt to the load and the tissue to repair and strengthen.

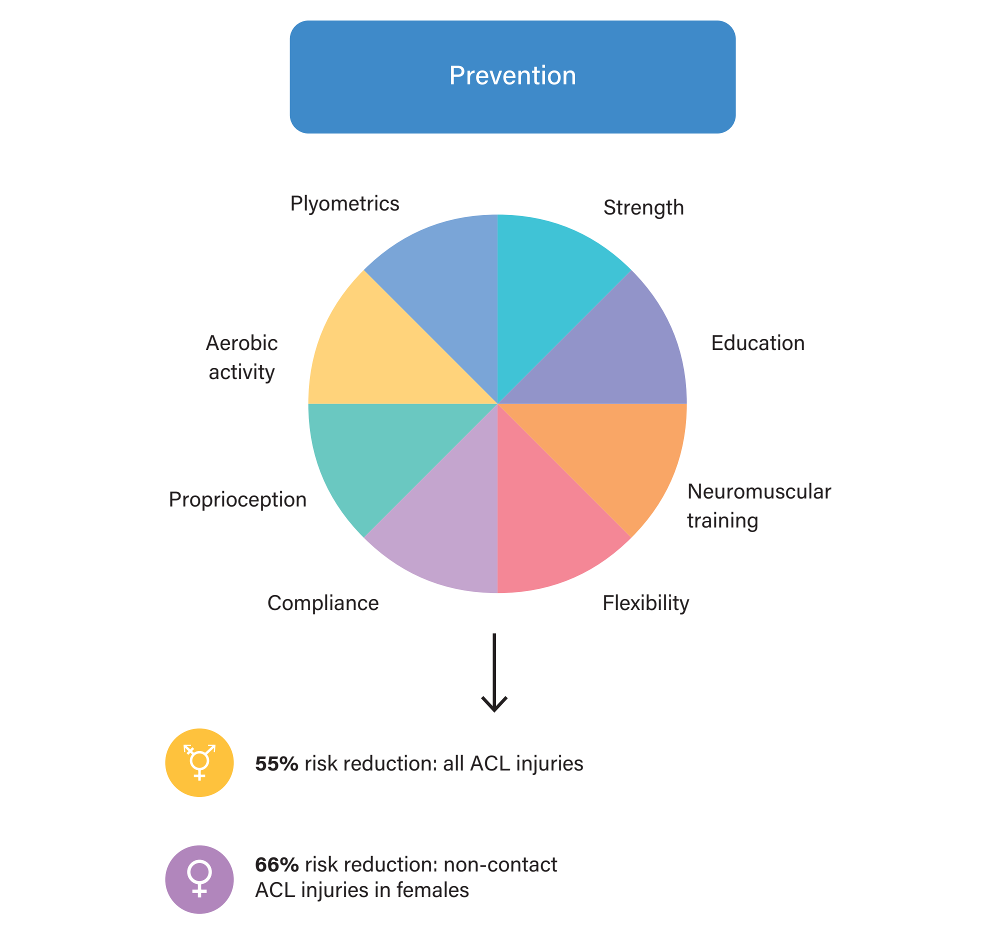


FIGURE 2.24 Research has shown that the risk of an ACL injury can be reduced through a range of strategies, and prevention involves more than just one approach.

Resistance training

Resistance training can focus on increasing muscle strength, endurance and power, and on strengthening the connective tissues (tendons and ligaments). It typically involves lifting weights, using resistance bands or performing bodyweight exercises such as push-ups, chin-ups or sit-ups. This type of training can reduce the risk of musculoskeletal injuries through improved strength and endurance, which also supports and stabilises the joints during movement. Stronger muscles can withstand greater forces and stress placed on the joints, reducing the likelihood of injuries such as sprains and strains.

Resistance training can address muscle imbalances by developing strength in specific muscle groups that may be weaker or underdeveloped compared to others; for example, your non-dominant side, which is often not as strong as your dominant side. Correcting muscle imbalances helps distribute forces more evenly across joints, reducing the risk of overuse injuries. Resistance training has also been shown to increase bone density, which can help reduce the risk of fractures and osteoporosis, especially in older adults.

Weblink
Supporting bone health – Healthy Bones Australia

SIGNPOST

To learn more about the importance of exercise in maintaining bone health, go to Healthy Bones Australia to access the exercise guidelines for supporting bone health.

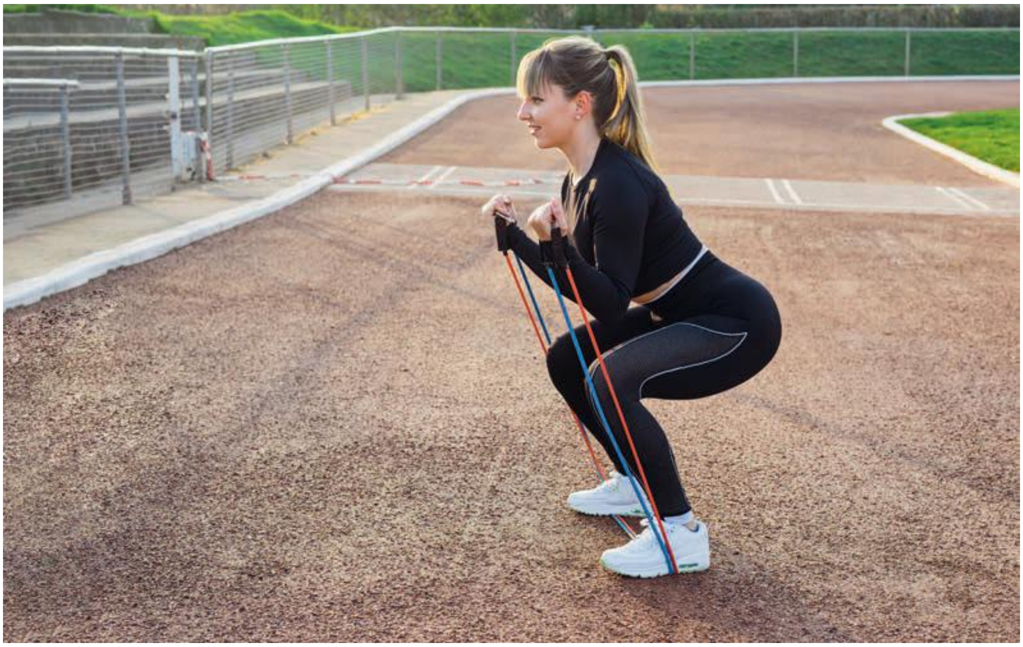

okrasiuk/Adobe Stock

FIGURE 2.25 Resistance band training can build strength and enhance joint stability, reducing the risk of injury.

LOOKING FORWARD
Training program design

Units 3&4 – Chapters 12, 13 and 14

In Units 3&4 of VCE Physical Education you will look at training principles (Chapter 12), training methods (Chapter 13) and how to design, implement and evaluate a training program (Chapter 14). You will also look at strategies for monitoring and recording training, a key factor in reducing the risk of injury, especially overuse injuries.

REAL WORLD APPLICATIONS

SportSmart

SportSmart is a New Zealand program that provides advice on how to improve performance by minimising the risk of injury. Developed by an expert panel of academics, clinicians and sports administrators, SportSmart uses the four Es of injury prevention:

- Education
- Enforcement (laws and rules of the game)
- Engineering (player equipment)
- Environment (physical and behavioural).

SIGNPOST

You can access the ACC SportSmart reference resource on its website.

On the same website, you can also watch the 'Have a hmmm' videos that encourage people to think about the risks before undertaking an activity.

Weblinks
ACC SportSmart
Have a hmmm

Injury rehabilitation

rehabilitation
A set of interventions designed to optimise functioning and reduce disability in individuals with health conditions in interaction with their environment (WHO, 2024)

Musculoskeletal injuries are an inevitable part of participation in physical activity, sport and exercise. Injury **rehabilitation** aims to return the individual to pre-injury form through the restoration of optimal form (anatomy) and function (physiology).

There are four stages of injury rehabilitation (see Figure 2.26). It is important to note that recovery from a musculoskeletal injury does not always progress through these stages in sequence. If the exercises prescribed at each stage result in further pain, swelling or fluid retention, the individual will relapse back to the previous stage.

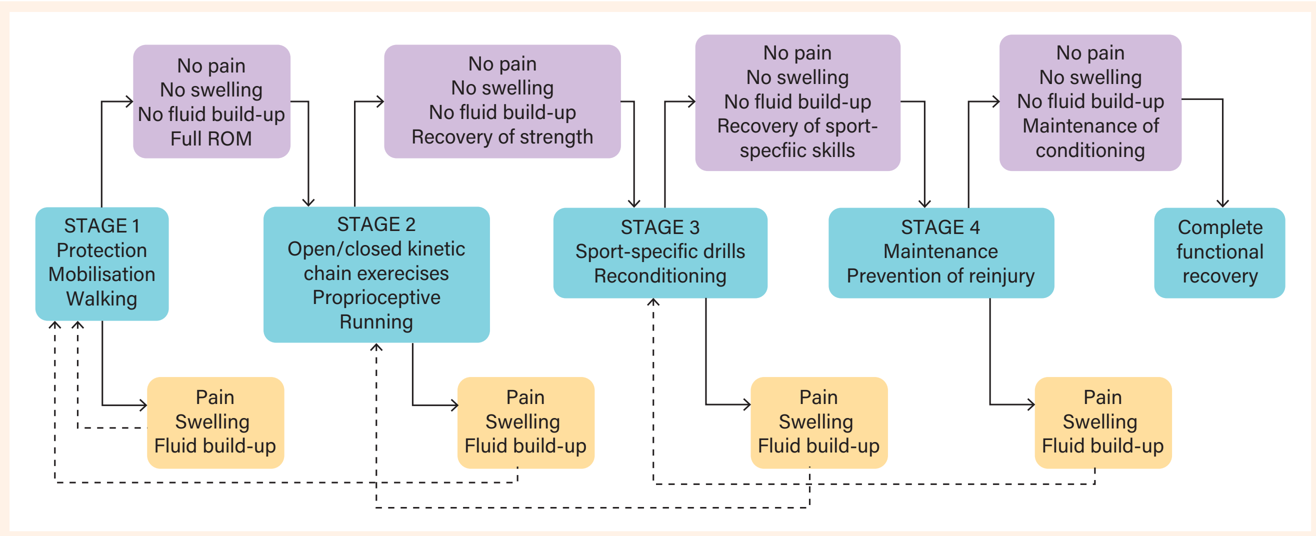


FIGURE 2.26 Stages of injury rehabilitation

Source: Physiopedia, 'Rehabilitation in Sport: Stages of Rehabilitation', https://www.physio-pedia.com/Rehabilitation_in_Sport#cite_note-p1-9

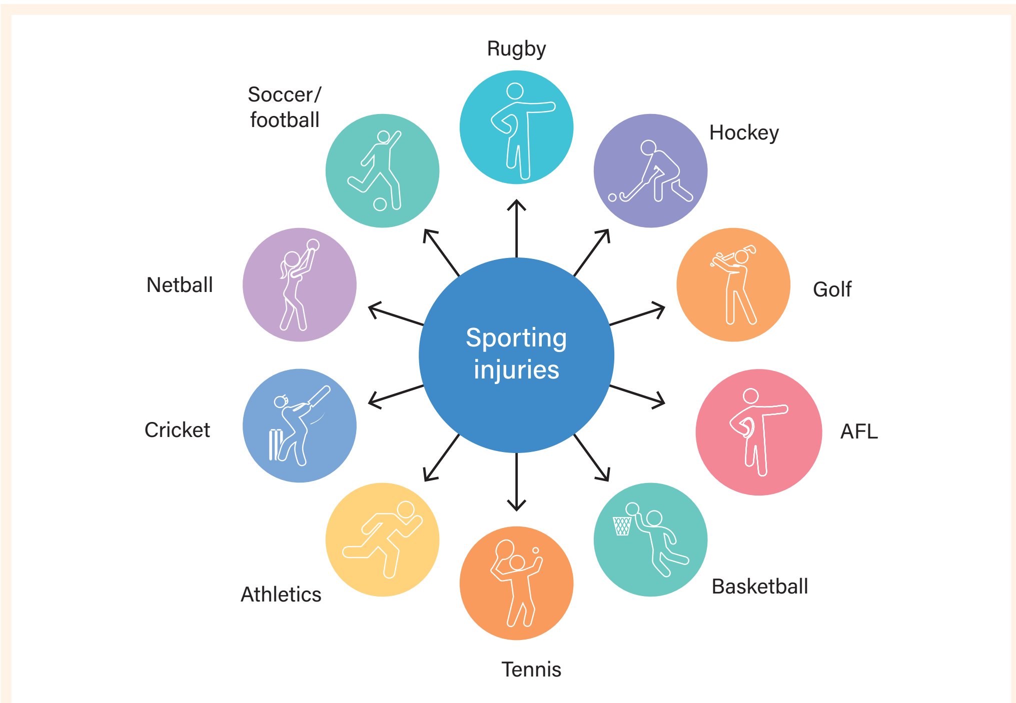


FIGURE 2.27 Sports injuries can occur in all physical activity, sport and exercise.

Source: Physiopedia, 'Rehabilitation in Sport', https://www.physio-pedia.com/Rehabilitation_in_Sport

A variety of rehabilitation strategies are used so that the individual can return to participating in the same activity and environment in which the injury occurred with the same (or better) functional capacity. Having a previous injury is the highest predictor of reinjury, therefore, rehabilitation plays an important role in monitoring athletes after they have returned to full participation.

Rehabilitation strategies

The most appropriate rehabilitation strategy will be determined by the type and severity of the injury, the individual's goals, and their readiness to return to physical activity, sport and exercise. A number of common rehabilitation strategies are outlined below.

Pain management

Strategies to decrease pain, inflammation and swelling are used as part of a rehabilitation program. The use of the RICER protocol (see page 64) – rest, ice, compression, elevation and referral – can help manage the pain associated with a soft tissue injury. Ice and heat can be used to alleviate pain for both acute and chronic injuries. Heat packs and medicated creams can also be used to provide temporary relief from the pain associated with muscular and joint injuries. Physiotherapists may also use ultrasound or TENS machines (**transcutaneous** electrical nerve stimulation) to ease pain.

transcutaneous
Penetrating or entering through unbroken skin

Ververidis Vasilis/Shutterstock.com

FIGURE 2.28 TENS machines deliver a small electrical current across the skin to stimulate the nerves and relieve pain.

DID YOU KNOW?

Nerves, muscles and bones combine to form a kinetic chain. Open/closed kinetic chain exercises differ in the way the limb (hand or foot) interacts with the surface or the environment during the movement. In closed kinetic chain exercises, the hand or foot is fixed or in contact with a stable surface or object (i.e. squats, lunges and leg presses). In open kinetic chain exercises, the hand or foot is free to move in space without being fixed to a surface or object (i.e. bicep curls, tricep extensions and shoulder presses).

Massage therapy

Massage therapy is the practice of manipulating and applying pressure to the muscles, tendons, ligaments and fascia. Massage therapy as a rehabilitation strategy aims to:

- reduce muscle tension
- relieve pain
- increase joint range of motion
- control swelling
- enhance performance
- aid recovery.

Exercise programs

Flexibility training

The inflammation, swelling and pain associated with musculoskeletal injuries can reduce flexibility. Flexibility training is an important component of rehabilitation to minimise the decrease in joint range of motion (ROM). A variety of stretching techniques can be used in improving range of motion, including **proprioceptive neuromuscular facilitation (PNF)** stretching, ballistic stretching and static stretching.

proprioceptive neuromuscular facilitation (PNF)
A stretch that involves stretching and contracting the muscle to increase the range of motion

iStock.com/DNY59

FIGURE 2.29 PNF stretching is beneficial in rehabilitation of soft tissue injuries as it involves both isometric and concentric muscle actions.

Strength and endurance training

Musculoskeletal injuries often result in skeletal muscle **atrophy** and weakness. Progressive strengthening exercises target the muscles around the injured area to restore muscle strength, endurance and stability. These exercises may involve bodyweight exercises, resistance bands or weight training, with a focus on proper form and technique.

atrophy
Decrease in the size of a muscle

Proprioception training

Loss of **proprioception** occurs with musculoskeletal injuries – specifically, injury to ligaments, tendons or joints. Proprioception training is used for injury rehabilitation and focuses on improving the body's ability to sense its position, movement and location in space. Proprioception is needed for balance, coordination, agility and joint stability.

proprioception
Ability to sense the status of movement, action and location of the musculoskeletal system

FIGURE 2.30 Proprioception training often uses a balance ball to provide an unstable base for the exercise.

2.2 CHECK-IN QUESTIONS

1 The RAMP protocol for effective warm-up activities stands for:
   A Raise, Activate, Mobilise, Potentiate
   B Raise, Activity, Mobility, Potentiate
   C Run, Activity, Muscles, Prepare
   D Rest, Action, Massage, Plan
2 What is the one thing that dynamic and static stretching having common?
3 Physiologically, how does a cool-down help restore the body to pre-exercise levels?
4 What is delayed onset muscle soreness (DOMS), what are the causes and how can the symptoms associated with DOMS be reduced?
5 Ruby is a competitive touch rugby player who recently tore her rotator cuff (shoulder joint muscles). She is keen to return to playing as soon as possible. **Explain** the importance to Ruby of proper progression and monitoring throughout each stage of the rehabilitation process in order to minimise the risk of reinjury.
6 Select one rehabilitation strategy and **outline** the mechanisms responsible for the repair and restoration of musculoskeletal function.

Assessment
2.2 Check-in questions

2.3 PHYSICAL AIDS TO SUPPORT AND PROTECT THE MUSCULOSKELETAL SYSTEM

In this module you will learn about:
- the role of physical aids that support the musculoskeletal system such as protective equipment, taping and braces

and learn to:
- implement and describe the correct application of physical aids and physiological strategies in a variety of sporting activities to maintain optimal functioning of the musculoskeletal system.

This module will look at the role of physical aids that support and protect the musculoskeletal system. Physical aids include protective equipment such as helmets, shin guards, mouthguards, eye and face protection and padding to protect players from extrinsic factors, as well as taping and braces, which are used to prevent injuries related to intrinsic factors.

Protective equipment

Protective equipment is used in many different sports and is often related to the level of risk that the activity presents. Consider a hockey goalkeeper who wears extensive padding (chest, leg and feet guards), helmet with face guard and padded gloves. A hockey ball is small and hard and travels very quickly, and players shooting for goal swing powerfully within close proximity of the goalkeeper. The nature of the game poses a high risk of a contact injury to the goalkeeper, so substantial protective equipment is needed. Compare this to a soccer goalkeeper who wears only shin guards and gloves. The risk of a contact injury for a soccer goalkeeper is quite low.

In many sports, wearing protective equipment is mandatory. In other sports, players may choose to wear protective equipment.

Brett Hemmings/Getty Images

Dean Mouhtaropoulos/Getty Images Sport/Getty Images

Pankaj Nangia/Getty Images Sport/Getty Images

James Worsfold/Getty Images Sport/Getty Images

FIGURE 2.31 Protective equipment varies across different activities. How does the equipment used in a sport relate to the level of protection required?

ABOVE AND BEYOND THE STUDY DESIGN

Head protection in Australian Rules football, p. 95

MANAN VATSYAYANA/AFP/Getty Images

FIGURE 2.32 Protective equipment is used to protect the hockey goalkeeper from direct contact injuries from the stick and ball.

TABLE 2.4 Examples of protective equipment used in physical activity, sport and exercise

	Protective equipment	Purpose	Commonly used in
 iStock.com/gurineb	Mouthguard	Covers the teeth and surrounding area to prevent or reduce injury to the teeth, tongue, lips and jaw	Hockey, basketball, football, squash, rugby, boxing, martial arts and lacrosse
 Spotmatik Ltd/Shutterstock.com	Helmet	Protects the skull bone from fractures and lacerations May help to protect the brain from injury during impact	Cycling, skating, cricket, baseball/softball, rugby, climbing and skiing/snowboarding and gridiron
 Insidefoto/LightRocket/Getty Images	Guards and padding (shin, knee, elbow, wrist, chest, groin, shoulder, hip, thigh)	Protect from cuts and abrasions and reduce the risk of soft-tissue injuries caused by absorbing the impact from a collision	Soccer, rugby, gridiron, cricket, lacrosse, skateboarding, hockey, snowboarding, volleyball, climbing, fencing and martial arts

	Protective equipment	Purpose	Commonly used in
 James Worsfold/Getty Images Sport/Getty Images	Appropriate footwear	Provides suitable traction, support and protection from impact, decreasing the risk of acute and overuse injuries	Running, cycling, athletics, baseball, football (all codes), netball, tennis, racquetball, golf and squash
 R.SATISH BABU/AFP/Getty Images	Eyewear	Reduces the impact of fast-moving objects such as a squash ball	Squash

DID YOU KNOW?

In most sports, the ball is larger than the eye socket, but in squash the ball is just the right size to fit into the eye socket. To avoid damage to the eye, squash glasses and goggles are recommended. In sports where the ball is bigger, the browbone and cheekbone protect the eye, but a squash ball can fit between these bones and cause damage, especially as the ball is usually travelling very fast.

fStop Images GmbH / Alamy Stock Photo

FIGURE 2.33 Taping can help prevent injuries.

Taping and braces

Taping and wearing braces during physical activity, sport or exercise aims to reduce the risk of injury to the musculoskeletal system. Athletes may tape an area that has been previously injured. As well as providing additional support, this may also provide a psychological benefit, giving the athlete the confidence to perform at full capacity.

Taping

Tape is generally used by athletes to stabilise or support an injury, relieve pain by de-loading weak or painful joints or muscles, and to facilitate normal movement, muscle action or postural patterns. Typically, taping is used on joints such as the ankle, knee, wrist and shoulder joints. However, taping can also be used to prevent injuries in muscles.

Primarily, tape is used to:

- prevent injury
- improve joint stability
- reduce the risk of injury recurrence
- reduce the load or strain on injured or weak areas
- correct faulty biomechanics
- inhibit muscle action

- facilitate muscle action
- enhance proprioception
- relieve pain
- enhance athlete confidence.

Different kinds of tape can be used, depending on the desired aim:

- Rigid strapping is a supportive tape that stabilises joints and is effective for both preventative and rehabilitation taping techniques. Rigid tape restricts the movement of ligaments, tendons and joints to prevent injury.
- Elastic strapping tape can also be used when less rigidity or support is required, as it provides more stretch, allowing for greater movement and conformity to the body. Can be used to manage soft tissue injuries through compression.
- Kinesiology tape is designed to provide comfort, increase stability and relieve pain in injured joints or muscles. This flexible tape allows full range of motion, improves blood flow and speeds up recovery from minor injuries.

Roger Parker/Alamy Stock Photo

FIGURE 2.34 Ash Barty had her thigh heavily taped during a match.

SIGNPOST

Sports Medicine Australia (SMA) offers a number of courses, including an introduction to taping course and an advanced taping course. The introductory course offers technical and practical advice, and techniques for use when taping athletes. More information can be found on its website.

Weblink
Taping courses – Sports Medicine Australia

Braces

Ankle, wrist and knee braces are used to support the musculoskeletal system. Braces are commonly used to:

- immobilise/limit joint motion
- reduced swelling through compression of a muscle or joint
- support and align a body part to promote good posture
- reduce stresses on the muscles and joints
- minimise pain.

Many athletes wear braces to prevent injuries; however, the evidence to support this is inconsistent, and the benefits for preventing injury are debatable. Braces have been shown to provide a false sense of security for athletes, resulting in greater stress being placed on the joint compared to if they were not wearing a brace.

For example, the use of knee braces to prevent knee injuries in children and adolescents should not replace sport-specific training programs to reduce injury, and rehabilitation programs should focus on flexibility, strength, range of motion and balance.

Braces are used to reduce the pain associated with 'tennis elbow', an overuse injury that causes inflammation of the muscles and tendons of the elbow. In treating tennis elbow, wearing a brace provides immediate relief from the pain. Conversely, the use of braces for alleviating wrist pain in gymnasts is not as clear cut. In a study involving young female gymnasts it was found that wrist guards limited extension of the wrist joint but increased wrist flexion, which may potentially lead to an increased risk of injury. The study concluded that the amount of time young female gymnasts wear wrist guards should be carefully controlled.

iStock.com/sportpoint

FIGURE 2.35 Wrist braces are commonly worn by both male and female gymnasts.

Assessment
2.3 Check-in questions

2.3 CHECK-IN QUESTIONS

1 Which of the following statements best describes the role of protective equipment, taping and braces in physical activity, sport and exercise?
   - **A** They are primarily used to enhance performance by providing additional support to athletes' joints and muscles.
   - **B** They are used to prevent all types of injuries and eliminate the need for proper warm-up and conditioning.
   - **C** They can help reduce the risk of certain injuries by providing support and stability to the joints and muscles.
   - **D** They are only necessary for professional athletes and are not beneficial for amateur or recreational sports participants.

2 **Outline** two reasons for wearing a mouthguard in a game of basketball.

3 Provide two rules relating to school sport that aim to reduce the risk of injury to students.

4 **Explain** why an athlete might tape their ankles before participating in a game of Australian Rules football. What are the advantages and disadvantages or preventative taping?

5 What is the relationship between flexibility and the risk of injury?

6 Think of a sport that does not require any protective equipment. What characteristics of the sport mean the risk of musculoskeletal injury is low enough to not need any protective equipment?

ABOVE AND BEYOND THE STUDY DESIGN

MODULE 2.3, p. 91

Head protection in Australian Rules football

There is an ongoing debate about the use of helmets to protect players from concussion in Australian Rules football. While concussion is a brain injury, it results from contact to the skull, which is part of the skeletal system. The helmet is designed to protect the skull and minimise the impact of contact with the head, usually from another player. Neuroscientist Professor Alan Pearce explains that the helmet protects the skull bone from fractures and lacerations, but the amount of force that a helmet can absorb isn't enough to prevent a brain injury.

However, there is an argument that helmets should be mandatory for junior footballers, and some junior football leagues have already made wearing helmets compulsory for players under 12 years of age due to concerns around the long-term consequences of repeated concussion and head trauma.

FIGURE 2.36 Many junior clubs have mandated the wearing of helmets for both training and games.

The Australian Institute of Sport (AIS) has developed resources to support the Australian Government's 'Concussion and Brain Health Position Statement', released in 2024. Additionally, the AIS has released the 'Australian Concussion Guidelines for Youth and Community Sport', which provide clear and consistent guidance on the prevention, recognition and management of concussion for parents, teachers, coaches, sideline staff and others involved in youth and community sport.

ABOVE AND BEYOND THE STUDY DESIGN

Connect Images/Alamy Stock Photo

FIGURE 2.37 Wearing helmets is encouraged in all sports where players are at risk of suffering head injuries, including cricket.

Weblinks
Concussion and Brain Health Position Statement
Australian Concussion Guidelines for Youth and Community Sport
Concussion in Sport

SIGNPOST

The Australian Government's 'Concussion and Brain Health Position Statement' can be found on the Australian Sports Commission website.

The 'Australian Concussion Guidelines for Youth and Community Sport' can also be found on the same website.

The Australian Sports Commission website has a range of other concussion in sport resources.

CHAPTER SUMMARY

2.1 Causes of musculoskeletal injuries

- When the forces acting on the body are greater than the body part can withstand, the result is a musculoskeletal injury.
- Intrinsic and extrinsic factors influence injury occurrence.
- Internal forces on the body, such as a sudden change in speed or direction, cause indirect injuries.
- External forces on the body, such as being struck with a ball, cause direct injuries.
- An acute injury is one that occurs suddenly, without warning.
- A chronic injury is a long-term overuse injury that is caused by repeated overuse of bones, muscle groups or joints.
- Overuse injuries can be caused by poor technique, repetitive nature of the activity, insufficient recovery, inadequate or incorrect footwear or inappropriate training surface.
- A strain is a muscle tear, usually caused by an eccentric muscle action that takes the muscle beyond its functional length, resulting in damage to the muscle.
- A sprain is damage to a ligament caused by an excessive force.
- The severity of a muscle strain or ligament sprain is graded as 1, 2 or 3. A Grade 1 sprain or strain is mild; Grade 3 is severe.
- The RICER protocol should be used to treat soft tissue injuries in the first 48–72 hours.
- A fracture is a break in a bone. Fractures can be acute or chronic injuries. Stress fractures are chronic injuries.
- Arthritis occurs when joints become inflamed, painful, stiff and swollen.
- Osteoarthritis is a chronic, degenerative joint disease where the cartilage that covers the ends of bones in joints deteriorates.
- Osteoporosis is a bone disease where the bone mineral density and bone mass decrease, resulting in an increased risk of a fracture.
- Osteoporosis can be prevented through regular weight-bearing exercise and resistance training, a diet rich in vitamin D and calcium, a healthy weight, not smoking, and limiting alcohol intake.
- Overtraining syndrome (OTS) can occur with prolonged, excessive training (high volume or high intensity) or a sudden increase in training without sufficient recovery.

Resource
Self-assessment checklist

Video
Masterclass: Chapter 2

2.2 Injury prevention

- The aim of the warm-up is to prepare the body physiologically and psychologically for physical activity. A warm-up will improve performance and reduce the risk of injury.
- Physiological benefits of a warm-up include increases in core body temperature, muscle temperature, blood flow to active muscles and muscle contraction and relaxation.
- RAMP is a protocol to develop an effective warm-up. The three key phases are: raise, activate, mobilise and potentiate/prepare.
- A cool-down aims to aid recovery and return the body to a pre-exercise state.
- Delayed onset muscle soreness (DOMS) is muscular soreness that is felt 12–24 hours after exercise.

- DOMS is caused by microscopic damage to the muscle fibres and the surrounding connective tissue, leading to soreness which can be relieved with low-impact activity, massage, foam rolling, ice or heat.
- Static stretching is appropriate at the end of an exercise or training session, as the muscles are warm. Stretching can lead to improved flexibility, which may reduce the risk of injury.
- Rehabilitation from injury utilises a variety of strategies to enable the individual to participate in the same activity and environment in which the injury occurred with the same (or better) functional capacity.
- Rehabilitation often involves pain management. Ice, compression and elevation can help manage the pain in the first 72 hours. Heat packs, medicated creams, TENS and ultrasound can also be used to provide temporary relief from the pain associated with muscular and joint injuries.
- Massage therapy aims to reduce muscle tension, relieve pain, increase joint range of motion, control swelling, enhance performance and aid recovery.
- Flexibility, strength, endurance and proprioception training can all be used in a rehabilitation program.

2.3 Physical aids to support and protect the musculoskeletal system

- Physical aids include protective equipment such as helmets, shin guards, mouthguards, eye and face protection and padding that generally protects players from extrinsic factors.
- Taping and braces are used to provide support to prevent injuries related to intrinsic factors.
- Taping is usually used on joints, but can also be used to prevent injuries in muscles.

CHAPTER REVIEW

Assessment
Chapter 2 Review

1 Factors related to an individual's ability to cope with the forces imposed on the body are known as:

- **A** extrinsic factors.
- **B** intrinsic factors.
- **C** chronic factors.
- **D** direct factors.

2 Which of the following may contribute to an overuse injury?

- **A** Collision with an opposition player
- **B** Flexibility training
- **C** Poor technique
- **D** Recovery

3 The structure that is damaged as a result of osteoarthritis, causing pain, is the:

- **A** cartilage that covers the ends of bones.
- **B** joints capsule.
- **C** ligaments.
- **D** bone mass.

4 **Outline** the PRICER protocol in relation to sports injury management.

5 Physiologically, how does massage aid in the rehabilitation process?

6 **Explain** the relationship between the load placed on the muscle or joint (stress) and the frequency of the application in relation to injuries.

7 **List** three extrinsic factors and explain how each factor might influence the chance of an injury occurring, using a specific example.

8 **Identify** a sport, list the protective equipment needed and explain how it is designed to protect the musculoskeletal system.

9 How is bone health managed across the lifespan? How does this reduce the risk of osteoporosis?

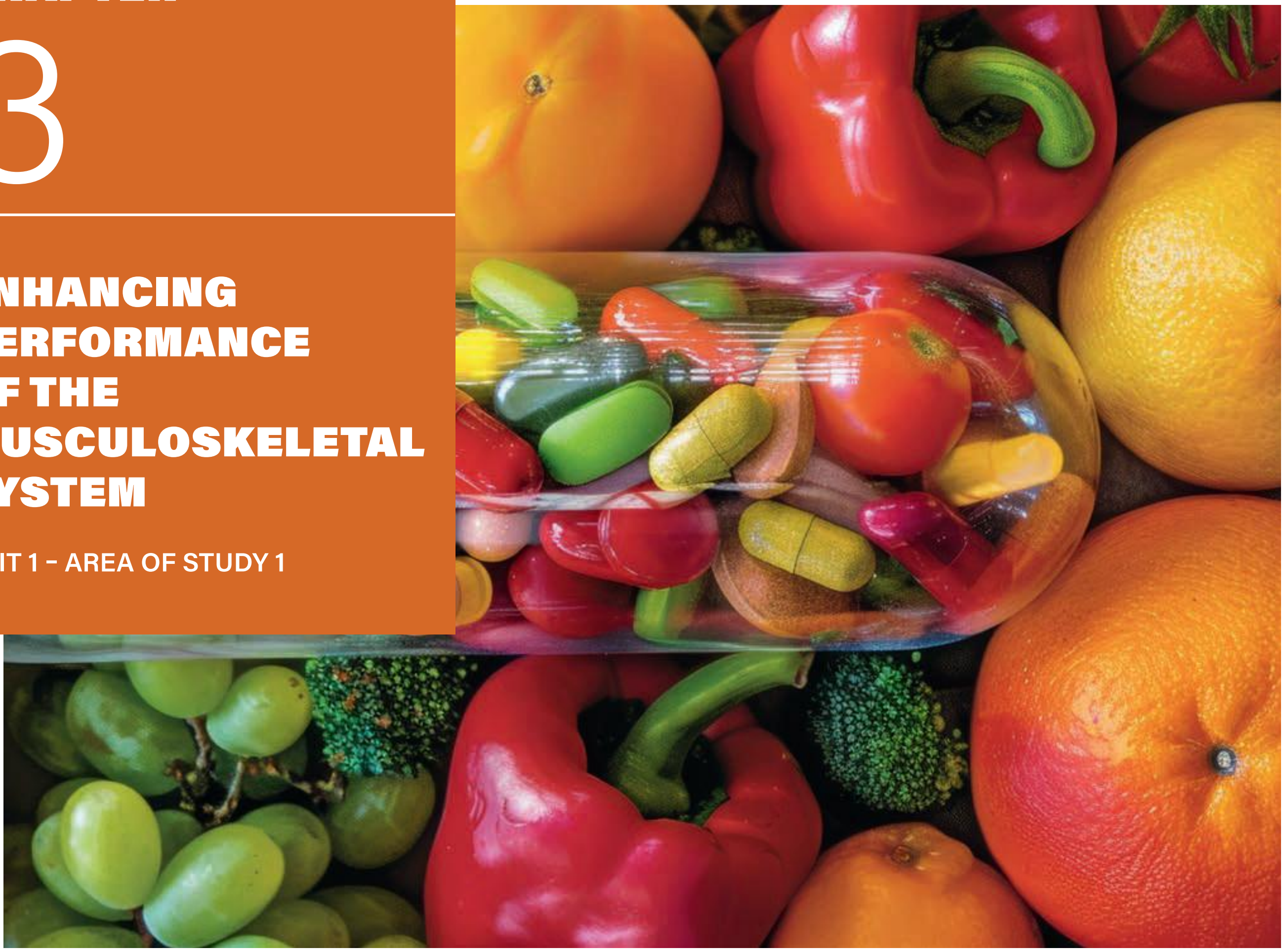
10 During a game of netball, a player jumps to intercept the ball and lands awkwardly, twisting their ankle. They immediately feel intense pain and are unable to put weight on the affected foot.

- **a** What type of injury is this classified as?
- **b** What are the potential musculoskeletal structures involved in this type of injury?
- **c** What signs or symptoms would indicate the severity of the injury?
- **d** How should the injury be treated in the first 72 hours?
- **e** After a successful rehabilitation program, the player is ready to return to playing. What protective measures do you suggest they use?

CHAPTER 3

ENHANCING PERFORMANCE OF THE MUSCULOSKELETAL SYSTEM

UNIT 1 – AREA OF STUDY 1



Denys/Adobe Stock

FIGURE 3.01 A 'Food First' approach is a risk-free alternative to nutritional supplements.

Quizzes

Chapter 3 Pulse check

3.1 Check-in questions

3.2 Check-in questions

3.3 Check-in questions

Chapter 3 Review

Videos

Masterclass: Chapter 3

3.2 In focus: How creatine enhances performance

Resources

Chapter 3 Self-assessment checklist

Nelson MindTap

To access resources above, visit **cengage.com.au/nelsonmindtap**

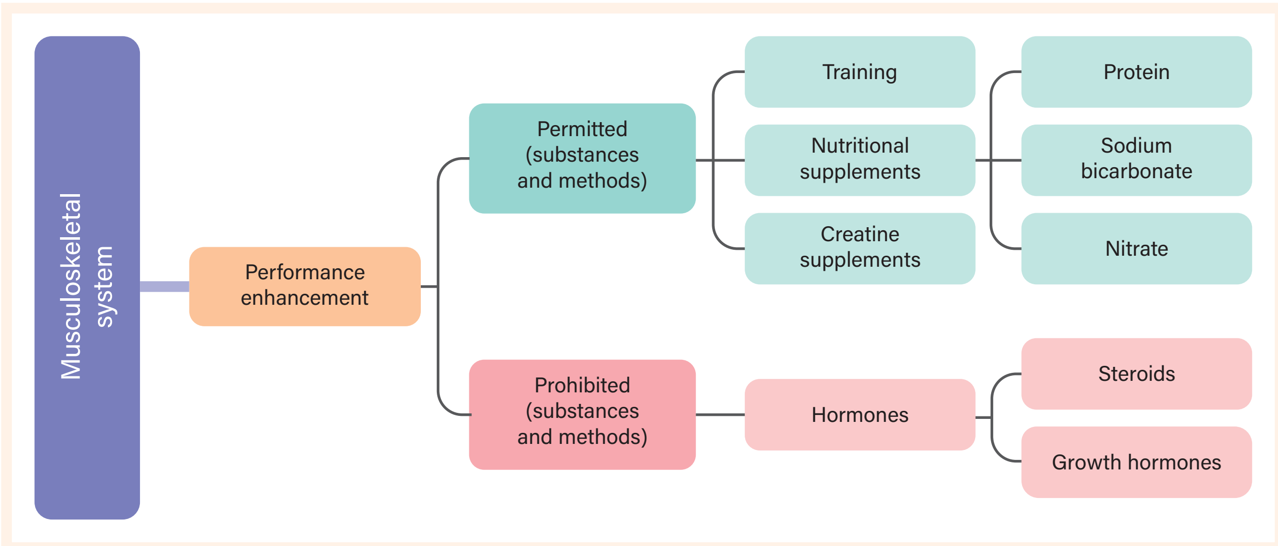
KEY KNOWLEDGE

- potential benefits and harms of permitted and prohibited substances and methods that enhance performance of the musculoskeletal system, such as training, nutritional supplements, creatine supplementation and hormones (including steroids and growth hormones)

KEY SKILLS

- investigate, evaluate and critically analyse the effects of a range of performance-enhancing substances and methods on the musculoskeletal system from a physiological perspective

Source: VCAA VCE Physical Education Study Design (2025–29)



Video
Masterclass: Chapter 3

Assessment
Chapter 3 Pulse check

In this chapter we will look at a range of permitted and prohibited substances and methods that can be used to enhance performance of the musculoskeletal system. We will describe the different methods and substances that affect the bones, joints and muscles, including training, nutritional and creatine supplements, and steroid and growth hormones. We will look at the potential benefits of each method or substance, and also the potential harms associated with their use.

PULSE CHECK

Take the pulse check quiz to check your prior knowledge and understanding of the concepts covered in this chapter.

1 **List** five methods or substances that could enhance the performance of the musculoskeletal system.
2 Classify each of the substances listed in question 1 as either permitted or prohibited.
3 **Outline** the risks of the methods and substances you classified as 'prohibited' in question 2.
4 Select a sport and **discuss** how one of the methods listed in question 1 may enhance performance in that sport.
5 Who is Sports Integrity Australia and what do they do?

3.1 PERFORMANCE ENHANCEMENT

In this module you will learn about:

- ergogenic aids and the difference between a permitted and prohibited substance or method used to enhance performance
- the World Anti-Doping Agency (WADA) criteria for determining if a substance is on the prohibited list

and learn to:

- distinguish the difference between a permitted and prohibited substance or method.

Athletes and individuals at all levels of physical activity, sport and exercise are often looking to improve their performance. At the elite level, this may meaning increasing speed by a fraction of a second, while at the community level it may be lifting more in the gym or gaining an edge during a game of football. To elicit an improvement in performance, some individuals or athletes may use a variety of substances and methods called **ergogenic aids**. Ergogenic aids include performance-enhancing substances, nutritional supplements, and pharmacological and/or physiological tools or methods aimed to increase energy, performance and recovery.

ergogenic aid
A method or substance used for the purpose of enhancing performance

LOOKING FORWARD

Why do athletes use performance-enhancing methods and substances?

Chapter 6

In Chapter 6 we will look more closely at the reasons why an athlete might use a method or substance to enhance their performance. You will explore the ethical and sociocultural influences on the use of permitted and prohibited performance-enhancing substances and methods.

Many performance-enhancing methods or substances, such as training and the use of nutritional and creatine supplements are permitted for use. Other methods and substances, such as steroids and growth hormones, are prohibited for use by athletes. Permitted simply means that something is allowed – in this case, permitted substances and methods are allowed to be used. Prohibited means that something is disallowed by an authority or law. In the case of substances and methods used in sport, that authority is the World Anti-Doping Agency (WADA).

For a substance or method to be prohibited by WADA, it must meet two of the following three conditions:

- It has the potential to enhance, or it does enhance performance in sport.
- It has the potential or represents an actual risk to the athlete's health.
- It violates the spirit of sport (this definition is described in the introduction to the Code).

Sport Integrity Australia, 2024

WADA is responsible for determining the substances and methods that are prohibited. WADA updates and publishes the Prohibited List every 12 months. The updated list comes into force on 1 January each year, and the role of Sport Integrity Australia is to promote the updated Prohibited List to Australian sports and athletes.

The list outlines:

- the substances and methods that are prohibited in and out of competition
- the sports in which the substances and methods are prohibited.

Throughout this chapter we will look at both permitted (Module 3.2) and prohibited (Module 3.3) substances that enhance performance of the musculoskeletal system. Generally, the substances and methods are intended to increase muscle mass, leading to increased strength, power and speed.

DID YOU KNOW?

The difference between first and eighth in the women's 50-metre freestyle event in the 2020 Tokyo Olympics was 0.60 of a second!

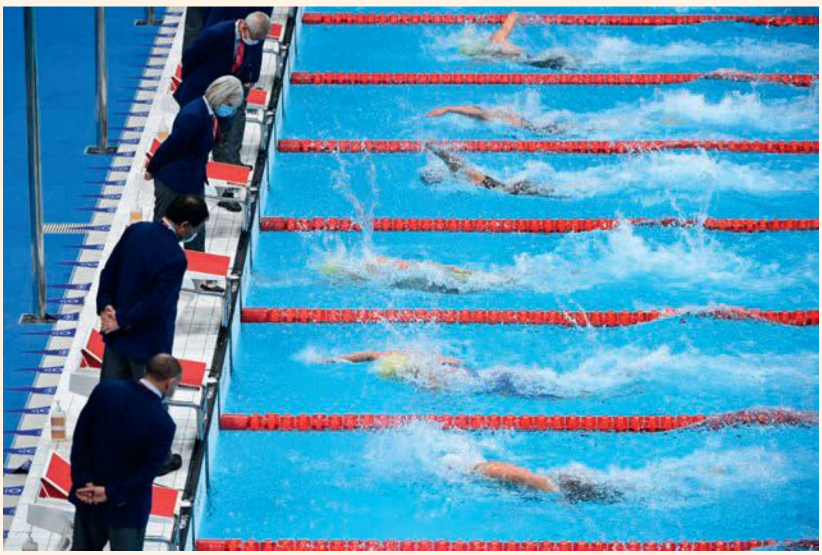


FIGURE 3.02 Australia's Emma McKeon touches the wall 0.26 seconds ahead of Sarah Sjoestroem of Sweden to win the final of the women's 50-metre freestyle swimming event during the Tokyo 2020 Olympic Games.

Weblinks
WADA Prohibited List
The science behind anti-doping

SIGNPOST

- You can access the Prohibited List on the WADA website.
- Go to the Sport Integrity Australia website to listen to the podcast 'The science behind anti-doping.' The podcast discusses prohibited substances and methods in sports, the dangers supplements pose to an athlete's career, as well as the role that education plays in the fight against drugs in sport.

3.1 CHECK-IN QUESTIONS

1 Which component of the musculoskeletal system is likely to benefit from a permitted and prohibited substance or method?
  A Cartilage
  B Tendon
  C Muscle
  D Bone
2 What is an ergogenic aid? Provide three examples of different ergogenic aids.
3 **Explain** the difference between a permitted and prohibited substance or method.
4 What is WADA's role in relation to permitted and prohibited substances or methods? What other role does WADA play in the world sporting community?

explain
Give a detailed account of why and/or how with reference to causes, effects, continuity, change, reasons or mechanisms; make the relationships between things evident

3.2 PERMITTED SUBSTANCES AND METHODS FOR ENHANCING PERFORMANCE

In this module you will learn about:
- potential benefits and harms of permitted substances and methods that enhance performance of the musculoskeletal system, such as training, nutritional supplements and creatine supplementation

and learn to:
- investigate, evaluate and critically analyse the effects of a range of performance-enhancing substances and methods on the musculoskeletal system from a physiological perspective.

Training

Training is a method for improving performance, particularly in relation to the musculoskeletal system. Regular physical training results in a series of chronic (long-term) adaptations that will be specific to the type of training being undertaken and lead to improvements in performance. The training methods used by an individual will be determined by the desired outcome or goal of the training program. A training program that aims to increase the functioning and performance of the musculoskeletal system will include a focus on maintaining and improving bone mass, building muscular strength, endurance and power, and increasing the flexibility of the muscles and joints.

There are a number of steps that need to be undertaken to make sure that the training program is safe (pre-participation health screening), appropriate to the individual (assessment of fitness), specific to the sport or activity (activity analysis), and to determine the required fitness components (training methods) and the goal of the program (training principles).

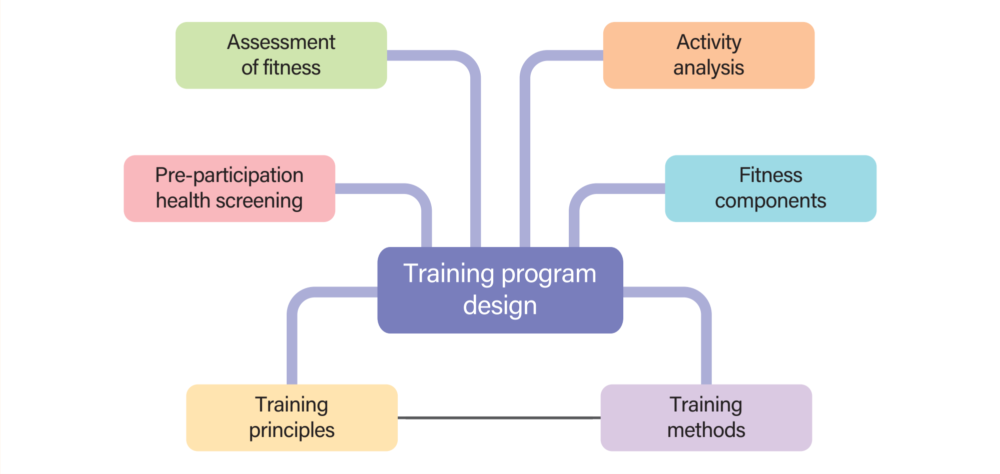


FIGURE 3.03 Designing a training program

LOOKING FORWARD
Training programs
Chapter 12 and Units 3&4 – Chapter 14

In Chapter 12 you will learn about the importance of pre-participation health screening to ensure that starting a training program is safe.

Unit 4 of VCE Physical Education looks at the design, implementation and evaluation of training programs. Chapter 14 of *Nelson Physical Education VCE Units 3&4* looks at methods of determining the focus of the training program (assessment of fitness), training principles and training methods before designing and evaluating different training programs.

Training can increase the force generated in a muscle and will elicit a physiological response when the load is near the muscle's current maximal force-generating capacity. The training volume, intensity or frequency need to be adjusted progressively as the muscle adapts, so that improvements and gains continue to be made. These adaptations allow the body to work harder or more efficiently. For example, resistance training that focuses on strength will result in an increase in the size of the muscle fibres and an overall increase in the cross-sectional area of the muscle. This will allow the muscle to produce greater force. In performance terms, this then means that the athlete can lift heavier weights, jump higher or sprint faster.

LOOKING BACK
Skeletal muscle fibres
Chapter 1

To revise the structure of a skeletal muscle go to Chapter 1.

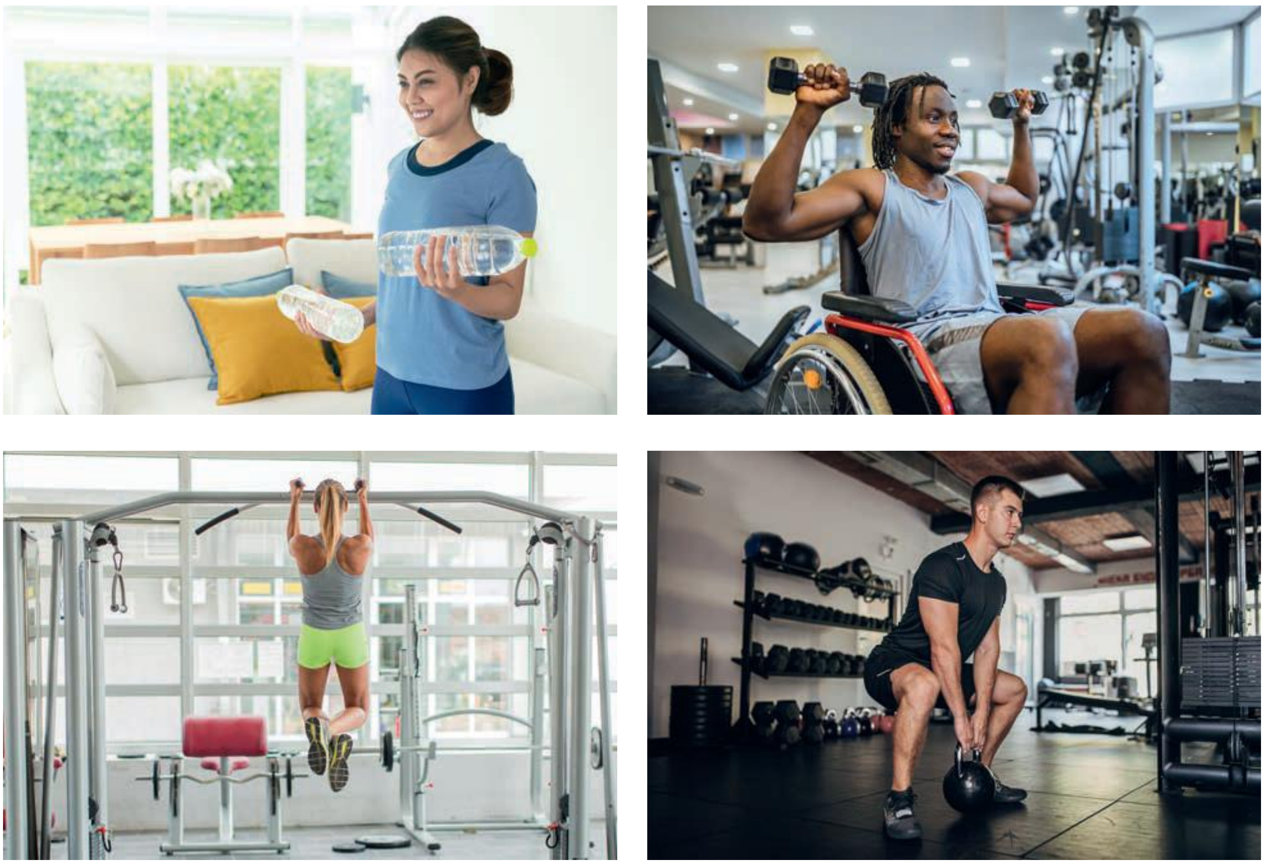
Resistance training

hypertrophy
An increase in the size of the muscle

Resistance training, as the name suggests, is any form of training where the muscles contract to overcome a resistance. People will often say that they are 'lifting weights' – this is the most common form of resistance training, and involves raising and lowering weights. In this case, the resistance is the weight being lifted. Muscle **hypertrophy** occurs when the fibres of the muscles sustain microscopic damage and as the body repairs the damaged fibres, the mass and size of the muscle increase. Rest and recovery are important with resistance training, as muscle growth occurs during recovery. Additionally, resistance training, particularly if weight bearing, has been shown to be beneficial for reducing bone loss, increasing bone mass and conserving bone tissue.

Protein is needed for growth and repair of muscle fibres in the body. When paired with resistance exercise, an increased protein intake has been shown to contribute to greater strength and muscle mass gains. We will look at the role of protein supplementation in the next section.

Examples of resistance training include the use of free weights, weight machines, your own body weight or resistance bands, and the equipment used includes barbells, dumbbells, kettle bells and weight machines.



ChayTee/Adobe Stock
iStock.com/LordHenriVoton
BGStock72/Shutterstock.com
iStock.com/Hirurg

FIGURE 3.04 Household goods, barbells, kettlebells or the body can all be used as the weight in resistance training.

The focus of a resistance training program will determine the appropriate **sets**, **repetitions (reps)** and weight to be moved and the rest required between sets. Programs that target muscular strength use heavy weights with low repetitions, while muscular endurance programs have lighter weights and higher repetitions. With any resistance training exercise, it is important to use correct technique, moving the joint through the full range of motion in a controlled manner. As the muscle adapts, a greater load will be required to continue to gain increases in muscle mass and strength. This is usually done by increasing the amount of resistance (weight) lifted in each exercise.

set
A series of repetitions performed without a rest

repetitions (reps)
The number of times an exercise is repeated in a row

TABLE 3.1 Resistance training guidelines

Desired outcome	% of 1RM (repetition maximum)	Repetition range	Sets	Repetition speed	Rest periods
Novice and intermediate					
Muscular strength	60–70%	8–12	1–3	Slow and moderate	2–3 minutes between sets
Muscular hypertrophy	70–85%	8–12	1–3	Slow to moderate	1–2 minutes between sets
Muscular power	30–60%	3–6	1–3	As fast as possible	2–3 minutes between sets
Muscular endurance	40–60%	15–25	1–3	Slow to moderate	1 minute
Advanced					
Muscular strength	80–100%	1–12 (emphasis on 1–6)	3–6	CON* 1–2 seconds ECC** 1–2 seconds	2–3 minutes between sets
Muscular hypertrophy	70–100%	1–12 (emphasis on 1–6)	3–6	Continuum	2–3 minutes between sets
Muscular power	30–60%	3–6	3–6	As fast as possible	2–3 minutes between sets
Muscular endurance	40–60%	15–25	3–6	Slow to moderate	1 minute

*CON = concentric muscle actions **ECC = eccentric muscle actions
Adapted from ACSM, 2014

Felix Sanchez Arrazola/Alamy Stock Photo

Arpad Radoczy/Alamy Stock Photo

FIGURE 3.05 Endurance and sprint runners have different goals for the type of resistance training they do.

DID YOU KNOW?

Australia's physical activity guidelines recommend that individuals participate in muscle-strengthening activities at least two days per week. We will look at the guidelines for different population groups in detail in Chapter 10.

Prostock-studio/Adobe Stock

FIGURE 3.06 Performing the exercise on a Swiss or BOSU ball makes the exercise more challenging.

Soloviova Liudmyla/Shutterstock.com

FIGURE 3.07 Reformer Pilates focuses on core strength.

Core strength training

Core strength and stability, developed through strength training, is important in preventing musculoskeletal injuries. Core strength relates to the diaphragm, abdominal, oblique, gluteal and paraspinal muscles of the torso, lower back and hip (including the pelvic floor) region. These powerful muscles stabilise the spine and pelvis and help to maintain good posture. While strength and resistance training can strengthen the core, specific training such as Swiss/BOSU ball and Pilates have been shown to be effective in developing core strength.

Swiss ball training provides an unstable base on which to perform the exercise. This increases the demand on the muscle, and the unstable position means that the muscles need to work harder to keep the body balanced throughout the movement.

Improved core strength is associated with improved:

- posture
- stability
- balance
- flexibility
- running performance
- transfer of power between the lower and upper body.

Developed by Joseph Pilates in the 1920s, Pilates exercises are initiated by stabilising the core before moving through a controlled range of motion. Pilates uses simple, repetitive exercises designed to increase muscle strength, endurance and flexibility and to improve posture and balance.

The two basic forms of Pilates are:

- **mat-based Pilates**: a series of exercises performed on the floor using gravity and your own body weight to provide resistance. The main aim is to condition the deeper, supporting muscles of your body to improve posture, balance and coordination
- **equipment-based Pilates**: includes specific equipment that works against spring-loaded resistance, including the 'reformer', which is a moveable carriage that you push and pull along its tracks.

COLLABORATIVE TASK
Prac activity

Acute response to flexibility exercises

AIM

To increase the range of motion of the shoulder joint

EQUIPMENT

Student's chair, masking tape or chalk

METHOD

1. Working with a partner, move the chair back slightly from your desk and make sure there is about 1 metre of space behind you.
2. Sit up straight in your chair, place your hands behind the back of the chair. Join your hands together. Have your partner mark the lowest point of your hands on the back of the chair with masking tape or chalk.

3. With your hands clasped together, raise your arms as far as you can. Have another student mark on the back of the chair the position of your hands (i.e. how high you were able to raise your arms).
4. Stand up and complete 10 arm circles forwards, and then 10 backwards. Make sure the movement is slow and controlled and takes the shoulder joint through its full range of motion.
5. Sit back in your chair and repeat step 3.
6. Measure the difference between the position of the hands in step 3 and step 5.

DISCUSSION

1. Were you able to raise your arms further after performing the arm circles?
2. Why do we see a response to flexibility exercises immediately?
3. How does increasing the range of motion of a joint benefit performance?

Flexibility training

The range of motion of a joint can be improved with flexibility exercises. A joint's range of motion is improved immediately after performing flexibility exercises, and chronic adaptations appear after about 3–4 weeks of regular (2–3 times per week) flexibility training.

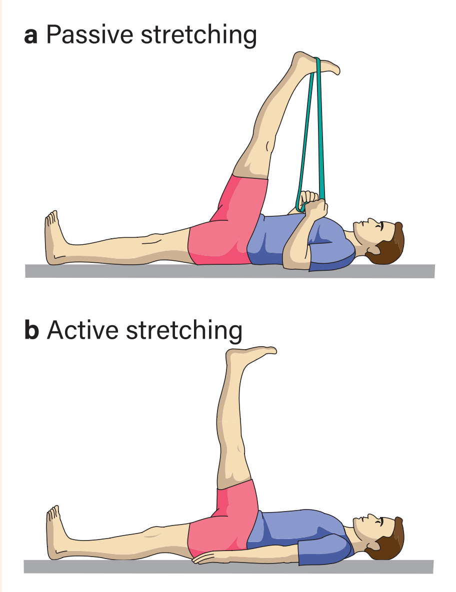


FIGURE 3.08 Static stretching can be passive **(a)** or active **(b)**.

Flexibility training aims to increase the range of motion of the joints through the major muscle and tendon groups, and can lead to improvements in stability (postural) and balance, especially if combined with a strength-training program. Flexibility exercises are most effective when the muscles are warm, therefore it is best not to perform flexibility exercises without first increasing muscle temperature (usually through an effective warm-up).

There are a number of different types of flexibility exercises.

Static stretching

Static stretching involves stretching a muscle slowly to the point of slight discomfort (not pain) or a feeling of tightness and holding for 10–30 seconds. Each flexibility exercise should be repeated 2–4 times, resulting in about 60 seconds of total stretching time for each muscle/muscle group.

Static stretching can be active or passive.

- Active stretching involves holding the stretched position using the strength of the agonist muscle; for example, the stretch performed in the prac activity on page 109 involves an active stretch. Active stretching is common in yoga.
- Passive stretching involves resistance such as another person, a resistance band or a ballet barre – for example, a hamstring stretch performed using a resistance band to hold the limb in position (see Figure 3.08a).

Dynamic stretching

Dynamic stretching involves the gradual movement from one body position to another, in a slow and controlled movement. There is a progressive increase in the range of motion of the joints involved with each repetition of the movement. For example, there is a stretch known as the 'world's greatest stretch', as it engages every major muscle group in the body.

Ballistic stretching uses the body's momentum to produce the stretch. It includes rapid, alternating movements or 'bouncing' at the end-range of motion. Ballistic stretching has the potential to increase range of motion quickly, but can also increase the risk of injury. Therefore, ballistic stretching is not recommended for the general population, and has limited application for athletes or individuals with specific training needs. Athletes using ballistic stretching must do so under the guidance of experienced coaches or trainers.

Daniel Gill/Adobe Stock

FIGURE 3.09 Why do you think this stretch is known as the 'world's greatest stretch'?

SIGNPOST

You can watch a short video, '21 Dynamic Stretching Warm Up Exercises', on the Redefining Strength channel on YouTube.

Weblink
21 dynamic stretching warm-up exercises

Proprioceptive neuromuscular facilitation (PNF)

Proprioceptive neuromuscular facilitation requires a partner to perform. All forms of PNF stretching include an isometric muscle action followed by a static stretch of the same muscle group, so the muscle goes through a sequence of contracting and relaxing.

Types of PNF stretching include:

- contract relax
- hold relax
- contract-relax agonist contract.

One recommended PNF technique is a 20–75 per cent maximum voluntary contraction against the resistance (partner, towel, band etc.), held for 3–6 seconds, followed by a 10–30-second assisted stretch.

grant pritchard/Alamy Stock Photo

FIGURE 3.10 PNF stretching often uses a partner but can also be done with a resistance band, towel or solid surface.

Nutritional supplements

Sports nutrition is a science, and the practice of eating to promote optimal health and performance plays an important role in enhancing athletic performance. The athlete's diet should meet their needs for growth, function, fuel and fluids, and should promote recovery and adaptation. An athlete's everyday training diet should support them to stay healthy, maintain optimal body composition and support the physiological adaptations they are trying to achieve through training.

Sport Integrity Australia promotes a 'Food First' approach, which is based on the following information:

- A planned and nutritionally balanced diet can meet virtually all of an athlete's nutritional needs.
- Very few performance supplements are backed by evidence.
- The majority of supplements are unnecessary and can pose a risk to an athlete's health and career.

The 'Food First' approach promotes unprocessed and conventional foods. While few nutritional supplements have scientifically demonstrated their effectiveness in enhancing performance, there are some supplements and sports foods that can be beneficial to the athlete.

The Australian Institute of Sport (2022) defines a supplement as a single or multi-ingredient product in powder, limited volume liquid, pill or capsule form that provides nutrients or other dietary components

iStock.com/fcafotodigital

FIGURE 3.11 The 'Food First' approach encourages athletes to meet their nutritional requirements through diet, not supplements.

Kmpzzz/Shutterstock.com

FIGURE 3.12 The use of any supplement comes with risk.

to achieve a specific health and/or performance benefit. Nutritional supplements include vitamins, minerals, herbs, meal supplements, sports nutrition products, natural food supplements and other related products used to boost the nutritional content of the diet.

Supplements that have been shown to enhance performance of the musculoskeletal system include protein, creatine, nitrate (beetroot juice) and sodium bicarbonate, particularly in recreational-level athletes. Research has shown that the better the individual's fitness level is, the less improvement shown in physical performance (Santesteban Moriones and Santos, 2017).

Protein supplements

Protein is important to the structure and function of all living cells, including muscle, bone, cartilage, skin, blood, enzymes and hormones, with approximately half of the body's protein found as skeletal muscle. Proteins are made up of chemical 'building blocks' called amino acids. There are about 20 different amino acids that the body uses to make new proteins, to build and repair muscles and bones, and to make hormones and enzymes. They can also be used as an energy source. Protein is also beneficial in recovery, and contributes to satiety, or feeling full after a meal.

Protein supplementation is perceived to be beneficial for muscle growth, and many recreational gym goers use protein powders, shakes, protein bars and other forms of protein supplements to boost their protein intake. However, high-protein diets do not lead to increased muscle mass. It's the stimulation of muscle tissue through exercise that leads to muscle growth. Studies have shown that weight-trainers who do not consume extra protein through diet or supplements gain muscle at the same rate as those who supplement their diets with protein.

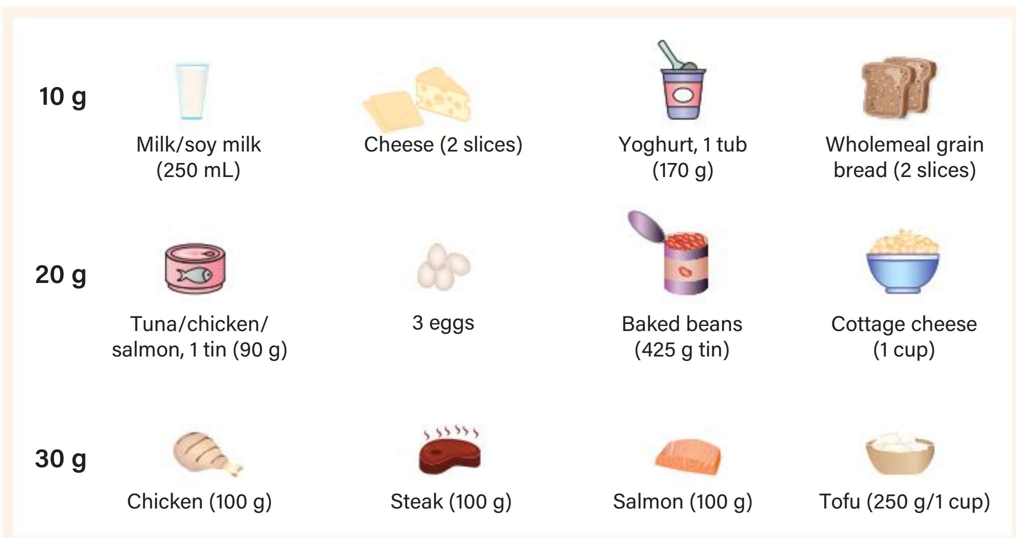


FIGURE 3.13 Protein-rich foods are readily available, raising the question of why an athlete would use a supplement.

Source: Australian Institute of Sport, 'AIS Sports Supplement Framework: Isolated Protein Supplements,' page 2 of PDF at https://www.ais.gov.au/__data/assets/pdf_file/0014/1001381/Isolated-Protein-Supplements-Infographic-final-1.pdf

As stated earlier, a 'Food First' approach should apply to the use of all supplements, including protein, as there are many protein-rich foods available. Many of these food choices can meet the nutritional needs of an athlete.

Protein supplements are usually either:

- protein only (>90 per cent protein) – i.e. isolated protein supplements, which are generally low in carbohydrate, fat and lactose
- protein blend – i.e. mixed macronutrient supplements which have variable amounts of protein and carbohydrate, plus micronutrients.

A protein supplement might be useful when:

- a food form of protein is not practical in terms of storage/travel/time
- the protein content of food options naturally low in protein need boosting
- rapid digestion of protein is required, e.g. immediately after key workouts
- an alternative to food is required when appetite is poor
- higher targets for protein are required when aiming to reduce fat mass and protect muscle mass (1.6–2.4 g/kg body mass)
- specialised weight loss programs require a higher protein intake within an energy-restricted diet to optimise the retention/increase in lean mass.

The amount of protein needed is determined by your age, gender, height and weight. Sedentary individuals need less protein than those who are involved in heavy training. Figure 3.15 shows the calculation of an athlete's daily protein intake target and how this can be achieved without supplements. A protein supplement will typically provide 20–30 grams of protein, and while convenient, they are, for the most part, unnecessary. Any excess protein taken in will either be excreted from your body as waste, or stored as weight gain.

Maxx-Studio/Shutterstock.com

FIGURE 3.14 Protein supplements are readily available from supermarkets, pharmacies and health food shops.

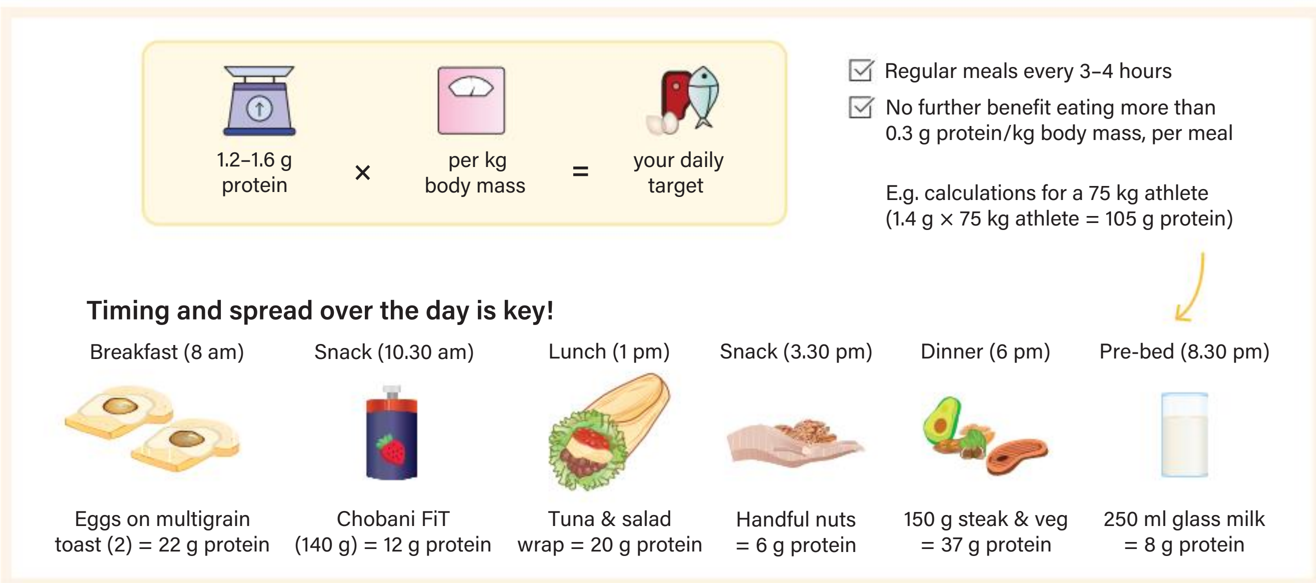


FIGURE 3.15 A protein rich diet can meet the protein needs of an individual.

Source: Australian Institute of Sport, 'AIS Sports Supplement Framework: Isolated Protein Supplements', page 1 of PDF at https://www.ais.gov.au/__data/assets/pdf_file/0014/1001381/Isolated-Protein-Supplements-Infographic-final-1.pdf

DID YOU KNOW?

Protein supplements are different to protein fortified foods (PFFs), but it can be hard to tell the difference. A protein supplement is likely to have the first ingredient listed on the product label as protein. PFFs, on the other hand, can contain unidentified protein ingredients or added botanical ingredients, making it difficult to tell if they contain trace amounts of a banned substance and so should be avoided by athletes.

LOW-RISK PFFS	HIGH-RISK PFFS
Breakfast foods (cereals) Weet-bix Protein Uncle Toby's Oats Super Blends Protein Uncle Toby's Breakfast Bakes	**Foods from cafes/food outlets** Unnamed protein balls Smoothies with added protein powder
Cereal/nut bar Carman's Gourmet Protein Bar Nice & Natural Protein Nut Bar	**Foods with hemp ingredients** Macro Protein Muffin Banana & Chia
Bakery Green's Protein Buttermilk Pancake Mix The Healthy Baker Protein Muffin Mix	**Foods with botanical ingredients** Crankt Protein Bar
Dairy/dairy-free Streets Blue Ribbon Protein Bar Ice-cream	**Non-batch tested protein powders, pre-workouts** Protein supplements, pre-workouts not listed on the Sport Integrity app
Drinks Up & Go Protein Energize	
Frozen foods Super Nature Super Protein Wellness Bowl Coles PerForm frozen meals	
Batch-tested protein supplements Supplements listed on the Sport Integrity app	

FIGURE 3.16 Low-risk and high-risk PFFs

Other nutritional supplements

Other important nutritional supplements are:

- sodium bicarbonate
- nitrate
- calcium and Vitamin D
- creatine supplementation.

placebo effect
When a person's physical or mental health appears to improve after taking a placebo or 'dummy' treatment

Sodium bicarbonate

Sodium bicarbonate has been shown to improve performance by increasing the body's buffering capacity, reducing the fatigue associated with a build-up of hydrogen ions (H+) during high-intensity exercise. There is, however, some aspect of the effect of sodium bicarbonate that is thought to be a **placebo effect** (Grgic et al., 2021).

Ingesting the correct amount of sodium bicarbonate without causing gastrointestinal upset can be difficult for athletes, and it is recommended that a dietitian is consulted to work out an appropriate protocol. Figure 3.17 shows one example of how much sodium bicarbonate should be taken before exercise.

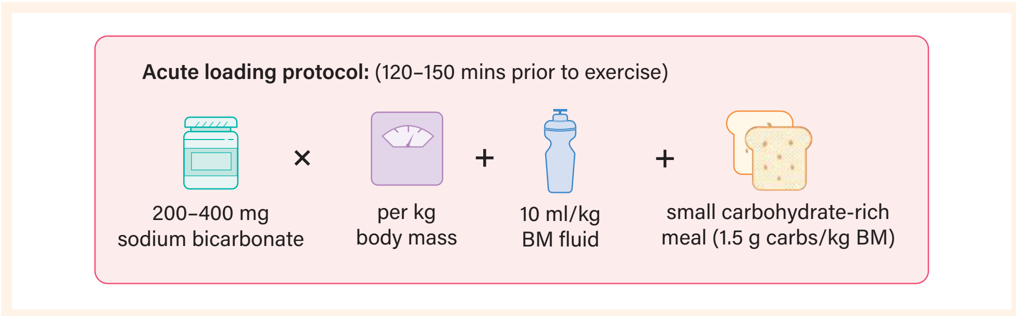


FIGURE 3.17 Sodium bicarbonate loading protocols vary and should be developed with a sports dietician.

Source: Australian Institute of Sport, 'AIS Sports Supplement Framework: Sodium Bicarbonate', page 1 of PDF at https://www.ais.gov.au/__data/assets/pdf_file/0015/1001382/Sodium-Bicarbonate-Infographic-Final.pdf

Nitrate

Dietary nitrate can be used to enhance the availability of nitric oxide (NO). Nitric oxide works as a vasodilator to lower blood pressure and increase oxygen flow to the muscles. It reduces the energy cost of exercise through increased mitochondrial respiration, increases vasodilation and blood flow to skeletal muscles, improves muscle contraction and enhances performance. Nitrate reduces the oxygen cost of exercise. This means that an athlete can exercise at a high intensity for the same energy cost, which is beneficial for endurance athletes. A common source of dietary nitrate is beetroot juice. It is also found in leafy greens (rocket, bok choy, celery, baby spinach etc.), some fruits, and processed meats.

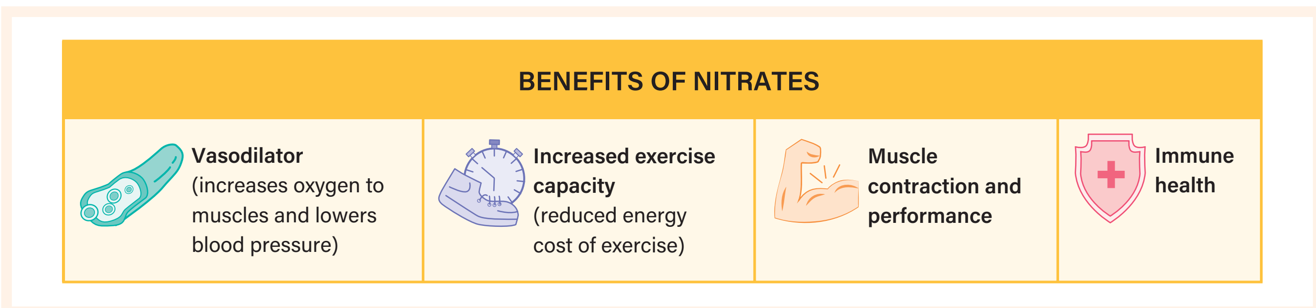


FIGURE 3.18 Nitrate may enhance athletic performance.

Source: Australian Institute of Sport, 'AIS Sports Supplement Framework: Beetroot Juice (Nitrates)', page 1 of PDF at https://www.ais.gov.au/__data/assets/pdf_file/0005/1001102/Beetroot-juice-Infographic-2pg.pdf

Calcium and Vitamin D

Calcium plays an important role in maintaining bone health and healthy nerve function. Insufficient levels of calcium may, over time, decrease bone mass and density, increasing the risk of osteoporosis (see Chapter 2) and leading to a higher risk of fractures.

Calcium supplementation should only be considered when the current dietary intake is insufficient or inadequate. The 'Food First' approach looks to incorporate more calcium-rich foods in the diet before supplements are taken. Calcium generally comes from dairy products, with smaller amounts found in bony fish, green leafy vegetables, legumes and some nuts. Three serves of dairy foods per day should result in sufficient calcium intake.

Vitamin D is needed to help the body absorb calcium and promote bone health. Vitamin D comes from exposure to UVB from the sun, and a deficiency can lead to an increased risk of bone injuries, chronic musculoskeletal pain and viral respiratory tract infections. Vitamin D supplementation in athletes with low levels of Vitamin D has been shown to enhance performance, specifically in relation to strength, power, reaction time and balance.

Tatjana Baibakova/Shutterstock.com

iStock.com/pepifoto

FIGURE 3.19 A 'Food First' approach is recommended over any nutritional supplement.

LOOKING BACK

Bone health

Chapter 2

To review the section on bone health, see Chapter 2.

Video
In focus: How creatine enhances performance

Creatine supplementation

Creatine is a non-essential nutrient that is naturally found in muscle cells, and is used as fuel for short, high-intensity exercise. Creatine produces energy very quickly, but only a small amount can be stored in the muscle, which is exhausted after about 8–10 seconds of maximal exercise.

LOOKING FORWARD

Creatine as a fuel source

Units 3&4 – Chapter 6

Unit 3 of VCE Physical Education looks at the three energy systems (ATP-CP, anaerobic glycolysis and aerobic) and the fuels that each system relies upon to produce ATP – the energy source for all movement. Ninety-five per cent of the creatine in the body is stored in the muscles, and is the most immediate energy source for high-intensity exercise. These topics are explored in chapter 6 of *Nelson Physical Education VCE Units 3&4*.

Creatine is ingested through foods such as meat, fish and poultry. However, the amount of creatine in food is not sufficient to elicit performance enhancement, so some athletes may use creatine supplementation. Creatine monohydrate is a supplement that is used to increase creatine stores and enhance high-intensity exercise performance.

Figure 3.20 shows what creatine has been found to be beneficial in.

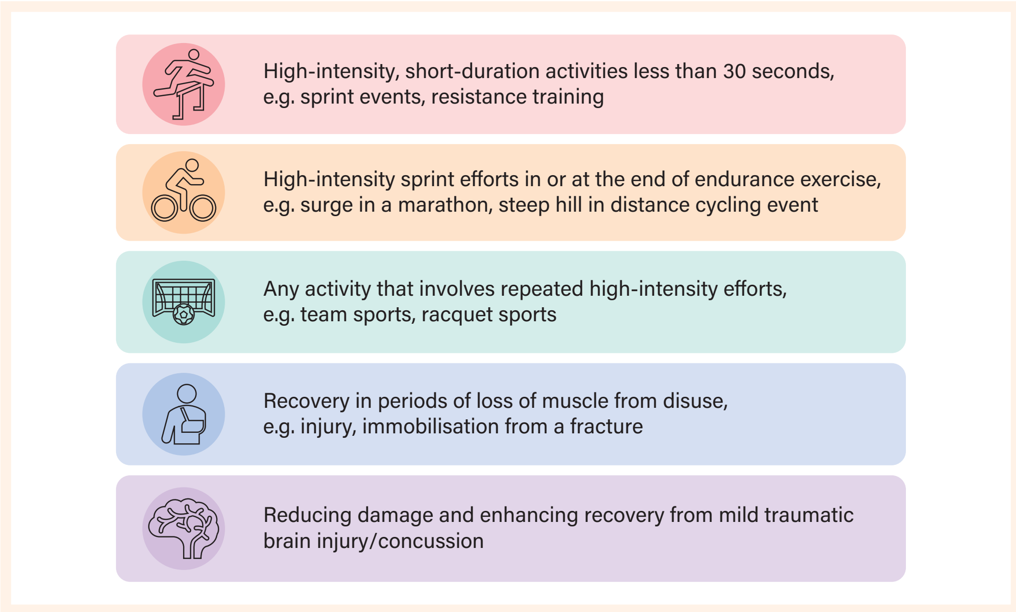


FIGURE 3.20 The benefits of creatine

The mechanisms responsible for creatine supplementation leading to an enhanced training response and the resulting improved performance are interrelated. The increased levels of creatine in the muscle increase protein synthesis, leading to an increase in muscle mass and a reduction in the reliance on glycolysis. This leads to a decrease in the accumulation of metabolic by-products, which in turn delays fatigue. With reduced fatigue, training intensity can be increased. Coupled with increased protein synthesis, this results in greater gains and an increase in the size of Type II muscle fibres, which results in an increase in performance.

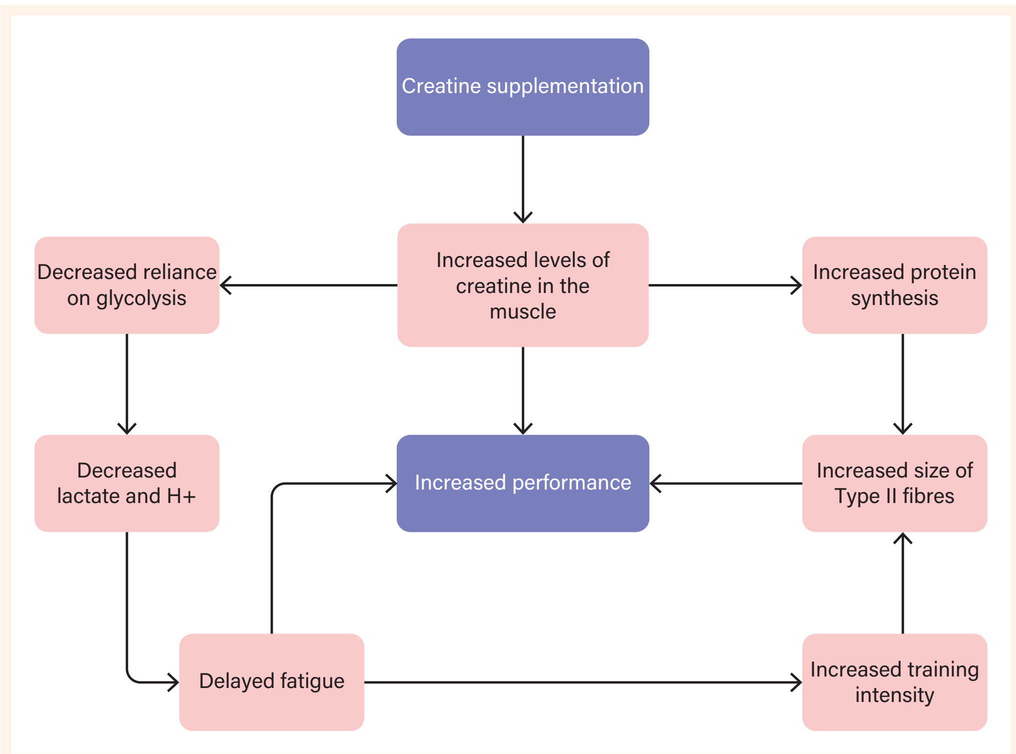


FIGURE 3.21 Creatine supplementation can increase performance through multiple mechanisms.

Ingesting creatine before exercise will increase the availability of creatine as an energy source for high-intensity, short-term efforts, while ingesting creatine after an exercise session may help replenish muscle creatine stores. Some evidence suggests that creatine ingestion post-exercise may be more effective and practical than pre-exercise, and that creatine uptake is maximised when consumed with carbohydrates. There is a limit to the amount of creatine that can be stored in the muscles, and once the muscle is saturated, any excess creatine is excreted from the body through the urine. If used at an appropriate dosage, creatine supplementation does not appear to have any long-term adverse effects for healthy individuals.

Sport Integrity Australia states that no supplement is 100 per cent safe to use, and that most don't actually improve performance. If an athlete is looking to use a supplement, they need to first ask themselves: Is it safe? Is it effective? Is it permitted for use in sport? The AIS supports athletes to make informed decisions about supplement use, and has provided a framework to assist with their decision-making. You can access the framework on Nelson MindTap.

Weblink
Athlete decision-making tree

LOOKING FORWARD
Batch testing
Chapter 6

Sport Integrity Australia has developed an app for athletes to check whether the supplement they plan to take has been batch tested. We will look at batch testing in more detail in Chapter 6.

TABLE 3.2 Summary table of the benefits and harms of permitted substances and methods

Substance or method	Benefits to the musculoskeletal system	Harm
Resistance training		
Strength training	• Increased bone density • Muscular hypertrophy (increased mass) • Increased strength of tendons and ligaments • Increased speed of muscular contraction • Increased efficiency in muscular recruitment • Increased stores of ATP, creatine phosphate and glycogen • Increased enzyme levels for anaerobic energy production	Nil if conducted safely and with correct technique and form
Endurance training	• Increased stores of glycogen and triglycerides • Increased size and number of mitochondria • Increased myoglobin content • Enhanced ATP production through aerobic glycolysis • Improved fat oxidisation and glycogen sparing	Nil if conducted safely and with correct technique and form
Flexibility training	• Increased range of motion of the joint • Increased balance • Increased postural stability	Nil if performed correctly (i.e. after a warm-up)
Nutritional supplements		
Protein	• Enhanced resistance training response • Increased protein synthesis • Enhanced recovery • Improved rate of growth and repair of muscle and bone • Increased energy availability	Some protein powders contain products that are harmful or banned. Overconsumption may have harmful effects on metabolism and gut comfort. A very high-protein diet can strain the kidneys and liver and prompt loss of calcium, increasing the risk of osteoporosis.
Sodium bicarbonate	• Improved metabolic function of muscle • Increased buffering capacity • Reduced fatigue	Gastrointestinal upset including nausea, stomach pain, diarrhoea and vomiting

>

Substance or method	Benefits to the musculoskeletal system	Harm
Resistance training		
Nitrate	▪ Regulation of blood pressure and increased blood flow ▪ Increased mitochondrial respiration ▪ Increased exercise capacity (reduced energy cost of exercise) ▪ Improved muscle contraction ▪ Increased immune function	Mild gastrointestinal discomfort Unlikely to be harmful, however, chronic use of nitrate supplements has not been well studied
Calcium and Vitamin D	▪ Increased bone health ▪ Increased nerve health ▪ Increased muscle contraction ▪ Blood pressure regulation	Gastrointestinal upsets such as bloating and constipation Possible increased risk of heart disease
Creatine supplementation		
	▪ Increased muscle creatine content ▪ Increased peak power output ▪ Increased muscle mass ▪ Increased muscular strength ▪ Increased capacity for high-intensity 'bursts' in endurance events	Fluid retention (increased body mass) Mild, temporary gastrointestinal upset

3.2 CHECK-IN QUESTIONS

1 **List** three benefits to the musculoskeletal system from resistance training that aims to develop strength.
2 **Outline** the potential harm of using creatine supplements.
3 **Describe** how using creatine can benefit performance.
4 How does muscle hypertrophy occur? Identify two performance-enhancement methods or substances that may lead to an increase in muscle mass.
5 **Explain** the interdependent changes that result in performance enhancement from taking creatine.
6 Zach is 18 and has recently joined the gym. His focus is to build muscle mass and strength. His mate Henry has suggested that he use a protein supplement such as a protein shake. What advice would you give Zach about the potential benefits and potential harms of incorporating protein supplements into his fitness regimen?

Assessment
3.2 Check-in questions

Command terms

list
Provide a series of related words, names, numbers or items that are arranged consecutively

outline
Provide an overview or the main features of an argument, point of view, text, narrative, diagram or image

3.3 PROHIBITED SUBSTANCES AND METHODS FOR ENHANCING PERFORMANCE

In this module you will learn about:
- potential benefits and harms of prohibited substances and methods that enhance performance of the musculoskeletal system, such as steroids and growth hormones

and learn to:
- investigate, evaluate and critically analyse the effects of a range of performance-enhancing substances and methods on the musculoskeletal system from a physiological perspective.

Anabolic steroids and body mass builders, such as human growth hormone, are the most-used performance-enhancing substances in competition. In this module we will look at these two prohibited substances, how they enhance performance of the musculoskeletal system, and the harms associated with their use.

Steroids

androgenic
Related to the development of male characteristics

anabolic
Promoting metabolic activity concerned with the building of complex molecules

Steroids are a group of synthetic drugs that are similar to the male sex hormone testosterone. You may have heard this group of drugs referred to as 'anabolic steroids' or 'anabolic androgenic steroids'. This is because steroids have both an **androgenic** effect (changes in primary and secondary sexual characteristics) and an **anabolic** effect (increases in muscle, bone and red blood cells and enhanced neural control).

The potential benefits of steroid use include:

- increased muscle mass
- increased strength, power, speed and endurance
- increased levels of aggression.

As a result, steroids were added to the Prohibited List in 1976, once a reliable test was available.

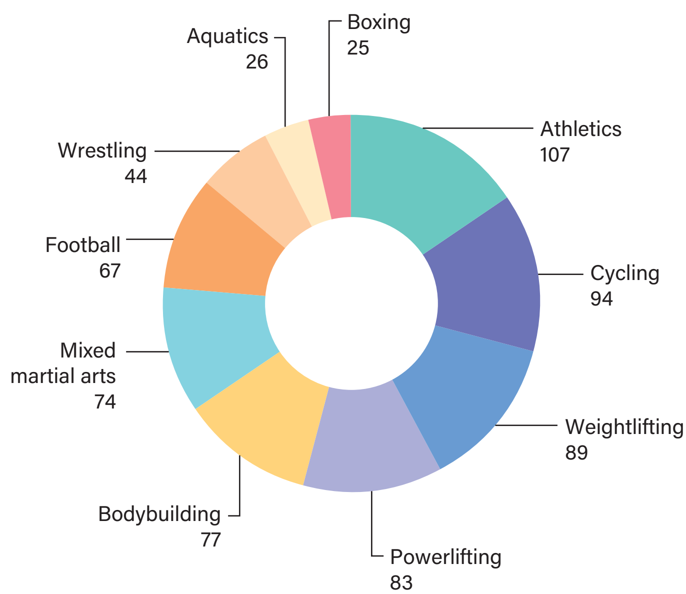


FIGURE 3.22 Sports with the highest number of anti-doping rule violations committed by athletes

Source: WADA, *World Anti-Doping Program May 2023 Report*, page 8, https://www.wada-ama.org/sites/default/files/2023-05/2020_adrv_report.pdf

Steroids usually come in a pill or tablet form, but they can also be injected when in liquid form, and applied to the skin as a gel or cream.

Physiologically, steroids are thought to produce the greatest outcome when combined with heavy resistance training to increase muscle size, strength, power and speed (see Table 3.3).

FIGURE 3.23 Steroids have been shown to work both with and without resistance training.

TABLE 3.3 Gains in muscle mass and strength shown with and without resistance training

No weight training group	Weight training group	Both groups
Bench press – 10 kg increase Back squat – 15 kg increase Increased arm and thigh muscle girth	Bench press – 22 kg increase Back squat – 35 kg increase Increase of 5 kg in lean mass	Increased lean mass Increased strength Increased muscle size

Source: Brooks, G.A., Fahey, T.D. & Baldwin, K.M. (2005). *Exercise Physiology: Human bioenergetics and its applications*, 4th edn. New York: McGraw-Hill.

Steroids have also been shown to allow athletes to train harder and recover faster. Increases in endurance are thought to be associated with the athlete's ability to train at higher percentages of their maximal oxygen uptake. Psychologically, steroids have been associated with a sensation of wellbeing and euphoria, as well as increased aggression and intolerance to stress.

DID YOU KNOW?

A group of experimental drugs called selective androgen receptor modulators (SARMs) have emerged on the sporting scene. These drugs claim to build muscle mass and bone density without the side effects of steroids. SARMs are on the prohibited list of substances, but what's of greater concern to athlete health is that many of these substances have not undergone clinical trials, and have not been deemed fit for human consumption.

Weblink
Bernice Wilson interview

SIGNPOST

Former British sprinter, Bernice Wilson, tested positive for steroid use and received a four-year ban, and then tested positive again.
Listen to the podcast 'Bernice Wilson on being manipulated into doping' on the Olympic Channel to hear about the experience of using steroids and the serious and long-term repercussions from an athlete's perspective.

Stu Forster/Getty Images Sport/Getty Images

FIGURE 3.24 Bernice Wilson

Potential harms of steroid use

The synthetic steroids used by athletes have been designed to maximise the anabolic properties of steroids while minimising the androgenic effect. However, the use of steroids has been linked to the following changes in men and women, which are associated with the androgenic effects of the drug.

TABLE 3.4 Side effects of steroid use in males and females

Men	Women
• Breast enlargement • Reduced sperm count • Testicular atrophy • Erectile dysfunction • Hair loss • Prostate problems	• Facial hair growth • Deeper voice • Change in facial features • Disturbances to menstrual cycle • Decreased breast size

In both males and females, other harmful effects associated with steroid use include:

- thickening and enlargement of the heart
- arteriosclerosis (hardening of arteries)
- heart attack and stroke
- liver disease and cancer
- acne
- kidney or prostate cancer
- fluid retention
- depression, aggression and psychosis.

Some of the side effects of using steroids are reversible; however, there is no safe level of drug use. The risks of irreversible damage are considerably higher with extended steroid use. However, there are legitimate uses for anabolic steroids. They can be used to treat some medical issues, such as hormonal issues in puberty, and to treat muscle loss caused by other diseases such as cancer and AIDS.

DID YOU KNOW?

It's not only athletes who take steroids. A study by the National Drug and Alcohol Research Centre found that in addition to competitive athletes, other users of steroids include people concerned about their body image, body-building professionals, people who need muscle strength to do their job (security, defence, construction workers) and young men looking to improve their athletic performance or who want to alter their physical appearance to match what is often portrayed in the media as an ideal male body type. A 'typical' user of steroids is a male in their mid to late thirties.

CASE STUDY PROHIBITED SUBSTANCE USE LEADS TO BAN

PROHIBITED SUBSTANCE USE LEADS TO BAN

Quinn Rooney/Getty Images Sport/Getty Images

FIGURE 3.25 Australian swimmer Shayna Jack was originally banned from swimming for four years.

In July 2019, in a routine out-of-competition drug test, swimmer Shayna Jack tested positive to Ligandrol, a banned substance, and was subsequently banned from swimming for four years.

Ligandrol is a selective androgen receptor modulator (SARM). SARMs are a group of experimental medicines that are claimed to build muscle mass and bone density, without the side effects of steroids. Not only are SARMs banned in sport, but many have not undergone clinical trials and have not been deemed fit for human consumption. Both the Australian Therapeutic Goods Administration (TGA) and the US Food and Drug Administration (FDA) have issued warnings about the health effects of SARMs, including adverse effects on the liver and heart.

Jack has maintained her innocence throughout, saying she had never missed a drug test and would not jeopardise her career by knowingly taking a banned substance.

'I did NOT take this substance knowingly. Swimming has been my passion since I was 10 years old and I would never intentionally take a banned substance that would disrespect my sport and jeopardise my career,' Jack said in 2019.

Jack appealed her ban with the Court of Arbitration for Sport, which reduced her suspension from four years down to two years, based on the finding that Jack did not knowingly ingest the substance.

Jack provided three possible scenarios for how the drug came to be in her system:

- The supplements she took could have been contaminated at manufacturing.
- The supplements were contaminated while being prepared or mixed in a blender that may have been contaminated or contained Ligandrol.
- Jack may have come into contact with the Ligandrol or ingested it as a result of using a pool and/or gym open to the public in Townsville or Cairns while training.

Jack served her two-year ban and returned to competitive swimming in 2022.

QUESTIONS

1 What are the potential musculoskeletal benefits of an athlete using a SARM such as Ligandrol?
2 What are the potential physiological harms to the athlete due to using Ligandrol?
3 Jack has suggested that the drug entered her system through a contaminated supplement. What steps can athletes take to avoid unintended ingestion of a banned substance?
4 **Evaluate** the arguments presented by Jack in her defence. How likely are each of the scenarios? Do you think that Jack took the drug intentionally or unintentionally? Discuss.

Growth hormone

Growth hormone (GH) or human growth hormone (HGH) is a polypeptide hormone that is produced in the pituitary gland. Growth hormone is a potential anabolic agent that influences the growth of muscle, connective tissue and bone, regulating our height. Athletes have used synthetic versions of growth hormone, mistakenly believing it will increase muscle size and strength.

Excessive growth hormone can cause an irreversible condition called acromegaly. Acromegaly is characterised by enlarged bones in the face, hands and feet. In adults, high doses of growth hormone will not result in any increase in the length of the bones, only in a thickening of the bone. The synthetic growth hormone increases the connective tissue, does not increase muscle strength, and can lead to muscle weakness.

Insulin-like growth factor (IGF-1), when stimulated by the growth hormone, is responsible for the anabolic effects of GH. IGF-1 can increase lean muscle mass and aid in recovery; however, it can cause serious harm.

Potential harms of growth hormone

There are serious and irreversible side effects associated with the use of growth hormone. These include:

- fluid retention (which leads to swelling in the arms and legs)
- joint and muscle pain
- carpal tunnel syndrome
- high blood pressure
- high blood sugar levels
- high cholesterol levels
- diabetes.

LOOKING FORWARD

Biological passport

Chapter 6

The concentration of IGF-1 in blood is tracked as a biomarker test for GH abuse. WADA monitors an athlete's use of GH and/or IGF-1 by examining their blood profile over time via the biological passport. Read more about biological passports in Chapter 6.

Assessment
3.3 Check-in questions

3.3 CHECK-IN QUESTIONS

1. What is the criteria for a substance or method to be prohibited?
2. Steroids have been shown to increase aggression. How might an increased level of aggression benefit a powerlifter?
3. What are four potential side effects in female athletes who use steroids?
4. What is the evidence to support the perceived benefits to the musculoskeletal system of taking growth hormone?

CHAPTER SUMMARY

3.1 Performance enhancement

- Ergogenic aids are performance-enhancing methods and substances.
- Permitted substances and methods are allowed to be used in physical activity, sport and exercise.
- Prohibited substances and methods are those that are not allowed to be used in physical activity, sport and exercise.
- WADA-prohibited substances must meet two of three conditions: the substance or method has the potential to enhance, or it does enhance performance in sport; it has the potential to or represents an actual risk to the athlete's health; and/or it violates the spirit of sport.

Resource
Self-assessment checklist

Video
Masterclass: Chapter 3

3.2 Permitted substances and methods for enhancing performance

- Most substances and methods that are perceived to be beneficial to the musculoskeletal system are intended to increase muscle mass, leading to increased strength, power and speed.
- Training is a method for improving performance through chronic (long-term) adaptations that lead to improvements in performance.
- Resistance training and flexibility training are most likely to elicit improvements in the musculoskeletal system.
- Resistance training may improve strength, power or endurance, or focus on increasing muscle size (hypertrophy).
- Flexibility training may include static, dynamic or PNF stretching.
- 'Food first' is a strategy that Sport Integrity Australia promotes to encourage athletes to find a suitable food source before turning to nutritional supplements.
- Nutritional supplements include vitamins, minerals, herbs, meal supplements, sports nutrition products, natural food supplements and other related products.
- Protein, creatine, nitrate (beetroot juice) and sodium bicarbonate have been shown to enhance performance of the musculoskeletal system.
- Sodium bicarbonate has been shown to increase the body's buffering capacity and reduce the fatigue associated with a build-up of hydrogen ions (H+) during prolonged high-intensity exercise.
- Sodium bicarbonate supplementation has been associated with gastrointestinal upsets.
- Nitric oxide increases oxygen flow to the muscles, lowers blood pressure, reduces the energy cost of exercise and improves muscle contraction, but can cause mild gastrointestinal discomfort.
- Creatine monohydrate supplementation is used to increase creatine stores and enhance high-intensity exercise performance.
- Creatine supplementation can cause fluid retention and mild, temporary gastrointestinal upset.

3.3 Prohibited substances and methods for enhancing performance

- Steroids are a group of synthetic drugs that mimic the male sex hormone, testosterone.
- Steroids have an androgenic effect and an anabolic effect, resulting in increased muscle mass, increased strength, power, speed and endurance. and increased levels of aggression.
- The potential harms of using steroids include thickening and enlargement of the heart, arteriosclerosis, heart attack, stroke, liver disease, cancer, acne and kidney or prostate cancer.
- Use of growth hormone (GH) as a potential anabolic agent that influences muscle, connective tissue and bone growth, is associated with severe and irreversible risks, including acromegaly.

CHAPTER REVIEW

Assessment
Chapter 3 Review

1 Which of the following stretching techniques involves holding a position without movement to increase the flexibility of the muscles?
   - **A** PNF stretching
   - **B** Static stretching
   - **C** Ballistic stretching
   - **D** Dynamic stretching

2 A nutritional supplement associated with an increase in the body's buffering capacity and reducing fatigue during prolonged high-intensity exercise is:
   - **A** protein.
   - **B** nitric oxide.
   - **C** sodium bicarbonate.
   - **D** creatine monohydrate.

3 What is one perceived benefit of protein supplementation for the musculoskeletal system?
   - **A** Lowered blood pressure and cardiovascular health
   - **B** Increased buffering capacity during exercise
   - **C** Improved flexibility and joint mobility
   - **D** Enhanced muscle growth and repair

4 **Explain** the perceived benefits and potential harms associated with creatine supplementation in the context of a 100-metre sprint performance.

5 Why might an 18-year-old AFL player consider using steroids?

6 How does the use of growth hormone as a potential anabolic agent influence athlete use in the context of competitive sport, and what are the potential harms that athletes should consider?

7 How does the 'Food First' strategy promoted by Sport Integrity Australia encourage athletes to approach supplementation, and why is it considered a recommended practice in the realm of sports nutrition?

8 Select one method or substance and conduct an investigation. Include the following in your findings:
   - **a** prevalence of use of the substance or method by athletes or others in the community
   - **b** physical activity, sport or exercise the substance or method would potentially benefit
   - **c** perceived benefits/potential harms of the method or substance
   - **d** an analysis of all of the available information to determine if the benefits outweigh the harms.

CHAPTER

4

THE CARDIOVASCULAR SYSTEM

UNIT 1 – AREA OF STUDY 2

FIGURE 4.01 The cardiovascular system is responsible for pumping blood around the body.

Quizzes

Chapter 4 Pulse check

4.1 Check-in questions

4.2 Check-in questions

4.3 Check-in questions

Chapter 4 Review

Videos

Masterclass: Chapter 4

4.1 In focus: Stroke Volume has a finite capacity

4.2 In focus: Cardiac output at rest and various exercise intensities

4.3 In focus: Thermoregulation

Resources

4.2 Template: Heart rate response to exercise test

4.2 Template: Heart rate and blood pressure test

4.3 Template: Thermoregulation test

Chapter 4 Self-assessment checklist

Nelson MindTap

To access resources above, visit **cengage.com.au/nelsonmindtap**

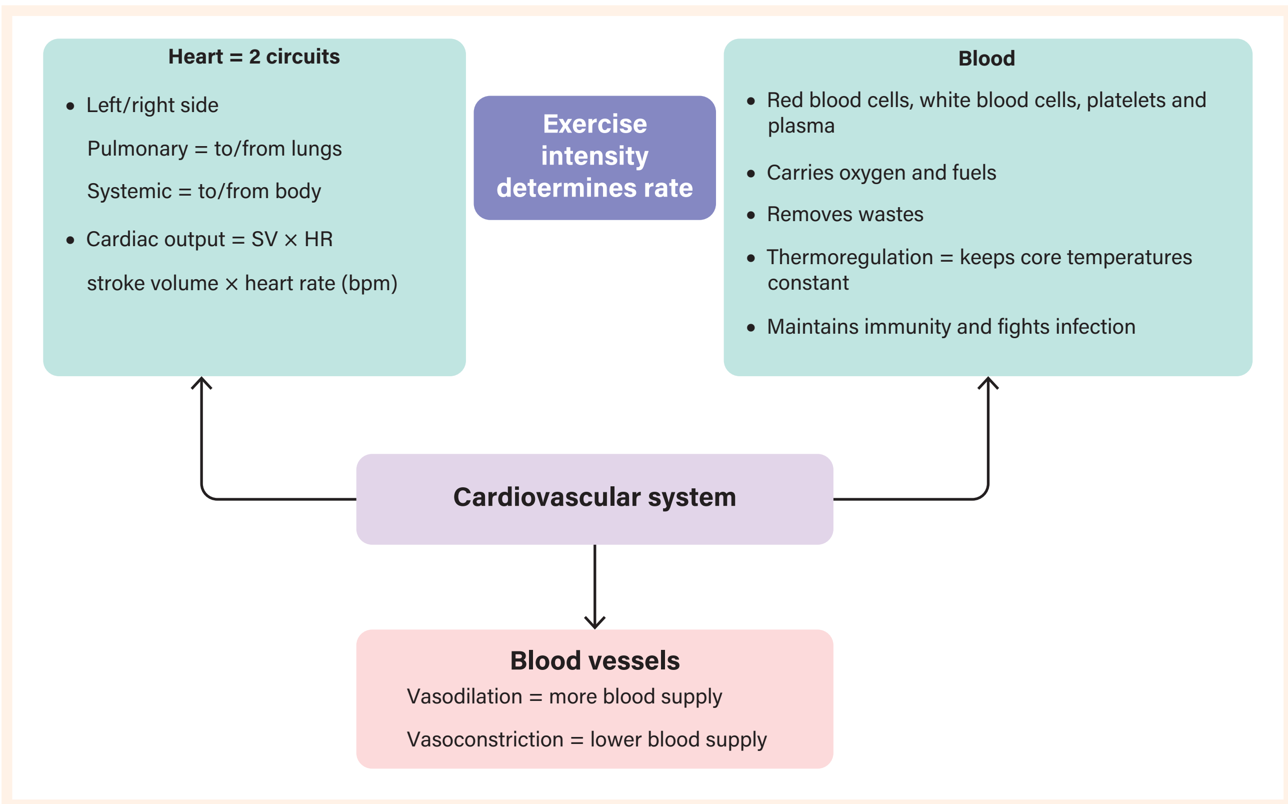
KEY KNOWLEDGE

- the structure and function of the cardiovascular system, including the heart, blood, blood vessels and blood flow around the body at rest and during various intensities of physical activity, sport and/or exercise
- the role of the cardiovascular system in thermoregulation, including vasodilation and vasoconstriction of the blood vessels to regulate blood distribution at rest and during physical activity, sport and/or exercise
- the relationship between stroke volume, heart rate and cardiac output at rest, and submaximal and maximal exercise intensities

KEY SKILLS

- apply and use anatomical terminology to identify the structures and function of the cardiovascular and respiratory systems
- use primary data to measure and analyse the changes to the cardiovascular and respiratory systems at rest compared with various exercise intensities
- examine the role and process of thermoregulation through participation in physical activity, sport and/or exercise

Source: VCAA VCE Physical Education Study Design (2025–29)



Video
Masterclass: Chapter 4

The cardiovascular system is made up of the heart, blood vessels (arteries, veins and capillaries) and the blood that is pumped through them to all parts of the body. This system is responsible for many functions, including transportation of gases and fuels, immunity, cellular repair and regrowth, and thermoregulation. The heart is both an organ and a powerful muscle that pumps blood through the blood vessels, which control the blood flow to specific parts of the body.

Our cardiovascular system consists of two main circuits: the systemic circuit and the pulmonary circuit. The systemic circuit transports oxygen and fuels to the major muscles and organs of the body, while the pulmonary circuit is responsible for transport between the heart and the lungs, where gaseous exchange occurs. In gaseous exchange, oxygen is taken up and transported back to the heart to then enter the systemic circuit, and carbon dioxide is exhaled.

Assessment
Chapter 4 Pulse check

PULSE CHECK

Take the pulse check quiz to check your prior knowledge and understanding of the concepts covered in this chapter.

1 What part or component of blood is responsible for the transportation of oxygen around the body?

2 **Outline** how blood keeps flowing in one direction throughout the vascular system.

3 **Define** the term 'vasodilation' and **explain** why it occurs within the cardiovascular system.

4 How would you describe the term 'thermoregulation' to someone who does not study physical education? Can you provide a sporting example to highlight this function?

5 Endurance athletes have larger hearts and more blood than non-endurance athletes. How would this give them a performance advantage in events such as a marathon or triathlon?

4.1 THE STRUCTURE AND FUNCTION OF THE CARDIOVASCULAR SYSTEM

Video
In focus: Stroke Volume has a finite capacity

In this module you will learn about:

- the structure and function of the cardiovascular system, including the heart, blood, blood vessels and blood flow around the body at rest and during various intensities of physical activity, sport and/or exercise

  and learn to:

- apply and use anatomical terminology to identify the structure and function of the cardiovascular and respiratory systems.

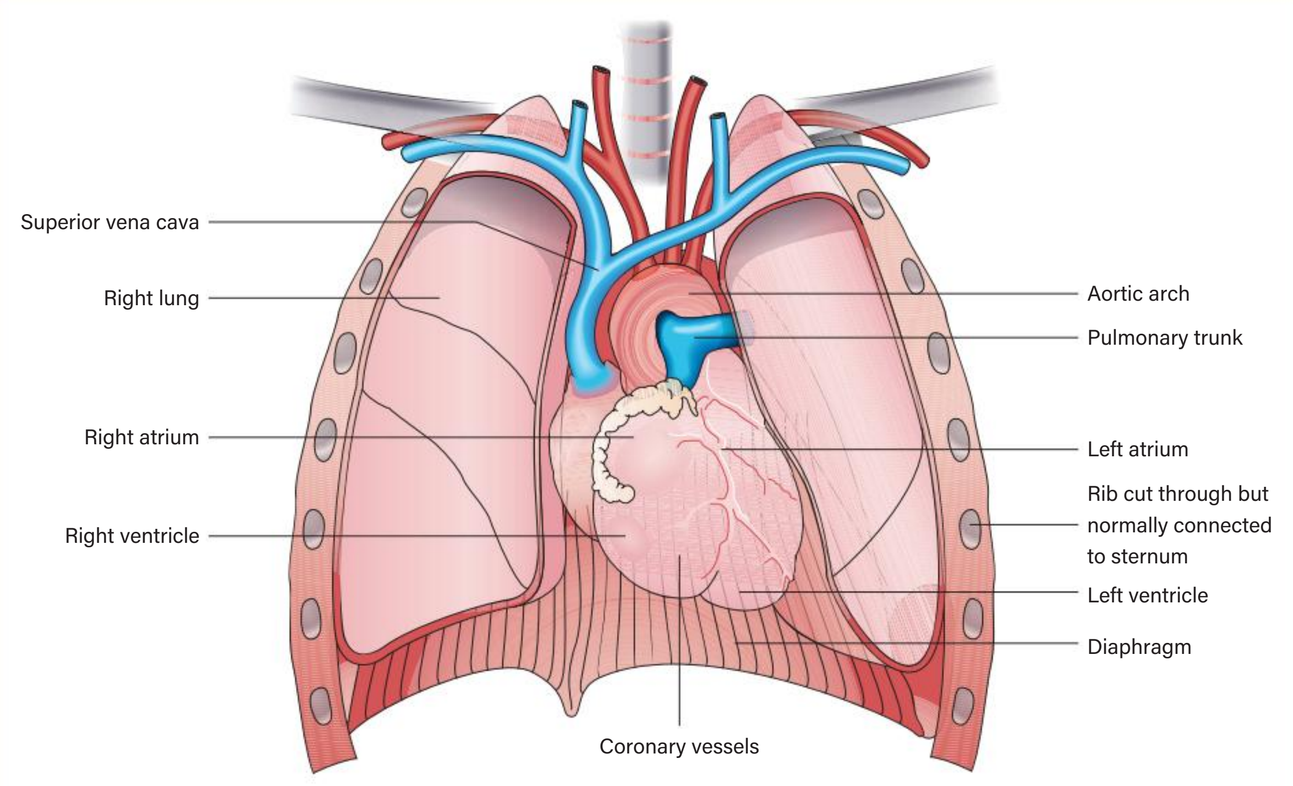


FIGURE 4.02 Location of the heart behind the sternum and its relationship to rib cage, lungs and diaphragm. Note that because the heart is a muscle, it has its own blood supply (coronary vessels, made up of arterioles and venules) and needs oxygen and fuel to function.

Structure and function of the heart

The heart is situated behind the sternum and is made up of four chambers:

- two upper chambers: the atria (singular: atrium)
- two lower chambers: ventricles.

The heart can be divided **transversely** into **superior** and **inferior** parts (atria and ventricles) and **sagitally** into left and right sides, divided by the septum.

On each side of the heart, blood is pumped from the atrium to the ventricle below it and then from the ventricle out of the heart. The heart also contains several one-way valves that ensure blood flows in the right direction through the heart. When the atria contract, the valves open, then when the ventricles contract, the valves close to prevent any 'backflow'. The bicuspid (or mitral) valve on the left side, between the atrium and the ventricle, is made up of two flaps, while the tricuspid valve on the right side is made up of three flaps. Sometimes these valves break down, but they can be replaced by artificial valves.

transversely
Divides the body or organ horizontally into upper and lower parts

superior
Describes a position above or higher than another part of the body

inferior
Describes a position below or lower than another part of the body

sagitally
Divides the body or an organ vertically into right and left sides

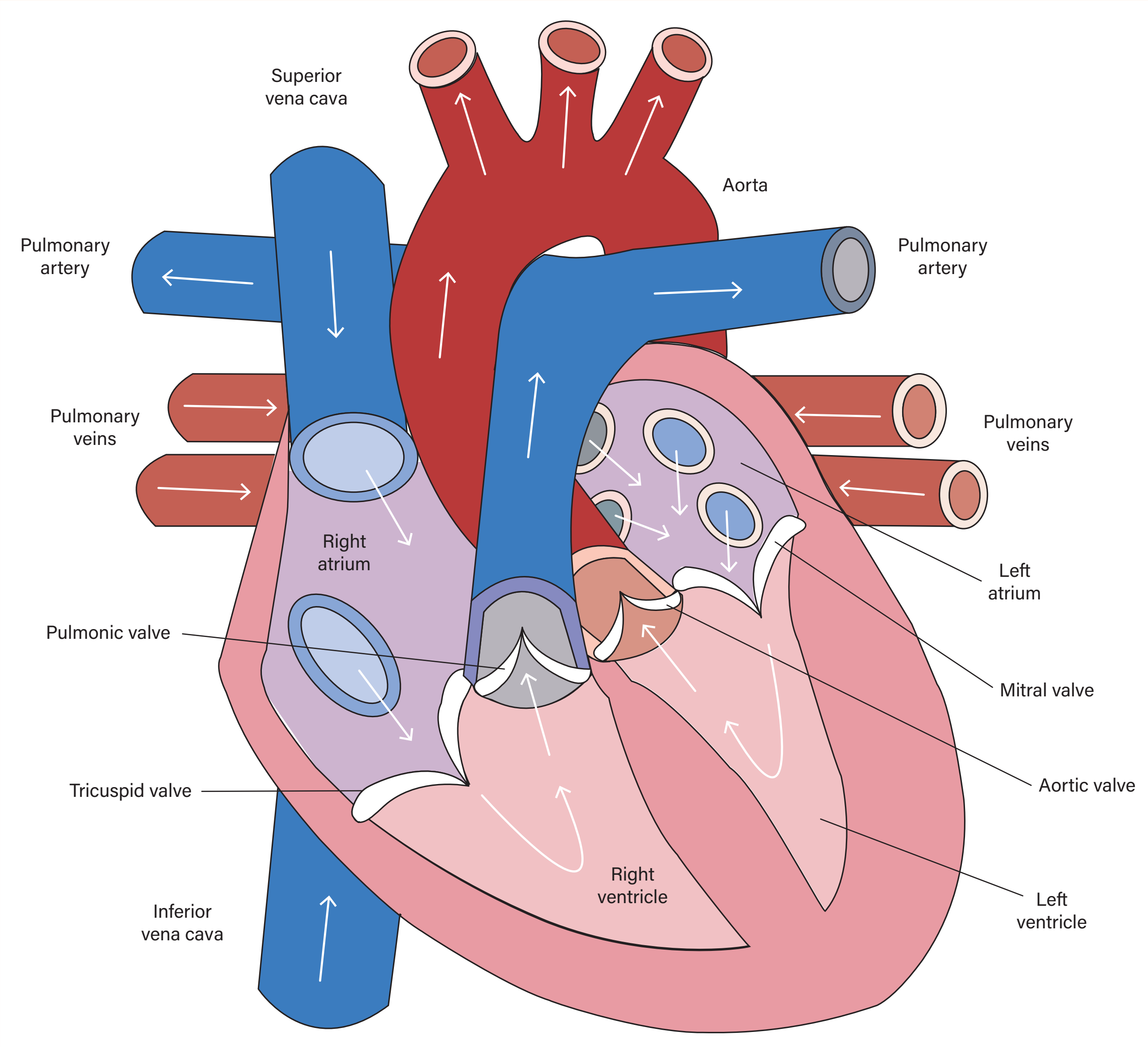


FIGURE 4.03 Structure of the heart showing the four chambers, multiple one-way valves and blood flow. **Note:** The blue section shows deoxygenated blood returning from the body to be pumped to the lungs to be oxygenated, as per the red section. Oxygenated blood then returns to the heart to be pumped out again.

DID YOU KNOW?

The heart is sometimes referred to as a 'double pump.' The left side pumps oxygen-rich blood to the entire body (systemic circulation), while the right side receives oxygen-poor blood and pumps this to the lungs to be re-oxygenated (pulmonary circulation).

LEARNING HACK

The table at right will help you understand what the roles of the different chambers of the heart are.

Right atrium Collects blood from the systemic circuit	**Left atrium** Collects blood from the pulmonary circuit
Right ventricle Pumps blood to the pulmonary circuit	**Left ventricle** Pumps blood to systemic circuit

The cardiovascular system

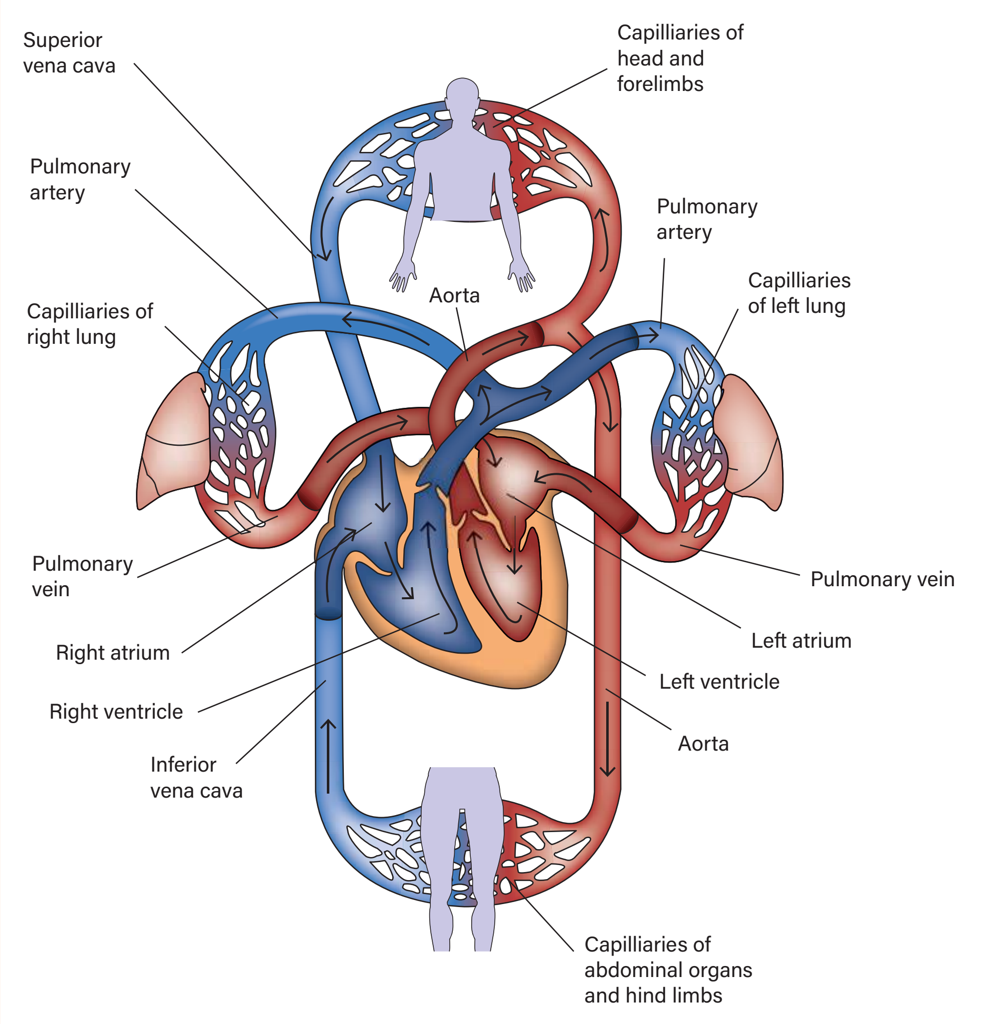


FIGURE 4.04 The cardiovascular system showing both the pulmonary and systemic circuits

Pulmonary circulation

Pulmonary circulation involves only the heart and lungs and the major blood vessels that connect them. Blood moves through the pulmonary circuit from the heart to the lungs and then back to the heart again, becoming oxygenated in the process. Specifically, the right ventricle of the heart pumps deoxygenated blood into the right and left pulmonary arteries. These arteries carry the blood to the right and left lungs, respectively. Oxygenated blood then returns from the lungs through the two right and two left pulmonary veins. All four pulmonary veins enter the left atrium of the heart.

pulmonary circulation
The closed circuit of vessels that transports de-oxygenated blood from the heart to the lungs

Blood sent to the lungs passes through increasingly small arteries, and finally through capillary networks surrounding the alveoli. This is where gaseous exchange takes place. The deoxygenated blood in the capillaries takes oxygen from the alveoli and gives carbon dioxide to the alveoli. As a result, the blood returning to the heart via the pulmonary veins is almost completely saturated with oxygen.

LOOKING FORWARD
Gaseous exchange
Chapter 5

In Chapter 5 you will look at how gaseous exchange occurs in more detail.

Systemic circulation

The oxygenated blood that enters the left atrium as part of pulmonary circulation then enters **systemic circulation**. This is the part of the cardiovascular system that transports blood to and from all the tissues of the body, providing oxygen and fuels and removing wastes.

systemic circulation
The closed circuit of vessels supplying oxygenated blood to and returning deoxygenated blood from the tissues of the body

The left atrium pumps oxygenated blood to the left ventricle, which pumps blood directly into the aorta, the body's largest artery. Major arteries branching off the aorta carry the blood to the head and upper body parts. The aorta also branches downwards to supply the lower parts of the body. The blood then returns to the heart through the network of increasingly large veins that make up the systemic circuit. All of the returning blood eventually collects in the superior vena cava (upper body) and inferior vena cava (lower body), which empty directly into the right atrium of the heart. This cardiac cycle then repeats.

The cardiac cycle

The cardiac cycle occurs when the heart beats. It is made up of two phases or parts:
- **systole** (contraction)
- **diastole** (relaxation).

systole
The period when the heart's ventricles contract and force blood out of the heart to the lungs and other body parts

diastole
The period when the heart relaxes and the both atriums fill with blood from the lungs and other body parts

Systole phase

Systole is the phase in which both ventricles contract. When the two chambers contract, the heart pumps blood out into the blood vessels moving away from the heart. As noted before, the right ventricle pushes blood to the lungs, while the left ventricle pushes blood into the aorta before being distributed to the rest of the body. During this phase, the contractions cause an increase in the pressure within the blood vessels.

Diastole phase

Diastole occurs when both ventricles relax. They fill with blood from each atrium, ready to pump out into the blood vessels when the cycle begins again. During this phase, no new blood is pumped into the blood vessels, and thus the pressure in the blood vessels is lower than during the systole phase. Systole and diastole phases continue repeating, and are referred to as the cardiac cycle.

Weblink
Blood flow through the heart in 2 minutes

SIGNPOST

To see the cardiac cycle and blood flow through the heart, watch the short video 'Blood Flow through the Heart in 2 Minutes' on the Neural Academy channel on YouTube.

DID YOU KNOW?

The average resting heart rate is between 60–70 beats per minute.

LOOKING FORWARD

The effect of systole and diastole phases on blood pressure

Units 3&4, Chapter 6

The effect of systole and diastole phases on blood pressure will be covered later on in this chapter. These acute cardiovascular responses to exercise will be addressed in Unit 3, when considering acute responses to exercise.

The blood vessels and blood

Blood vessels make up the vascular network through which all blood flows to all parts of the body, including the heart itself.

There are three major types of blood vessels:

- **arteries**: carry oxygen-rich blood away from the heart to the body
- **capillaries**: very small blood vessels that allow for the exchange of gases (oxygen and carbon dioxide), water, nutrients and waste products to and from the blood
- **veins**: carry blood (low in oxygen) back to the heart.

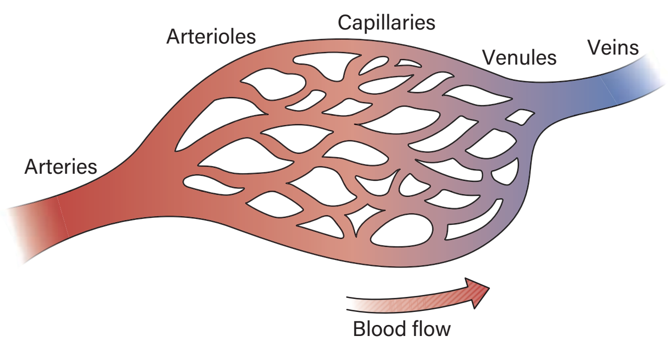


FIGURE 4.05 Blood flows through the blood vessels.

Arteries

Arteries are blood vessels that carry blood away from the heart. The walls of these vessels are elastic in nature, which allows them to expand and contract as the heart pumps blood through them. Further away from the heart, the size of these vessels decreases. The aorta subdivides many times into smaller arteries and arterioles until they become the smallest vessels, known as capillaries. Every time this division or 'split' happens, the cross-sectional area of the blood vessel increases, allowing for greater exchange of gases, nutrients, fuels and wastes.

The heart has its own set of arteries to supply it with blood, called the coronary arteries. The heart's powerful pumping action exerts pressure on the walls of the arteries as blood flows through them, causing them to expand. This rhythmic expansion and contraction of the blood vessels can be felt as the pulse (or heart rate), and it can be measured as blood pressure.

DID YOU KNOW?

The vascular network consists of arteries that branch into arterioles, which further branch into capillaries (the smallest blood vessels in the network). The capillaries then connect to venules, which then become veins. One-way valves keep blood flowing in one direction and prevent 'backflow.'

Blood pressure

Blood pressure is the force exerted by the blood against the blood vessel walls. Blood pressure in the arteries increases and decreases during the cardiac cycle. It is at its highest when blood is pumped into the aorta during ventricular systole, and at its lowest during ventricular diastole.

By the time blood reaches the capillaries, blood pressure is much less than when it travelled through the coronary (heart) arteries. Systolic blood pressure is experienced when blood is pumped from the heart, and diastolic blood pressure is experienced when the heart relaxes and fills with blood.

prehypertension
Occurs when blood pressure is high, but not high enough to be considered hypertension. Regular monitoring is recommended, and strategies to reduce this should be considered

Blood pressure is typically measured using a sphygmomanometer or digital blood pressure recorder. A typical reading for adults at rest is $\frac{120\text{ mmHg}}{80\text{ mmHg}}$, where mmHg stands for millimetres of mercury. A systolic pressure of 120–140 mmHg or a diastolic pressure of 80–90 mmHg is considered to be **prehypertension**, and needs to be monitored on a regular basis. Similarly, when blood pressure is lower than 120 over 80, possible reasons need to be considered and investigated. Doctors often recommend aerobic-based exercise for patients who have high blood pressure. Medication might also be suggested, depending on the risk the elevated blood pressure is thought to present.

Halfpoint/Adobe Stock

FIGURE 4.06 Blood pressure can be measured using a sphygmomanometer.

LOOKING FORWARD

Health risks of performance-enhancing practices and physical inactivity

Chapter 6 and Chapter 9

Chapter 6 investigates legal and illegal performance-enhancing practices and their effects on the cardiorespiratory system. There, you will learn about beta-blockers, which are used to lower blood pressure.

In Chapter 9 you will consider the health risks associated with being physically inactive. Higher blood pressure is often associated with inactivity.

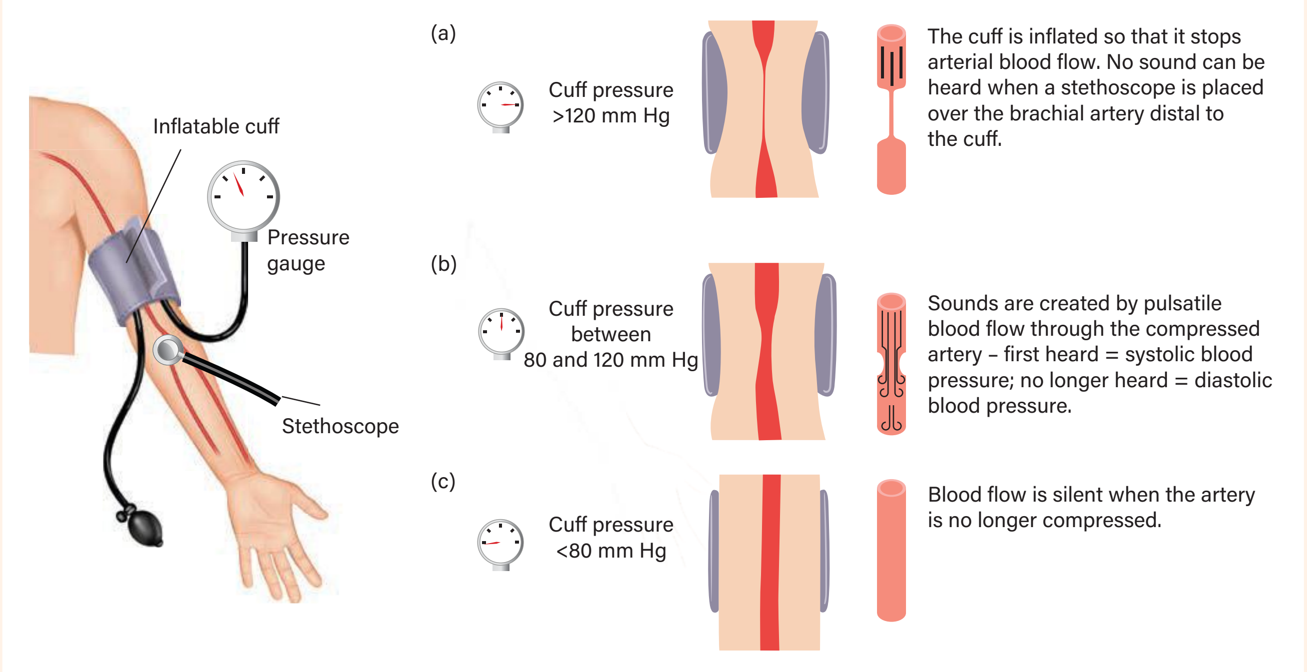


FIGURE 4.07 Manual blood pressure measurement using a sphygmomanometer

Capillaries and veins

As mentioned previously, arteries feed into arterioles, which eventually become capillaries – the smallest blood vessels in the vascular system. These vessels are thin enough to allow the products carried within the blood to be exchanged among the surrounding muscle cells and tissues. These products include:

- nutrients and fuel sources derived from food
- oxygen
- carbon dioxide
- waste products
- metabolic by-products.

As waste products and carbon dioxide collect in the capillaries, many capillaries come together and form larger vessels to transport the blood back to the heart. These larger vessels are the veins.

Venules collect blood from the capillaries and return it to the heart via veins. Veins do not have the same elasticity as arteries, so muscular contractions help them return blood to the heart. Because of this, and the fact that they transport blood further away from the heart, the blood pressure in these vessels is much lower than in arteries. Veins all carry low-oxygen blood back to the heart, where the cardiac cycle then repeats itself.

venules
The smallest veins that transport blood from capillaries into larger veins

SIGNPOST

To better understand the similarities and differences found in the three different blood vessels, watch the video, 'Blood Vessels: Type of Vessels' on the Aasoka channel on YouTube.

Weblink
Blood vessels

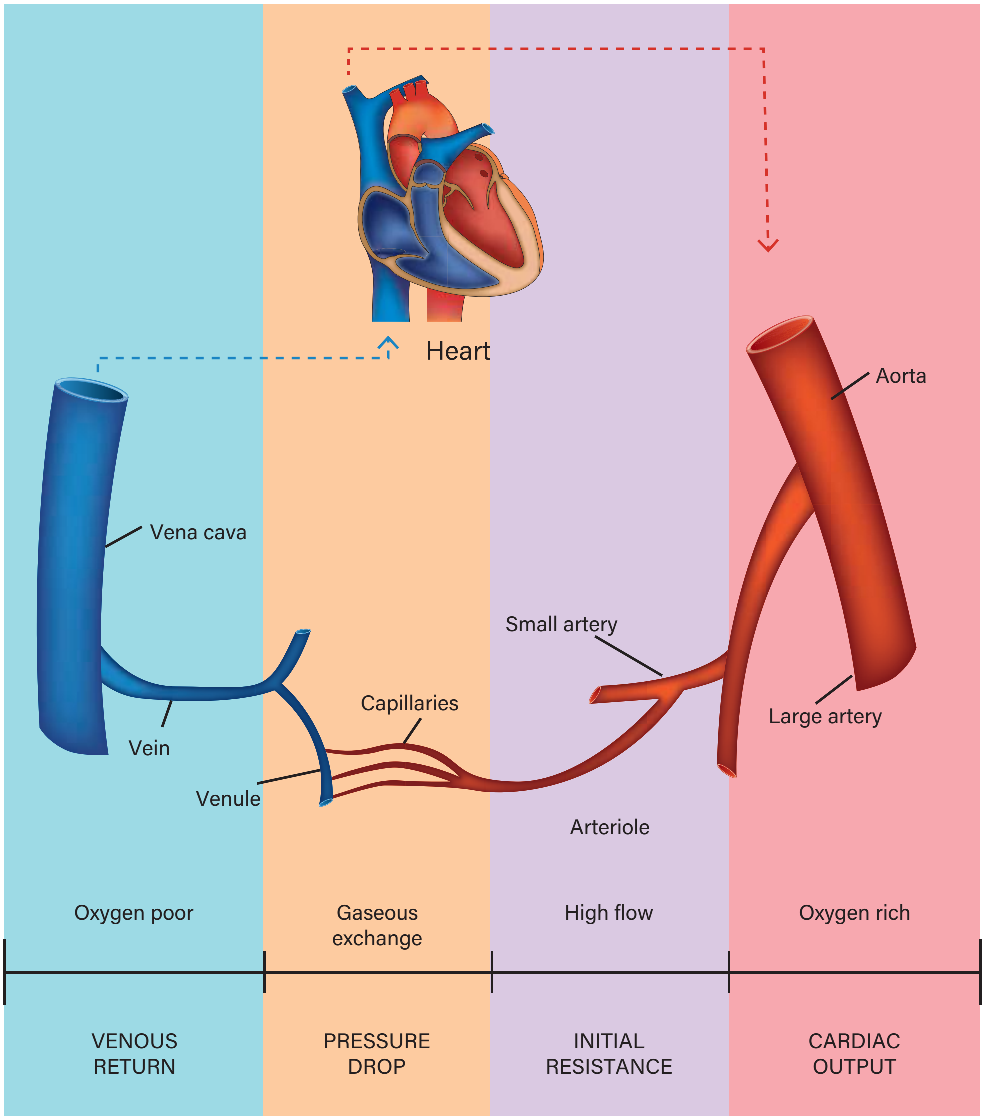


FIGURE 4.08 The structure and function of different types of blood vessels in the cardiovascular system

vascular shunt mechanism
The redistribution of blood in response to the demands of physical activity

Blood flow through capillaries is controlled by minute structures called precapillary sphincters. These bands of smooth muscle encircle each capillary branch at the point where it branches from the arteriole. Forceful contraction of the precapillary sphincter can close the branches off to blood flow while others open elsewhere. In this way, more blood is sent to working muscles and less to major organs as exercise intensifies (see Figure 4.09). This leads to more oxygen and fuels being transported to meet the demands of working muscles. Higher intensities are associated with increased blood flow to muscles and decreased blood flow to other parts of the body. This mechanism, known as the **vascular shunt mechanism**, will be discussed in more detail in Module 4.2.

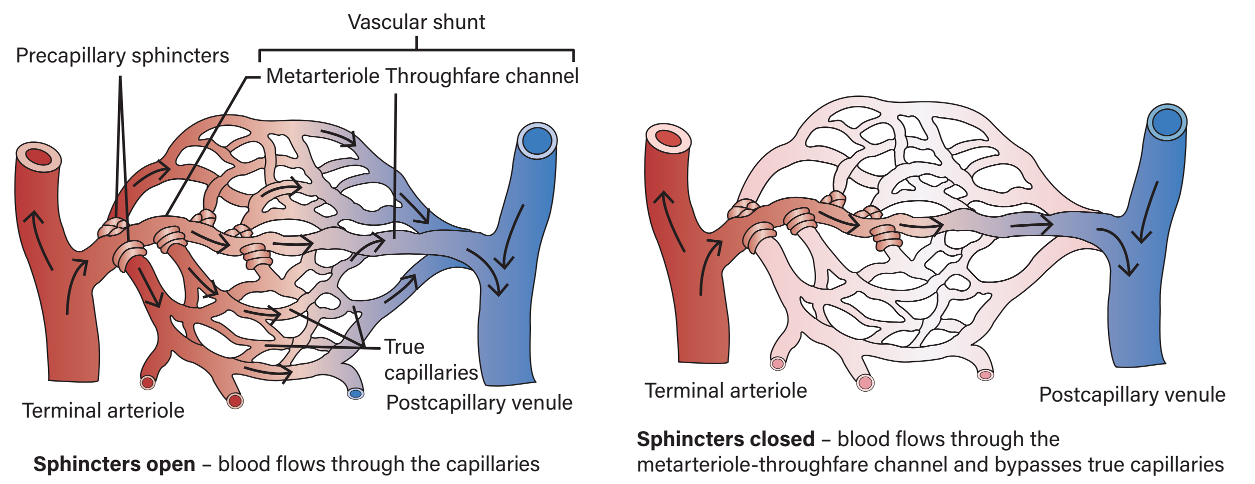


FIGURE 4.09 Vasoconstriction results in less blood moving through capillaries and more blood being redirected to areas where vasodilation is occurring, resulting in more oxygen and fuels being supplied, and wastes being removed.

DID YOU KNOW?

It takes approximately 20 seconds for a blood cell to circulate around the entire body at rest. Blood makes up around 8 per cent of your total body weight.

TABLE 4.1 Comparing the characteristics and functions of the three major blood vessels

Characteristic/Function	Artery	Capillary	Vein
Blood flow direction	Away from the heart	From arteries to veins	Towards the heart
Wall structure and thickness	Three thick layers, highly elastic and thick	Single layer and very thin = one cell	Three thin layers, not very elastic
One-way valves	Absent	Absent	Present to assist venous return
Oxygen transport	Transports oxygenated blood (except for pulmonary artery)	Oxygen exchanged for carbon dioxide at muscles and cells	Transports deoxygenated blood (except pulmonary vein)
Blood pressure	High	Reduces with flow from arteriole to venule	Low

The composition and functions of blood

Blood consists of many components in two broad categories: plasma (55 per cent) and blood cells (45 per cent).

Red blood cells

Red blood cells give blood its colour. They are produced in bone marrow (mainly in bones such as the sternum, ribs and vertebrae). They contain the protein haemoglobin, which carries oxygen to body tissues and muscles. Women have slightly lower **haemoglobin** levels than men.

haemoglobin
A vital protein in red blood cells that carries oxygen and carbon dioxide throughout the body

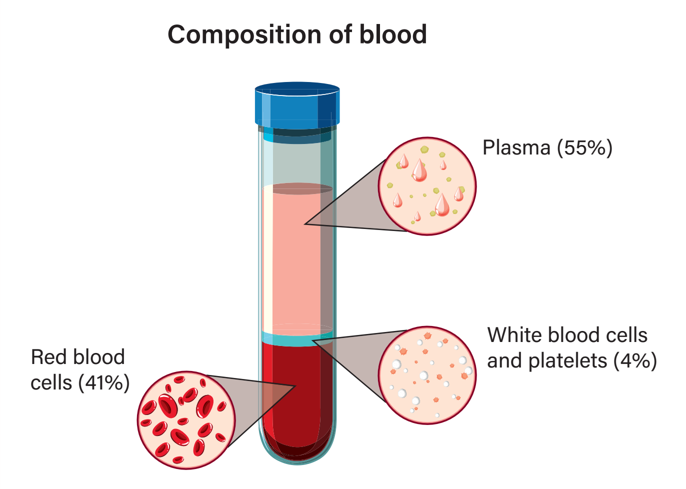


FIGURE 4.10 The composition of blood

White blood cells

White blood cells fight infection by absorbing and digesting disease-causing organisms. They are produced in bone marrow, lymph tissue and the spleen.

Platelets

Platelets are cells that help form blood clots to stop bleeding. They are produced in bone marrow.

Plasma

Blood plasma is a clear yellowish fluid that carries nutrients. It also transports waste products and assists with their removal from the body. Plasma is 90 per cent water, which counters dehydration, but it also contains the protein fibrinogen, which assists platelets in blood clotting.

TABLE 4.2 The different components of blood

	Function(s)
Red blood cells (erythrocytes)	• Carry oxygen to working muscles and other cells and remove carbon dioxide • Red blood cells contain haemoglobin, a respiratory pigment that binds to either oxygen or carbon dioxide. This allows oxygen to be transported around the body to tissues and organs and carbon dioxide to be taken away
White blood cells (leucocytes)	• Form a major part of the immune system
Platelets (thrombocytes)	• Facilitate blood clotting – the purpose of which is to prevent loss of body fluids
Plasma	• The medium in which the blood cells are transported around the body (by the blood vessels) and are able to operate effectively • Helps maintain optimum body temperature • Helps control the pH of the blood and the body tissues, maintaining this within a range at which the cells optimally function • Helps maintain an ideal balance of electrolytes in the blood and tissues of the body • Removes wastes from the body

DID YOU KNOW?

Red blood cells contain haemoglobin molecules. One haemoglobin molecule can bind with up to four oxygen molecules, forming what is known as oxyhaemoglobin. This is how oxygen is transported to working muscles.

LOOKING FORWARD

Legal and illegal practices to improve performance

Chapter 6

In Chapter 6 you will discover how endurance athletes such as triathletes and road cyclists try to illegally increase their red blood cell count in an effort to improve their performance. You will also be presented with many legal ways to improve endurance performance.

SIGNPOST

Take a minute to view this great summary of the vascular system and components of blood in the video 'The Components of Blood and Their Importance' on the American Society of Hematology channel on YouTube.

Weblink
Components of blood and their importance

DID YOU KNOW?

Adult males have approximately 5–6 litres of blood in their bodies, and adult females have approximately 4–5 litres. Highly aerobically trained endurance athletes such as cross-country skiers and triathletes can have up to twice as much blood as sedentary individuals.

Functions of blood

Blood has many roles and functions in the human body. It is responsible for:

- transportation of gases, fuels and minerals
- protection against dehydration
- maintaining equilibrium (**homeostasis**) via enzyme and hormone regulation
- **thermoregulation**
- carrying cells and antibodies that fight infection
- bringing waste products to the kidneys and liver, which filter and clean the blood.

Blood transports oxygen from the lungs and heart to working muscles and cells, and then removes **metabolic by-products** such as carbon dioxide from muscle sites. It also transports fuels such as glucose to working muscles and removes lactate that might be produced under anaerobic conditions. It protects the body by moving white blood cells to sites of infection, and platelets to areas that need blood flow stopped and clotted in order to limit haemorrhaging, loss of blood and cell damage.

Blood also carries enzymes and chemicals to areas where metabolic processes require them – especially for maintaining a constant pH. It regulates temperature and maintains homeostasis by moving heat away from working muscles to other areas of the body, including the skin's surface. As you can see, blood is very important in about achieving peak performance during physical activity.

In summary, the plasma and red blood cell components of blood work together to ensure that nutrients, hormones and proteins are transported to where they are needed. They are also important in the removal of wastes from cells. Red blood cells contain a special protein called haemoglobin, which helps carry oxygen from the lungs to the rest of the body and then returns carbon dioxide from the body to the lungs so it can be exhaled.

homeostasis
A physiological process that keeps the body's internal environment stable and balanced

thermoregulation
A process that allows your body to maintain its core internal temperature. All thermoregulation mechanisms help return your body to homeostasis. This is a state of equilibrium

metabolic by-products
Metabolic wastes left over from metabolic processes (such as cellular respiration) that cannot be used (they are surplus or toxic), and must be excreted

The plasma and red blood cells respond to increased demands during exercise, transporting gases, fuels, hormones and enzymes as required, and also helping with the removal of wastes. White blood cells and platelets are less important during exercise and sport, but are vital to ensuring our immune system functions properly. They also minimise fluid loss via bleeding by helping with the clotting process.

Assessment
4.1 Check-in questions

Command term

identify
Recognise and name and/or select an event, feature, ingredient, element, speaker and/or part from a list or extended narrative or argument, or within a diagram, structure, artwork or experiment

4.1 CHECK-IN QUESTIONS

1 The pulmonary artery, like other arteries, carries blood away from the heart. **Identify** a major difference between the pulmonary artery and other arteries in the body.
2 Consider why males, who have more blood than females, are able to perform better in endurance events such as a marathon. Your response should focus on the vascular system only.
3 What roles do valves have in the cardiovascular system? **Discuss** why veins are the only blood vessels that have one-way valves.
4 Why is it important that capillaries are only one cell thick and not larger?

4.2 THE CARDIOVASCULAR SYSTEM DURING REST AND VARIOUS EXERCISE INTENSITIES

In this module you will learn about:
- blood flow at rest and various intensities
- cardiac output in relation to exercise intensity
- redistribution of blood to meet exercise demands

and learn to:
- link cardiovascular responses to exercise demand/intensity
- collect data and consider practical links to coursework covered in class.

Video
In focus: Cardiac output at rest and various exercise intensities

Gorodenkoff/Shutterstock.com

FIGURE 4.11 Running on a treadmill creates changes in the cardiovascular system.

When we exercise, play sports or are involved in physical activities, many physiological changes take place to ensure muscles receive sufficient oxygen and fuels to meet the activity demands. Blood vessels are able to dilate (widen) and constrict (narrow) to redirect the flow of oxygenated blood to working muscles and away from non-essential organs and sites. Because the cardiovascular system is what is known as a 'closed circuit', whenever blood vessels dilate in one part of the body, they simultaneously constrict somewhere else.

Cardiac output

Stroke volume is a measure of how much blood is squeezed out of the heart into the aorta each time it beats – in other words, per systole (think of systolic blood pressure). The average adult stroke volume at rest is between 70 and 90 millilitres. As you start to exercise, the demand for oxygen and fuels increases. The heart responds by pumping more forcefully and frequently. More blood is squeezed out per beat, so the stroke volume increases. In adults, stroke volume typically increases by 40 per cent when maximum exercise levels are reached (see Table 4.3 on p. 144).

Cardiac output is the amount of blood pumped out of the heart per minute, and is easily calculated:

Cardiac output (Q) = stroke volume × heart rate

At rest, cardiac output might be 80 mL × 60 bpm = 4800 mL/min, or 4.8 L/min. At maximal exercise, cardiac output might increase to be 130 mL × 200 bpm = 26 000 mL, or 26 L/min.

stroke volume
The volume of blood pumped out of the left ventricle of the heart during each systolic cardiac contraction

cardiac output
The volume of blood pumped out of the left ventricle per minute. The symbol for cardiac output = Q and it is the product of heart rate (HR) and stroke volume (SV)

heart rate
Sometimes referred to as 'pulse'; the number of times your heart beats per minute

contractility
The contractile function of the ventricles, in particular the left ventricle, which pumps blood to all parts of the body (except the lungs)

DID YOU KNOW?

Maximal heart rate can be roughly calculated by subtracting a person's age from 220.

Maximum HR = 220 – age

However, this does not take into account other variables such as sex, training status and body composition. The only way to accurately determine a person's maximum heart rate is to have them undertake a 'stress test.' This is done under controlled conditions in a laboratory or sports science facility and supervised by qualified staff with medical assistance on hand.

The graph in Figure 4.12 clearly shows that stroke volume reaches its maximum at around 50–60 per cent of maximal **heart rate**, but when the heart rate keeps increasing to meet exercise demands, cardiac output increases. In other words, stroke volume has a finite capacity or limit that is reached well before maximal efforts are reached. Think of it this way: while performing at a comfortable pace, your stroke volume may have already reached its capacity. However, when you increase your pace and need to send more blood, fuels and oxygen to working muscles, even though your stroke volume can't increase any further, the heart can increase both its rate of contraction (frequency) and force of contraction (**contractility**). It is worth noting that there is a linear relationship between exercise intensity and both cardiac output and heart rate.

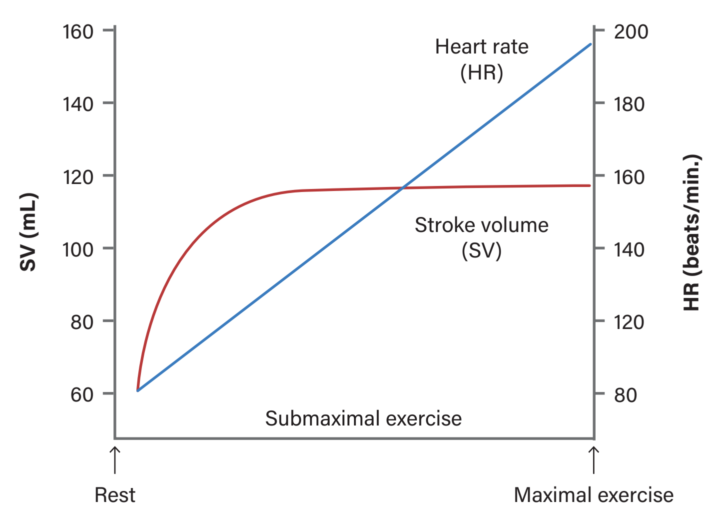


FIGURE 4.12 Heart rate and stroke volume responses to increased workloads

TABLE 4.3 Heart rate, stroke volume and cardiac output for untrained, trained and endurance athletes

	Untrained athletes	Trained athletes	Endurance athletes
Heart rate (bpm)			
At rest	60–65	50–55	45–50
Stroke volume (mL)			
At rest	80	110	125
At maximal exercise	120	130	190
Cardiac output (L/min)			
At rest	4.8	6.0	6.5
At maximal exercise	20	30	45

LOOKING FORWARD
Cardiovascular responses to exercise

Units 3&4 – Chapters 5 and 15

In Units 3&4 VCE Physical Education you will learn about other cardiovascular responses to exercises (Chapter 5), as well as how the body adapts to training (Chapter 15). Training brings about long-term changes, or adaptation, which are associated with improved performance.

COLLABORATIVE TASK
Prac activity

Heart rate response to exercise

AIM

To collect and analyse data relating to the range of acute effects that physical activity has on the cardiovascular system.

EQUIPMENT

For each group of students, you will need a heart-rate monitor (smart watch with digital readout is okay) and a metronome capable of being set at 30, 40 and 50 bpm. TempoPerfect is a free software metronome also available as a free iPhone app.

METHOD

There is a lag associated with heart-rate monitoring; that is, someone could be working maximally, but this won't show on the heart rate monitor immediately, if at all. For this laboratory activity, the rate of perceived exertion (RPE) will be used as an additional indicator of intensity and work rate.

Rate of perceived exertion	Description
0	No exertion at all
1	Very light exercise, very easy
3	Moderate, feels fine, no problems continuing with exercise
5	Heavy, it feels hard, but there's no great problem continuing
7	Very hard and very strenuous; need to push to keep up
10	Max, extremely strenuous, probably the most strenuous experienced

>

1 Students will ideally work in groups of two – one will be the subject, the other will monitor correct adherence to the tempo required, as well as recording heart rate and RPE at each stage/minute. **Roles will be swapped for each member.** Record the subject's pre-exercise levels for heart rate.

2 Subjects will be required to complete three minutes of step-ups onto a bench/seat at approximately knee height at each of 30 bpm, 40 bpm and 50 bpm as set on the metronome. Record heart rate as well as rate of perceived exertion every minute for the duration of the test, including four minutes of passive recovery from the activity.

Complete the nine minutes of continuous step-ups followed by four minutes of passive recovery and then record all parameters in a table, as shown below. This data should be processed/graphed.

Time	Step-up rate (bpm)	Heart rate	RPE
Pre-exercise	0		0
1 min	30		
2 min	30		
3 min	30		
4 min	40		
5 min	40		
6 min	40		
7 min	50		
8 min	50		
9 min	50		
Recovery			
1 min			
2 min			
3 min			
4 min			

DISCUSSION

1 **Discuss** any relationship between heart rate, exercise intensity (step rate) and rate of perceived exertion.

2 Is there any evidence that steady state (when oxygen supply equals oxygen demand) has occurred during the step-up test? **Discuss** why this has or has not been achieved during the test, and how the cardiovascular system contributes to this.

3 **Compare** your recovery heart rate to that of another classmate and discuss why any differences might exist in the rate at which heart rate returns to pre-exercise levels.

4 **Identify** the stage of the step-up test where you believe stroke volume has reached its finite capacity. What occurs at this stage?

Template
Heart rate response to exercise test

Redistribution of blood during exercise

With the onset of exercise, the brain quickly decides where to send more blood and where to send less. Blood that would have gone to the stomach, kidneys or other vital organs gets redirected to the muscles. As exercise commences, the sympathetic nervous system stimulates the nerves to the heart and blood vessels, causing those blood vessels to contract or constrict. This is known as vasoconstriction. Vasoconstriction reduces blood flow to tissues.

Our muscles also get the signal to vasoconstrict, but the metabolic by-products produced within the muscles override this command and cause vasodilation, a widening or opening of the blood vessels. Because the rest of the body gets the message to constrict the blood vessels while the muscles dilate theirs, blood flow from non-essential organs such as the stomach, intestines and kidney is diverted to working muscle. This helps increase the delivery of oxygenated blood and fuels to working muscles, and increases the rate at which wastes can be removed.

Weblink
Vasoconstriction and vasodilation

SIGNPOST

View the short video 'Vasoconstriction and vasodilation' to discover how vasodilation and vasoconstriction are called upon to bring about multiple functions throughout our body. You can watch the video on the Bio20 Norquest channel on YouTube.

Blood flow at rest and exercise

Earlier we learnt about the vascular shunt mechanism that occurs when blood is redirected to parts of the body that need it most during exercise. In the next module we will unpack how this process helps with thermoregulation.

Figure 4.13 reveals where blood flows during rest, and contrasts this to near maximal exercise, where the demands for oxygen and fuels are greatest in working muscles. Just as there is a direct relationship between heart rate and exercise intensity, a correlation also exists between blood flow to working muscles and exercise intensity.

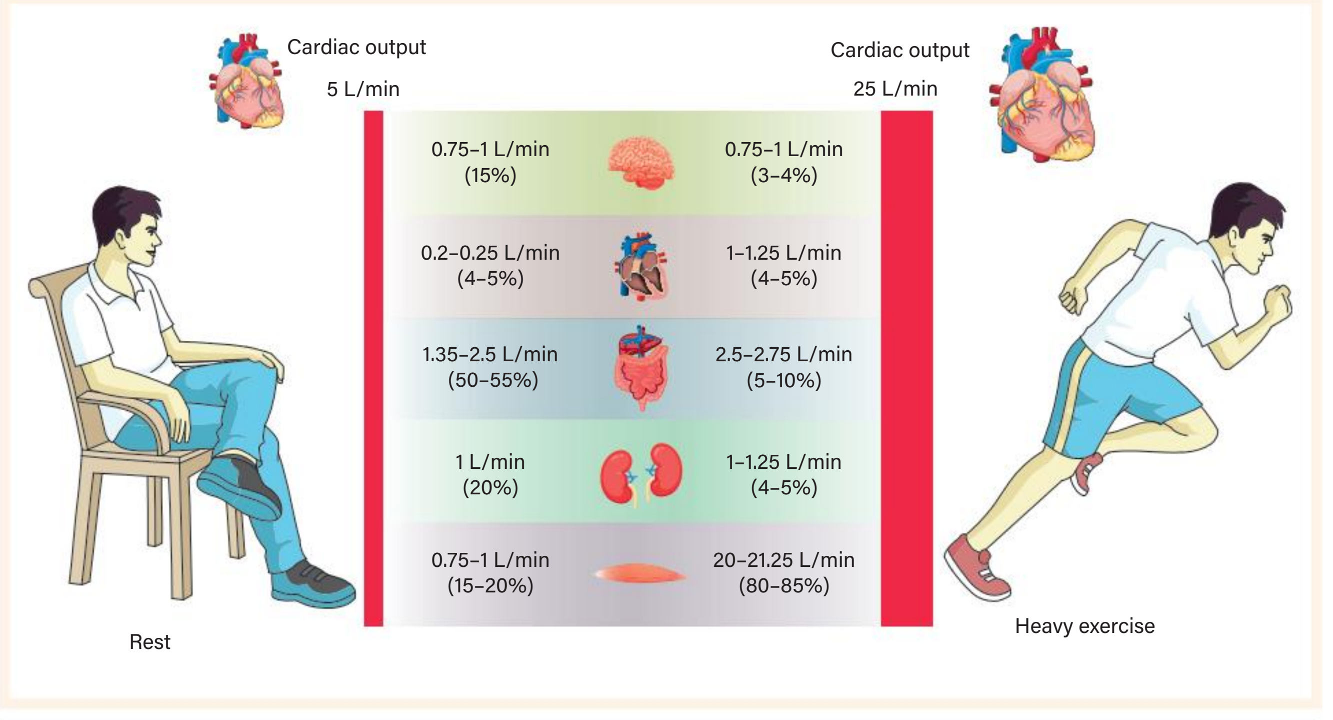


FIGURE 4.13 The redistribution of blood during heavy exercise

Source: Adapted from Taylor, J.A., et al. (2023). Multisystem physiological perspective of human frailty and its modulation by physical activity. *Physiological Reviews*, 103(2), 1137–1191.

COLLABORATIVE TASK

Prac activity

Heart rate and blood pressure

AIM

To investigate heart rate and blood pressure response during rest and exercise for different class members.

EQUIPMENT

Exercise bike (Repco, Monarch or similar), blood-pressure monitor (preferably electronic) or sphygmomanometer, heart-rate monitor (manual readings are acceptable) or smart watch with digital heart rate monitoring capability

Note: It is important to have the subject seated so the blood pressure can be measured with relative ease and heart rate recorded using a smart watch (the measurement instrument most likely to be used).

METHOD

1 Divide the class (wherever practical) into two groups, according to the kind of exercise they do in their daily lives:
   - Group 1 – students involved in no training
   - Group 2 – students involved in regular aerobic training.

2 Work in pairs. One student takes a comfortable seated position on the exercise bike and has their resting blood pressure and heart rate recorded by the other student. The student on the bike starts pedalling. Once they have reached a workload of 75 watts, they maintain an even pace for three minutes. Their heart rate and blood pressure are recorded over the last 15 seconds of this three-minute period. Then, over the next minute, the student should slow their pedalling rate down to stationary.

3 Record the heart rate and blood pressure at the end of the first minute of 'cool-down', and then again at the three-minute mark of rest/recovery.

4 Repeat steps 2 and 3 for a workload of 300 watts.

5 Use a table similar to the one shown here to record your results. A blank table can be found on Nelson MindTap, which can be reproduced and used by classes conducting this laboratory.

	Workload	
	75 watts	300 watts
Heart rate		
Resting		
End of three-minute exercise period		
First minute of recovery		
Third minute of recovery		
Systolic blood pressure		
Resting		
End of three-minute exercise period		
First minute of recovery		
Third minute of recovery		

Template
Heart rate and blood pressure test

	Workload	
	75 watts	300 watts
Diastolic blood pressure		
Resting		
End of three-minute exercise period		
First minute of recovery		
Third minute of recovery		

6 Share the heart/pulse rates for the class. Construct two graphs, one for each workload, showing the effect exercise has on both heart rate and blood pressure for each member of the different groups.

Discussion

1 What is the relationship between systolic blood pressure and exercise intensity? Does the same relationship exist for diastolic blood pressure? **Discuss**.

2 Are there any differences in either heart rate or blood pressure response to the different workloads between students in each of the two groups?

3 During recovery, which group took the longest for heart rate and blood pressure to return to resting levels? How do you account for this difference?

Assessment
4.2 Check-in questions

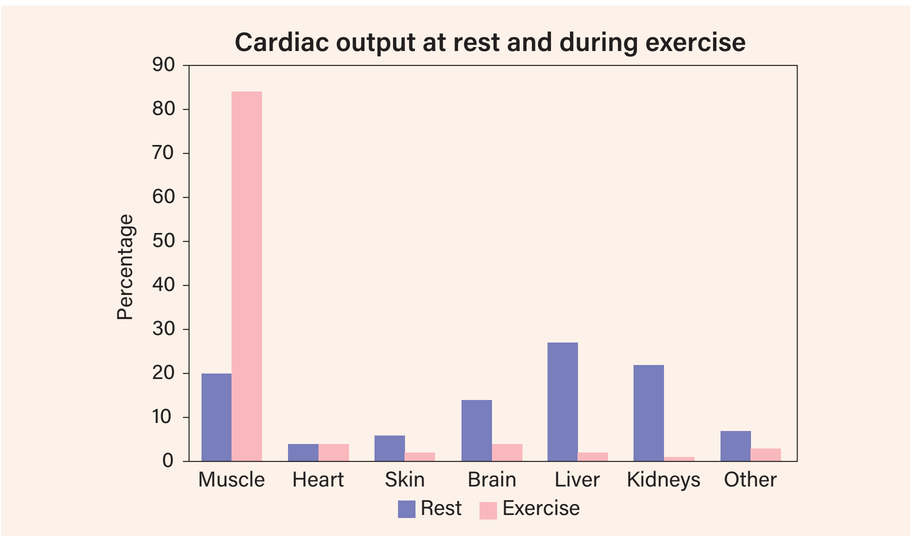
outline
Provide an overview or the main features of an argument, point of view, text, narrative, diagram or image

4.2 CHECK-IN QUESTIONS

1 **Outline** the relationship that exists between exercise intensity and heart rate, and discuss when heart rate remains unchanged during exercise.

2 Referring to the formula for cardiac output, **discuss** why someone with a larger stroke volume is likely to have a lower resting heart rate than those who have smaller stroke volumes.

3 At the start of exercise there is a redistribution of blood flow away from organs to the working muscles, as shown in the graph below.



a By referring to the data in the graph, **explain** why a redistribution of blood flow is needed during exercise. (3 marks)

b **Explain**, physiologically, how this redistribution takes place. (2 marks)

4 **Explain** how the vascular shunt mechanism works in redistributing blood that leaves the heart in response to exercise. Your response should contain the terms 'vasodilation' and 'vasoconstriction'.

4.3 THE CARDIOVASCULAR SYSTEM ASSISTING THERMOREGULATION

In this module you will learn about:
- homeostasis and thermoregulation
- hyperthermia and hypothermia

and learn:
- how various mechanisms try to regulate body heat so it remains constant.

thermoreceptors
Specialised sensory receptors, primarily found in the skin, that detect changes in temperature and play a crucial role in our perception of hot and cold sensations

The word homeostasis means 'same state', and refers to the process of keeping the internal body environment in a steady state. Temperature homeostasis, known as thermoregulation, is controlled by the thermoregulatory centre in the hypothalamus. It receives input from two sets of **thermoreceptors**. Receptors in the hypothalamus itself monitor the temperature of the blood as it passes through the brain (the core temperature), and receptors in the skin (especially on the trunk) monitor the external temperature. Both sets of information are needed so that the body can make adjustments as required. The thermoregulatory centre sends impulses to several different effectors around the body to adjust body temperature.

Thermoregulation

Thermoregulation refers to the body's efforts to maintain its optimum operating temperature of around 37°C. Thermoregulation involves the body's ability to dissipate heat and its ability to gain and reduce the loss of heat in the following ways:
- radiation
- evaporation
- conduction
- convection.

Radiation is energy transferred when heat passes from the blood vessels to the skin and across the air space above the skin.

Evaporation is the conversion of a liquid to a gas. Evaporation of sweat is the method used by the body to cool itself and keep it within its proper operating temperature.

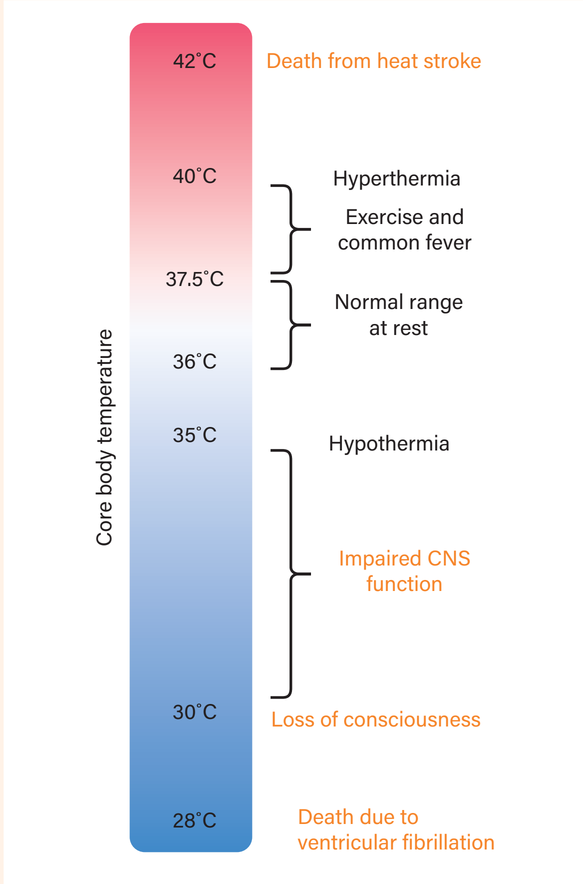


FIGURE 4.14 Variations to core body temperature and associated body responses

Source: Adapted from Kuht, J. & Farmery, A.D. (2014). Body temperature and its regulation. *Anaesthesia & Intensive Care Medicine*, 15(6), 273–278.

Video
In focus: Thermoregulation

Weblink
Olympic Marathon Trials: How the hydration stations work

Conduction is the transfer of thermal energy between two solids in contact with each other. Consider how an ice-vest is used to cool sportspeople performing in hot environments during breaks in play.

Convection occurs when heat is transferred by the circulation of a fluid (e.g. water) or gas (e.g. air). You may have experienced this when pouring water over your body, or standing in front of a fan to cool down.

REAL WORLD APPLICATIONS

The next time you see competitors in a marathon going through a drink station, take a close look at what the runners do with their containers. Some of them consume the liquids, which can either be water or an electrolytic drink, while others pour water over their head and body. These different practices aim to rehydrate and cool the body respectively, in an effort to thermoregulate.

To find out more about the hydration logistics organisers face when planning for a marathon and the different practices runners adopt to maximise their performance, read the article, 'Olympic Marathon Trials: how the hydration stations work' on the Runners World website.

Jonathan Moore/Getty Images

FIGURE 4.15 Maintaining hydration is essential in athletic events such as marathons.

Heat exchange at the skin

The most common methods our body uses to regulate heat exchange occur between the skin and the environment. The two mechanisms of heat exchange inside our body are:

- tissue conductive heat transfer
- vascular convective heat transfer.

Heat conductance through tissues in the human body is a very slow process, and is primarily dependent upon a temperature gradient between muscle and skin. This type of heat exchange is particularly important during exercise in cold environments, which produces a large temperature gradient between deep muscle and the skin. When there is no temperature gradient between muscle and surrounding skin, such as during exercise in warm environments, heat conductance does not occur.

Hypothermia and hyperthermia

Hypothermia and **hyperthermia** are conditions that occur when body mechanisms are overwhelmed and the hypothalamus is trying to bring the body back to normal. Hypothermia occurs when the core temperature of the body falls below the minimum temperature required to maintain basic metabolic functions. When the body gains more heat than it loses, this is called hyperthermia.

As discussed previously, the brain can 'instruct' the vascular system to redirect blood in order to maximise performance. Sometimes the brain decides the body needs to retain heat in colder environments, or needs to give off heat in hotter environments. It is more common for athletes to thermoregulate by trying to lose heat than it is by trying to maintain or gain it.

The body can become overheated in moderate temperatures as a result of repeated muscle contractions, as is the case in endurance-based activities and events. Becoming dehydrated, coupled with decreased plasma levels, further adds to the heat load placed on the body. The brain will sense this and try to cool down quickly and efficiently.

hypothermia
Low body temperature; a condition that occurs when body temperature drops below 35°C

hyperthermia
An elevated core temperature which is greater than 38.5°C

TABLE 4.4 The way the body maintains, decreases or increases core temperature and associated physiological responses

<table>
<tr><th colspan="8">Core temperature of blood</th></tr>
<tr><td colspan="3">Decrease</td><td rowspan="3">↓
↓</td><td rowspan="3">↑
↑</td><td colspan="3">Increase</td></tr>
<tr><td colspan="3">Hypothermia</td><td colspan="3">Hyperthermia</td></tr>
<tr><td colspan="3">Mild hypothermia: 32–35°C
Moderate hypothermia: 28–31°C
Severe hypothermia: Lower than 28°C</td><td colspan="3">Heat cramps: 36–37°C
Heat exhaustion: 37–40°C
Heat stroke: Higher than 40°C</td></tr>
<tr><td colspan="3">↓</td><td colspan="2">Hypothalamus = 'thermostat'</td><td colspan="3">↓</td></tr>
<tr><td colspan="4">Heat conversion responses</td><td colspan="4">Heat loss responses</td></tr>
<tr><td>↙</td><td>↓</td><td>↓</td><td>↘</td><td>↙</td><td>↓</td><td>↓</td><td>↘</td></tr>
<tr><td>Vasoconstriction</td><td>Decreased heart rate</td><td>Shivering</td><td>Body hair lowered</td><td>Vasodilation</td><td>Increased heart rate</td><td>Sweating</td><td>Body hair raised</td></tr>
<tr><td colspan="8">Return to core temperature of blood</td></tr>
</table>

DID YOU KNOW?

Approximately 50 per cent of the energy liberated during muscle contraction appears as thermal energy/heat.

LOOKING FORWARD

The effects of elevated body temperatures

Units 3&4 – Chapter 7

Chapter 7 in *Nelson Physical Education Units 3&4* covers elevated body temperatures and dehydration and the fatigue effect they can create unless they are able to be reversed.

Whenever heat gain outweighs heat loss caused by environmental and/or activity levels, our internal body temperature increases. We have important regulatory mechanisms aimed to keep our internal temperature within a relatively narrow range (36–37.5°C). These heat-dissipating responses include increases in cardiac output through a combination of elevation in heart rate and cardiac contractility. More blood needs to be pumped to the skin to cool down, hence the increase in heart rate and associated cardiac output. The redistribution of blood from one part of the body to another is known as the vascular shunt mechanism. Because we have a closed vascular circuit, when more blood is shunted somewhere via vasodilation, less blood is sent to other parts of the body as a result of vasoconstriction. Interestingly, stroke volume does not change significantly when the heart pumps more blood to the skin in order to dissipate heat there.

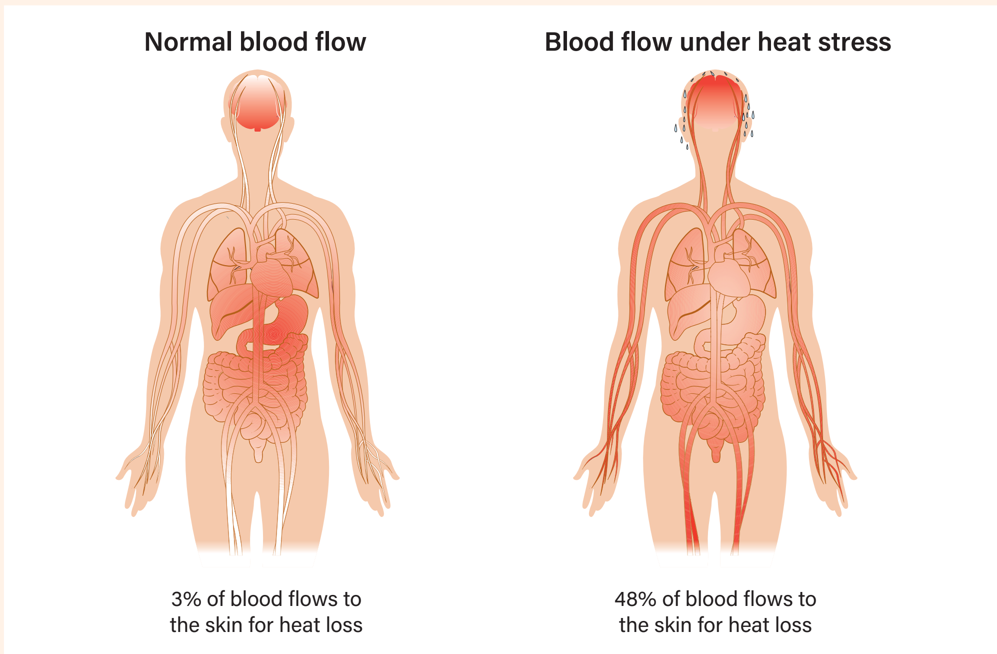


FIGURE 4.16 Thermoregulation via evaporation and radiation of heat assisted by increased blood flow to the skin as the body overheats

The sweating mechanism

Sweating is the primary mechanism the body uses to cool itself via evaporation. Warm blood is shunted to the skin via vasodilation of associated blood vessels for cooling. At the same time, less blood is directed to working muscles, meaning they receive less oxygen and fuels, and there is also reduction in the rate of waste removal. As a consequence, performance intensity needs to decrease dramatically and the person 'slows down' in order to cool their body down.

DID YOU KNOW?

A 0.3°C increase in core temperature can initiate vasodilation and sweating at the skin. Think about this the next time you are doing a gentle warm-up!

FIGURE 4.17 Sweating is a mechanism that helps the body thermoregulate.

At the skin, sweat glands secrete water so it can be evaporated. In order for the water to evaporate, it needs to absorb energy from the skin, and through this process, blood at the skin and in the capillaries is cooled. This cooled blood is transported back to the body's core tissues and working muscles, where it picks up heat produced from metabolic processes and the cycle is repeated again.

DID YOU KNOW?

When trying to promote heat loss, hair covering the body will become raised in an effort to release any hot air at the skin's surface. This is an example of radiant heat loss.

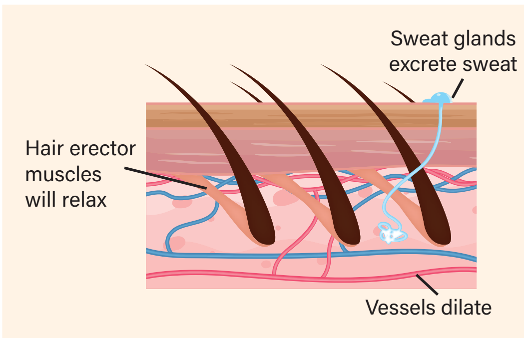


FIGURE 4.18 Sweat glands in the skin

This so-called 'cooling' mechanism continues to work as long as an adequate volume of body fluid is maintained. Dehydration causes surface blood vessels to constrict, effectively halting sweat production to conserve blood volume. This leads to a dramatic increase in core temperature, a breakdown of the thermoregulatory system, and a concurrent increase in body temperature.

The effects of rising body core temperatures

When the body's core temperature begins to rise, this tends to occur in three stages: heat cramps, heat exhaustion and heat stroke, with the last being the most serious.

Heat cramps → Heat exhaustion → Heat stroke

FIGURE 4.19 Elevated body temperature becomes more serious unless it can be reserved.

Heat cramps

Heat cramps are often an early sign of heat illness and dehydration. Typically, the athlete complains of cramping in the specific muscles exercised, which cannot be relieved with stretching. Cramps can occur after intense, prolonged exercise and result from water loss and imbalances of body electrolytes. Physical exhaustion and dizziness (especially notable in younger participants) may also be experienced. Poorly acclimatised athletes are more susceptible to heat cramps. It is important to immediately treat the athlete in order to avoid more serious thermal injury.

Heat exhaustion

Heat exhaustion is more serious, and is caused by an excessive loss of body fluids due to prolonged sweating. This condition is characterised by profuse sweating, cool, clammy and pale skin, and a weak, rapid pulse. The athlete is usually light-headed, experiences chills or shivering and is unable to concentrate. If left untreated, this can progress to heat stroke, which is a severe, acute, life-threatening injury that can quickly result in severe brain damage or death.

Heat stroke

Heat stroke is an emergency requiring immediate medical attention. It is characterised by three major symptoms: core temperature greater than 40°C, marked mental confusion and/or unconsciousness, and shock. The individual will likely not be sweating, and their skin will be hot, dry and red. Their pulse will be rapid and bounding, and their breathing fast and deep in an effort to cool rapidly.

First aid and treatment

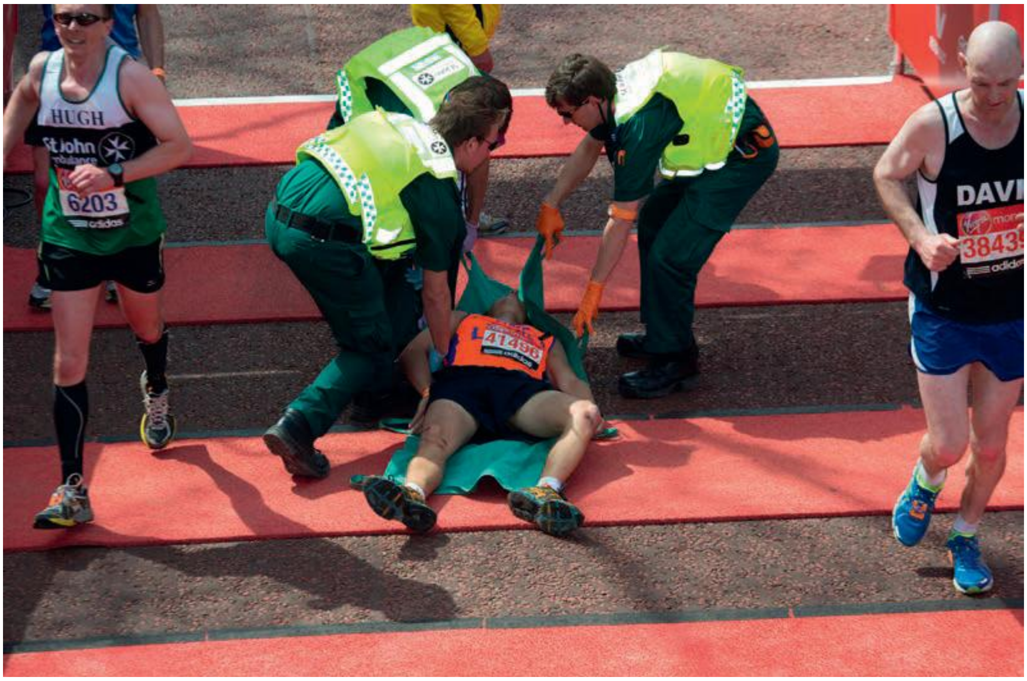
Heat cramps

This relatively mild condition is a warning to decrease or stop exercise. Remove the athlete from the heat source, re-hydrate with fluids such as water and diluted fruit juices, and monitor for symptoms of a more serious thermal injury. Eating fresh fruit such as a banana will help replenish potassium.

Heat exhaustion and heat stroke

Remove the athlete from the heat source and move them to a cool area (in the shade or indoors). Death due to heat stroke is directly related to the length and degree of temperature elevation, so the aim is to bring the temperature down to normal as soon as possible. The person's clothing should be loosened or removed. Sponging cold water on their body while cooling them with a fan will help increase the rate of heat loss. If shivering occurs, stop fanning the body.

As long as the athlete is conscious, have them drink cool fluids. In cases where the athlete is unconscious, seek emergency medical attention so IV fluids can be applied. Finally, applying ice packs to major arteries in the neck, groin and armpit regions and placing cold, water-soaked sheets, towels or clothing over the athlete will help cool the blood returning to the heart.



Allsorts Stock Photo/Alamy Stock Photo

FIGURE 4.20 Heat exhaustion during endurance events may cause loss of consciousness.

DID YOU KNOW?

During exercise, heat produced by the working muscles can increase to up to 15–20 times that of resting levels. This translates to an increase in core body temperature of 1°C every five minutes. Excessive heat build-up can do tremendous damage to the human body and, in extreme cases, can be fatal.

COLLABORATIVE TASK

Prac activity

The role and process of thermoregulation

AIM

To examine the role and process of thermoregulation through participation in physical activity.

EQUIPMENT

- Heart rate monitor
- Liquid crystal (flexible) thermometer
- Stop watch/timer

METHOD

Divide the PE class into pairs. One partner will participate in a set of full-court (basketball) sprints with changed recovery times, and the other will be required to participate in a continuous run around the perimeter of the basketball court – eight laps. Each sprint and lap time need to be recorded by the partner not currently performing

>

the activity. The subject's temperature should also be measured at the end of each sprint or lap by placing the flexible liquid crystal thermometer on the forehead until a reading is obtained.

Acute responses to exercise such as heart rate, temperature and evidence of sweat will need to be collected during the laboratory. The non-participating partner acts as a recorder of:

- heart rates (from device = smart watch, chest strap) or manual reading
- temperature (flexible strip/liquid crystal thermometer)
- evidence of sweat.

Full court return (up and back) Sprint (maximal)	Sprint time (sec)	Recovery time	Partner 1 Heart rate	Partner 1 Temperature	Sweat (Y/N) Amount (L/M/H)	Lap of basketball court @ moderate pace (100 m approx.)	Lap time (sec)	Partner 2 Heart rate	Partner 2 Temperature	Sweat (Y/N) Amount (L/M/H)
Resting										
1		30 sec				1				
2		30 sec				2				
3		20 sec				3				
4		20 sec				4				
5		15 sec				5				
6		15 sec				6				
7		15 sec				7				
8		15 sec				8				
Recovery		1 min				Recovery	1 min			
		2 min					2 min			
		3 min					3 min			

DISCUSSION

1 Which activity (full court sprint or continuous run) was associated with the greatest increase in heart rate? Can you provide an explanation for the difference?

2 What evidence did you collect that might indicate the body was trying to thermoregulate?

3 Explain how the mechanisms you have indicated in question 2 above contribute to cooling the body down.

4 Which group returned to pre-exercise levels fastest? How do you account for this?

Template
Thermoregulation test

Heat acclimatisation

Through heat acclimatisation, the body has time to adjust to new external temperatures in a controlled way. Preparation in hot conditions means that during extreme exercise, climate becomes less of a factor, giving athletes more control over their performance.

The following steps can improve performance through body acclimatisation.

- Practise once a day in the first five days in a new climate.
- Avoid practising more than three hours a day.
- Wear light gear until day six of practice, then you can switch to full gear if needed.
- Avoid full-contact drills until day six.
- Follow days with multiple practices with a single-practice day or a rest day.
- Increase the intensity of your practice slowly over a few days.
- Increase the sodium in your diet for the first few days. Sodium helps the body retain the fluid necessary for temperature regulation.
- Keep cooling stations stocked with ice towels and tubs during practice.
- Take plenty of breaks to allow the body to cool down.

ANNE-CHRISTINE POUJOULAT/Getty Images

FIGURE 4.21 Endurance cyclists pouring water over themselves to cool down

SIGNPOST

Watch the video, 'Loughborough Sport Physiology Lab – Heat Chamber' on the Loughborough University's YouTube channel.

Read the Gatorade Sports Science Institute's article on how athletes can use heat acclimatisation practices and training in order to improve their performance when placed under heat load.

Weblinks
Loughborough Sport Physiology Lab – Heat Chamber

Heat acclimatisation practices

Hypothermia

Although less common, hypothermia will also cause performance decrements, and unless countered by the body will lead to more significant health risks. During exposure to cold environments, most heat loss escapes through the skin (up to 90 per cent). The remainder tends to be exhaled from the lungs during respiration. Heat loss through the skin happens primarily through radiation and speeds up when the skin is exposed to wind, moisture or cold water.

DID YOU KNOW?

Heat loss due to convection and being immersed in cold water can occur 25 times faster than it would if exposed to air of the same temperature.

The hypothalamus works to raise body temperature by triggering processes that heat the body. Shivering when exposed to cold temperatures is a protective response designed to produce heat through muscle activity. In another heat-preserving response, the blood vessels temporarily narrow via vasoconstriction.

The heart and liver produce most of our body heat, but as core body temperatures drop, these organs produce less heat due to a protective 'shut down' designed to preserve heat and protect the brain. Low body temperature can slow brain activity, breathing and heart rate. Confusion and fatigue can set in, hampering a person's ability to understand what is happening and make intelligent and informed decisions.

Hypothermia symptoms coincide with the physiological body responses and include:

- shivering, which may stop as hypothermia progresses (shivering is actually a sign that a person's heat regulation systems are still active)
- slow, shallow breathing
- confusion
- drowsiness, muscular fatigue, exhaustion
- slurred/mumbled speech
- loss of coordination
- a slow, weak pulse (hypotension).

REAL WORLD APPLICATIONS

Some people believe that wearing a hat/beanie during cold conditions slows the rate of heat loss significantly because the head accounts for 50 per cent of heat loss. This is actually a myth. Heat loss from an uncovered head in cold conditions tends to be around 10 per cent, which is roughly the head's percentage of the body's total surface area. In reality, the amount of heat loss from the head is the same as it is for any other body part that is uncovered in the cold. Heat loss is proportionate to the amount of exposed skin.

iStock.com/SimonSkafar

FIGURE 4.22 We lose the same amount of heat from our head when exposed to the cold as from any other body part.

Treatment for hypothermia

Hypothermia is a potentially life-threatening condition that requires emergency medical attention. If medical care isn't immediately available, take the following steps:

- Remove any wet clothes, including hats, gloves, shoes and socks.
- Protect the person against wind, draughts and further heat loss with warm, dry clothes and blankets.
- Gently move the person to a warm, dry shelter as soon as possible.
- Begin rewarming the person with extra clothing. Use warm blankets. Other helpful items may include an electric blanket to the torso area, and hot packs and a heating pad on the torso, armpits, neck and groin. However, be aware that these can cause burns to the skin. Use your own body heat if nothing else is available.
- Offer warm liquids, but avoid alcohol and caffeine, which speed up heat loss. Don't try to give fluids to an unconscious person.

If the hypothermic person is unconscious, or has no pulse or signs of breathing, call 000 immediately. If a pulse can't be felt and there is no sign of breathing, CPR should be given immediately. Feel for the pulse for up to a whole minute before starting CPR, because the heart rate may be extremely slow. You should not start CPR if there is any heartbeat present.

CASE STUDY OLYMPIC ATHLETES AND VOLUNTEERS IN TOKYO 'TORTURED' BY HOTTEST GAMES EVER

OLYMPIC ATHLETES AND VOLUNTEERS IN TOKYO 'TORTURED' BY HOTTEST GAMES EVER

Olympic athletes and volunteers in Tokyo are being 'tortured' by dangerous heat, meteorologists have said, as the hottest Games in history puts pressure on organisers to rethink the future of sport in a climate-disrupted world.

Temperatures hit 34C in the Japanese capital on Thursday with humidity of nearly 70%. Athletes and sports scientists say the combination of heat and moisture has led to 'brutal' conditions that must be avoided at future events.

This could limit the range for endurance sports in terms of geography, season and time of day. Pressure will grow for big events to be moved to cooler seasons, higher latitudes, morning and evenings.

Tokyo 2020 has highlighted the risk of trying to continue with sporting business as usual. At least two tennis players – Kazakhstan's Zarina Diyas and Spain's Paula Badosa – retired mid-match with heat exhaustion, and Badosa was taken off court in a wheelchair. Russia's Daniil Medvedev needed two medical timeouts in his men's singles quarter-final.

'I can finish the match, but I can die,' he told the umpire. 'If I die, are you going to be responsible?' Medvedev said after the game that he hadn't been able to breathe, felt 'darkness' in his eyes and 'was ready to just fall down on the court'.

The world No 1, Novak Djokovic said the conditions were tougher than anything he had experienced in a 20-year career. 'You're constantly dehydrated, you feel you have weights on your shoulders because there's so much heat and humidity and stagnated air,' he said.

He and others have demanded a rethink of the schedule, and organisers have said they will add two days to the tournament at the next Olympics to allow for more recovery time and fewer matches in the midday sun.

Water sports have offered no relief. Long distance swimmers had to wake up before dawn so their event could start at 6:30am and finish before the worst of the morning heat. Even so, the water temperature in Tokyo Bay rose to 29C, which was described as being as 'hot as soup'. The artificial rapids for the canoe slalom were so warm that one competitor, Matej Benus of Slovakia, described them as 'like paddling in bathwater'.

VINCENZO PINTO/AFP/Getty Images

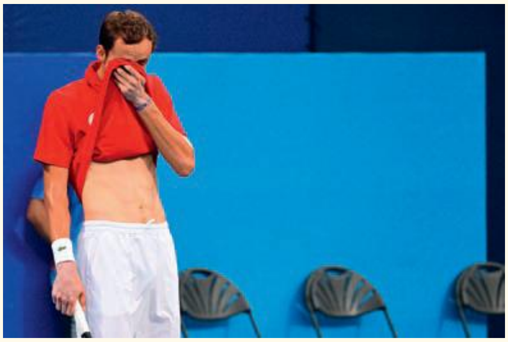


FIGURE 4.23 Daniil Medvedev needed two medical timeouts in his men's singles quarter-final.

The Russian archer Svetlana Gomboeva was treated for heat exhaustion, and beach volleyball players said the sand had been almost too hot to stand on. Brazil's 2016 gold medallist Bruno Schmidt, was astonished: 'The first two weeks here are one of the hottest that I had in my life, believe it or not.'

Sayaka Mori, a meteorologist with the NHK broadcaster, said the high moisture content of the air on Wednesday meant that temperatures felt above 40C, which is dangerously high. 'Oppressive heat is really torturing the Olympians and volunteers in Tokyo,' she tweeted. 'Be careful of heatstroke.' Thursday was warmer still.

The director general of the Games, Toshiro Muto, said only 30 people had suffered mild heat-related illness thanks to countermeasures, including ice jackets, mist-sprays, salt tablets and rescheduling events to cooler evenings. 'I believe our steps have been working well so far,' he said.

For the highest risk events – which include athletics, beach volleyball, cycling, football, hockey, marathon swimming, modern pentathlon, rowing, rugby, tennis and triathlon –sports scientists advised organisers to set up 'heat decks' for treatment, including cool-down baths.

Two endurance events – the marathon and the race walk – were moved 800km north to the usually much cooler Hokkaido, but the island is in throes of its most severe heatwave for 97 years.

Summer Olympics in Los Angeles, Athens, Atlanta, Sydney, Beijing and Rio de Janeiro all registered peak temperatures in the mid 30Cs. But Tokyo is more relentlessly warm and humid, the two elements in wet bulb globe temperature (WGBT), which is the key measurement for heat-stress risk.

'Tokyo is regularly experiencing WBGT conditions of more than 30C, some days peaking above 32C. That is several degrees above Rio, London, Beijing and other Olympics,' said Oliver Gibson, a senior lecturer in exercise physiology at Brunel University.

BEHROUZ MEHRI/AFP/Getty Images

FIGURE 4.24 A man cools off at a mist station installed at Shiokaze Park during a beach volleyball test event.

It's a far cry from the 'mild and sunny weather' that the Tokyo bid committee had promised in 2013 as 'an ideal climate for athletes to perform at their best'. They should have known better. As early as 1964 – the last time Tokyo hosted the Olympics – organisers were wary enough of the summer heat to schedule the Games in October.

'Athletes testing themselves at the highest levels of human capacity are being asked to compete in environments that are becoming hostile to human physiology. Our love and appetite for sports risks straying into brutality,' he wrote ahead of the Games.

Exertional heatstroke is one of the top three causes of sudden death in athletes and explains why heatwaves tend to kill a disproportionately high number of 15 to 19-year-old men. It occurs when strenuous exercise, often in hot and humid conditions, pushes core body temperatures to 40C, beyond which sweating and other cooling techniques are inadequate and organ functions start to collapse.

Athletes can adapt, up to a point. Paul Hough, a sports scientist at Oxford Brookes University, has helped British Olympians, F1 drivers and tennis players with heat acclimatisation, usually carried out on a treadmill in an enclosed chamber where humidity can be raised as high as 86%.

Hough said heat stress came in three stages: heat cramps, which affect performance and can make the athlete dizzy; heat exhaustion, when energy is so run down that competitors have to withdraw, as was the case with Paula Radcliffe in the 2004 Athens marathon; and heatstroke, which can be fatal if not treated rapidly by ice-jackets, cold baths and slush drinks – all of which are in use in Tokyo.

In WBGT conditions in the mid-30Cs, however, even this is not always enough. 'You can do all the acclimatisation training you like, but there is a point when the body reaches its limits. You can just about play football in 40C, but all the quality goes out of the game. When you reach those extremes, organisers have to move things around, schedule in the evening or choose a different date in the calendar.'

Next year's World Cup in Qatar has been moved to the winter for this reason. In the UK, the British Association of Sport and Exercise Science recently started work on an action plan to 'tackle the climate emergency'. It is scheduled for release ahead of Cop26 in Glasgow in November.

Gibson predicts heat will change the way sport is run in the future. 'With climate change and the globalisation of sport, I think it is certain that the sporting landscape will be impacted by temperature more and more. In the future, we may be looking at some locations being unable to host sporting competition due to rises in temperature.'

It may also be necessary to arrange more breaks in play, delay competition and adjust schedules. 'I foresee the big battle here will likely be with broadcasters, rather than the sportsmen and women themselves.'

Source: Jonathan Watts, 'Olympic athletes and volunteers in Tokyo "tortured" by hottest Games ever', *The Guardian*, 6 August 2021, https://www.theguardian.com/environment/2021/aug/05/olympic-athletes-and-volunteers-in-tokyo-tortured-by-heat. Copyright Guardian News & Media Ltd 2024.

QUESTIONS

1 **Discuss** how 'cool-down baths' can be used to treat elevated core temperatures and help overheated athletes return to pre-exercise conditions.

2 Some people argue that a mist station cools the body more efficiently than placing a cold towel on the limbs. **Justify** which of these two practices you believe would cool the body more effectively.

3 Investigate and **discuss** how in some instances, humid conditions can lead to greater heat stress than hotter environments.

Assessment
4.3 Check-in questions

Command terms

explain
Give a detailed account of why and/or how with reference to causes, effects, continuity, change, reasons or mechanisms; make the relationships between things evident

suggest
Put forward for consideration a solution, hypothesis, idea or other possible answer

4.3 CHECK-IN QUESTIONS

1. The Ironman Triathlon consists of a 3.86-km swim, a 180.25-km bicycle ride and a 42.20-km marathon, raced in that order. Races generally last eight hours for world-class performers. The Ironman Triathlon is usually scheduled to be held at a time when athletes will not have to compete in high temperatures. **Explain**, physiologically, what occurs when exercising in high temperatures and suggest what implications this could have on an athlete's performance. (4 marks)
2. **Discuss** how conduction can be used to assist someone who has been performing outdoors in cold and windy conditions and is showing signs of hypothermia.
3. Sweating is one way of trying to cool the body down. Clearly **discuss** why athletes need to be fully hydrated in order for this to improve their performance rather than hinder it.
4. Some AFL teams playing in Brisbane against the Brisbane Lions 'struggle in the heat.'
   - a **Discuss** if heat acclimatisation is likely to be a strategy that would work in this instance.
   - b **Suggest** two other strategies that might be considered to ensure that when playing against the Brisbane Lions in hot/humid conditions players do not 'overheat.'

CHAPTER SUMMARY

4.1 The structure and function of the cardiovascular system

- The cardiovascular system is made up of the heart, blood vessels and the blood.
- The heart is both an organ and a muscle consisting of four chambers (two upper atria and two lower ventricles).
- A larger heart will have bigger ventricles and thicker walls, allowing it to contract more forcefully and eject more blood per beat/minute.
- The left side of the heart pumps blood to the major organs (except the lungs), tissues and muscles of the body, and is known as the systemic circuit.
- The right side of the heart pumps blood to the lungs and is known as the pulmonary circuit.
- One-way valves keep blood flowing through the heart in one direction. The only blood vessels that have valves are veins.
- There are three types of blood vessels: arteries, veins and capillaries.
- Arteries generally take blood away from the heart. Capillaries are where exchange of gases, nutrients and fuels occur, and veins return blood to the heart.
- Blood is mainly made up of plasma, but also contains red blood cells (important for transport of oxygen and carbon dioxide), white blood cells (important for body defence/immunity) and platelets (important for clotting).

Resource
Self-assessment checklist

Video
Masterclass: Chapter 4

4.2 The cardiovascular system during rest and various exercise intensities

- Cardiac output (Q) = stroke volume (SV) × heart rate (HR).
- Stroke volume peaks around 50–60 per cent of max heart rate and cannot increase beyond this finite capacity.
- There is a direct linear relationship between exercise intensity and both heart rate and systolic blood pressure.
- Resting heart rates tend to be lower for individuals who have larger ventricles as well as greater blood volumes (males or trained athletes).
- Steady state is reached when the body receives sufficient oxygen to meet demands (rest or exercise), at which point the heart rate will level off or 'plateau.'
- Maximum heart rate can be roughly estimated using the formula: 220 – age.
- Vasoconstriction reduces blood flow to parts of the body while vasodilation, which occurs at the same time, increases blood flow to parts of the body.
- The redistribution of blood by the brain to different body parts is often referred to as the 'vascular shunt mechanism.'
- During exercise, more blood is sent to working muscles and less to non-vital organs.

4.3 The cardiovascular system assisting thermoregulation

- The cardiovascular system is used to thermoregulate and try to keep internal temperatures between 37–37.5°C.
- Hyperthermia occurs when the body overheats and hypothermia occurs when the body is exposed to cold conditions.
- Heat can be gained or lost by radiation, conduction and convection. It can only be lost via evaporation.
- Evaporation is effective in cooling the body when more blood is directed to the skin's surface and sweat aids the cooling process.
- When more blood is sent to the skin (vasodilation), less is able to be sent to working muscles (vasoconstriction). This commonly results in reduction of work rate/intensity.
- Sweating helps cool the body, but unless accompanied by adequate hydration will lead to dehydration and loss of plasma.
- Decreases in plasma lead to increased blood viscosity (thickness), making the heart work harder to pump it around the body. This also results in more blood being sent to the heart muscle and less to working muscles.
- Sweating becomes less efficient in humid conditions, which slow the rate of evaporation and increase perceived heat – 30°C might feel like 37°C when humidity is high.
- Acclimatisation to hot and cold environments is a strategy used (if time permits) by athletes to reduce the environmental effects on their performance.
- When the body cannot thermoregulate effectively, body functions are compromised and performance decrements occur. Severe temperature changes may result in severe injury.

CHAPTER REVIEW

Assessment
Chapter 4 Review

1 Which of the following statements is true?

- **A** All blood vessels have one-way valves.
- **B** Systolic blood pressure is always higher than diastolic blood pressure.
- **C** Vasodilation leads to less blood being sent to different body parts.
- **D** Gaseous exchange occurs in the arteries because they have the greatest gas gradient.

2 Which of the following athletes is likely to have the lowest resting heart rate?

- **A** Mountain bike competitor (50 km)
- **B** Netball centre player
- **C** Cross-country skier (50 km)
- **D** Marathon runner

3 Peta has accidentally cut her leg on a sharp coral while surfing.

- **a** In an effort to reduce blood flow and loss to this area, how might her cardiovascular system respond?
- **b** What can Peta do to reduce blood flow to this injured part of her body?

4 **Describe** how someone who is fully hydrated at the start of a marathon should be able to outperform someone who has lower levels of hydration.

5 **List** two symptoms that might suggest the heart has faulty valves. Explain how faulty valves would cause someone's fitness levels to decrease – i.e. how might this compromise their ability to meet their daily physical demands?

6 **List** three different strategies you could use to minimise the negative effects of performing in colder environmental conditions. Select one and clearly **discuss** how this would be useful in maintaining optimal performance.

7 Clearly **discuss** how electrolytes (mainly sodium and potassium) found in sports drinks such as Gatorade and Powerade affect the cardiovascular system and seek to maintain homeostasis.

CHAPTER

5

THE RESPIRATORY SYSTEM

UNIT 1 – AREA OF STUDY 2

Maridav/Adobe Stock

FIGURE 5.01 The respiratory system takes up oxygen and exchanges gases at the lungs.

Quizzes

Chapter 5 Pulse check

5.1 Check-in questions

5.2 Check-in questions

5.3 Check-in questions

5.4 Check-in questions

Chapter 5 Review

Videos

Masterclass: Chapter 5

5.2 In focus: Gaseous exchange

5.3 In focus: VO_2 max during a ramp treadmill test

5.3 In focus: Active vs passive recoveries and effects on EPOC

Resources

Chapter 5 Self-assessment checklist

Nelson MindTap

To access resources above, visit **cengage.com.au/nelsonmindtap**

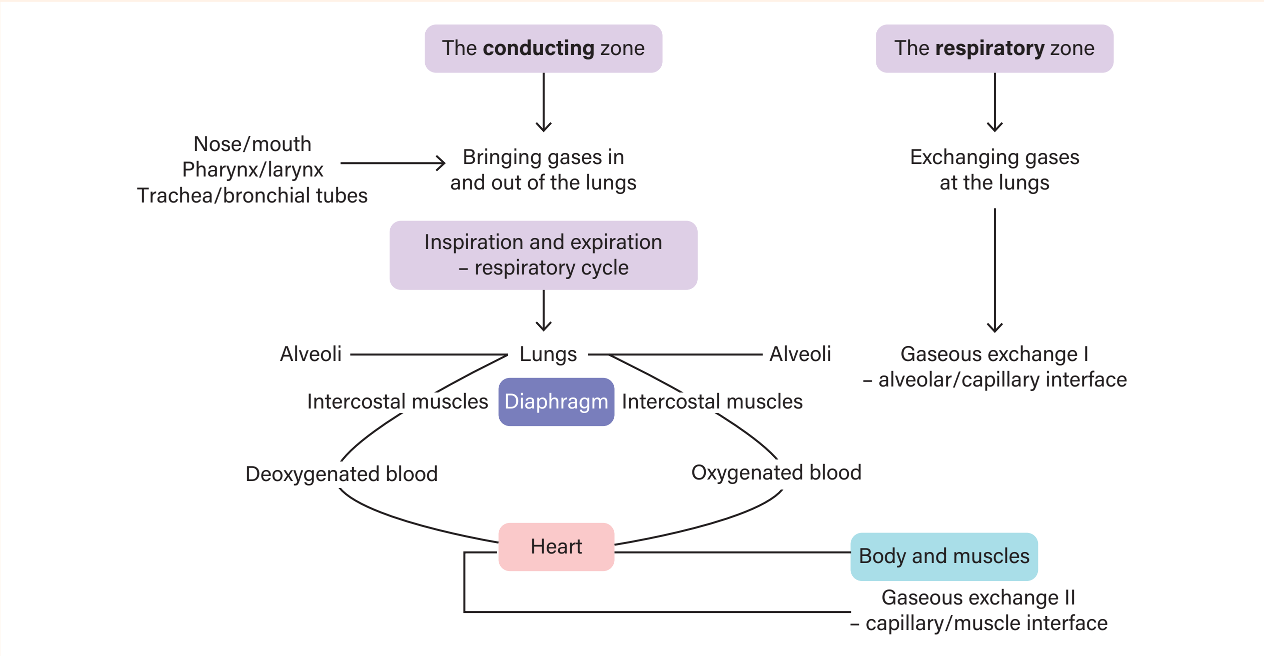
KEY KNOWLEDGE

- the structure and function of the respiratory system, including the lungs, mechanics of breathing and gaseous exchange at the alveoli/capillary and the capillary/muscle interface
- the interaction of the cardiovascular and respiratory systems to transport oxygen around the body at rest and during physical activity, sport and/or exercise
- the impact of regular aerobic exercise on enhancing the capacity and functioning of the cardiovascular and respiratory systems

KEY SKILLS

- apply and use anatomical terminology to identify the structures and function of the cardiovascular and respiratory systems
- investigate and describe the process of gaseous exchange
- collect primary data to measure and analyse the changes to the cardiovascular and respiratory systems at rest compared with various exercise intensities
- evaluate the impact of regular aerobic exercise on enhancing the capacity and functioning of the cardiovascular and respiratory systems

Source: VCAA VCE Physical Education Study Design (2025–29)



Video
Masterclass: Video 5

Breathing involves gaseous exchange through a respiratory cycle involving inspiration and expiration of air. The respiratory system has the following main structures: nose, mouth, pharynx, larynx, trachea, bronchi and lungs. Aside from the lungs, there are also respiratory muscles and a vast network of blood vessels that facilitate the process of respiration. The cardiovascular and respiratory systems work together to introduce oxygen into the body cells, tissues and organs and to remove carbon dioxide from these sites.

Similar to the cardiovascular system, there is a direct linear relationship between exercise intensity and ventilation – the greater the demand for oxygen due to increased workloads, the higher the ventilation. You may recall that stroke volume has a finite capacity. When considering the respiratory system, tidal volume has equivalent limitations. Regular aerobic exercise improves the functioning of both the respiratory and cardiovascular system, leading to improved health benefits.

Assessment
Chapter 5 Pulse check

PULSE CHECK

Take the pulse check quiz to check your prior knowledge and understanding of the concepts covered in this chapter.

1 When we exercise, multiple changes occur throughout the respiratory system to supply the muscles with greater amounts of oxygen. **List** three respiratory changes that enable this to occur.

2 **Describe** how gaseous exchange occurs at the lungs and also at the muscles.

3 Why are males generally able to take up more oxygen per breath than females?

4 Have you ever been winded? Consider how the diaphragm contracting irregularly and experiencing muscle spasms adversely affects breathing.

5 VO_2 is the amount of oxygen that can be taken up, transported and used by muscles. **Discuss** two ways the respiratory and cardiovascular systems work together to take up and transport oxygen to working muscles.

VO_2
The amount of oxygen that can be taken up, transported and used by muscles

5.1 THE STRUCTURE AND FUNCTION OF THE RESPIRATORY SYSTEM

In this module you will learn about:
- the role of different structures and zones of the respiratory system
- how inspiration and expiration occur

and learn to:
- explain how ventilation changes with different exercise intensities
- describe the journey air takes from the environment to the lungs.

conducting zone
Parts of the respiratory system responsible for bringing air into the lungs

respiratory zone
The site of gaseous exchange, namely the alveolar capillary surface area

The respiratory system can be divided into two distinct zones: a conducting zone and a respiratory zone. The **conducting zone** includes the organs and structures that bring air into and out of the lungs. These are not directly involved in gas exchange. Gaseous exchange occurs in the **respiratory zone**.

The conducting zone

The conducting zone consists of the following organs and structures: mouth and nose, pharynx, larynx, trachea and bronchus.

Mouth and nose

Both the mouth and nose provide an entry and exit point for air to move through the respiratory tract. Inhaled air can enter via the mouth, but it is not 'filtered' or warmed. Air inhaled through the nasal cavity is filtered, warmed and humidified, making it more comfortable for it to be taken up at the lungs.

Matthias Hangst/Getty Images Sport/Getty Images

FIGURE 5.02 Cross-country skiers have large oxygen demands and should breathe in through the nose so cold air is warmed.

Pharynx

The pharynx is a tube-like structure that connects the nasal cavity and back of the mouth to other structures lower in the throat, including the larynx. The pharynx has dual functions: both air and food/liquid pass through it, making it part of both the respiratory and digestive systems. Air passes from the nasal cavity through the pharynx to the larynx (as well as in the opposite direction). Food passes from the mouth through the pharynx to the oesophagus and then to the stomach, while the epiglottis covers the trachea during swallowing to prevent food/liquid from incorrectly making its way into the lungs.

Larynx

The larynx connects the pharynx and the trachea and is used to conduct air through this part of the respiratory tract. It is also called the voice box because it contains the vocal cords.

Trachea

The trachea, also known as the windpipe, connects the larynx to the lungs. The trachea branches at its end to form two bronchi (singular = bronchus).

DID YOU KNOW?

The trachea is the widest passageway in the respiratory tract. It is formed by rings of cartilage, which stop it from collapsing and make it very strong and resilient.

Bronchi

Each bronchus divides into secondary and tertiary bronchi, which also divide, creating bronchioles, which are smaller in diameter. When terminal bronchioles subdivide for the last time, they become respiratory bronchioles. This is when they become a part of the respiratory zone.

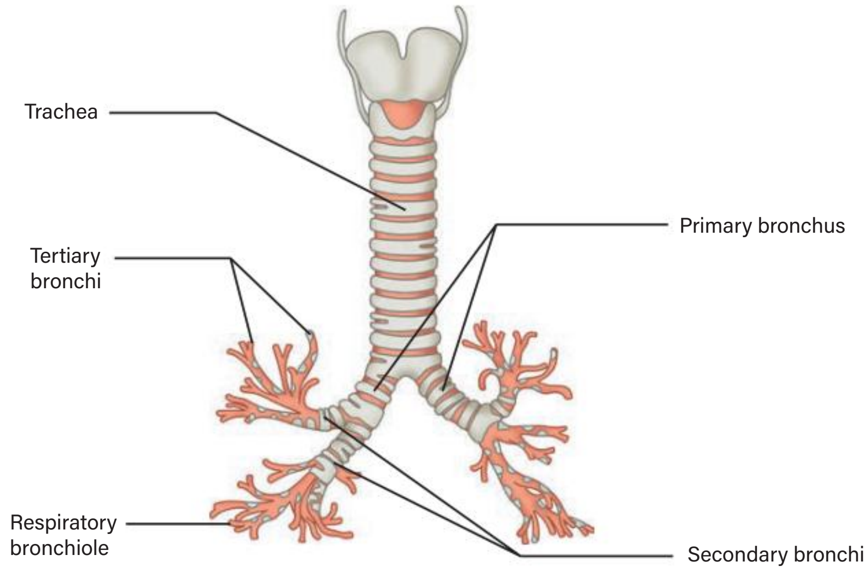


FIGURE 5.03 The trachea dividing into two main bronchi and then into secondary, tertiary and eventually respiratory bronchioles.

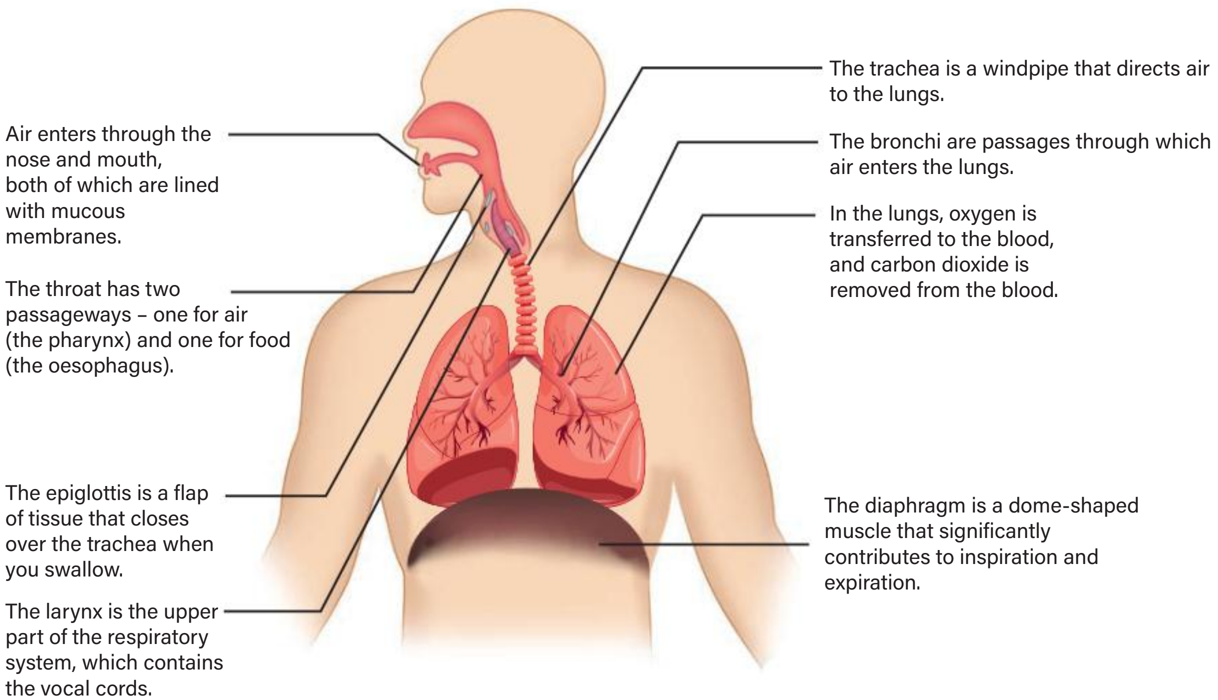


FIGURE 5.04 The major structures of the respiratory system

The respiratory zone

The respiratory zone consists of the following structures: respiratory bronchioles and alveolar ducts.

Respiratory bronchioles

The respiratory bronchioles subdivide into several alveolar ducts. Numerous alveoli and alveolar sacs surround the alveolar ducts. The alveolar sacs resemble bunches of grapes tethered to the end of the respiratory bronchioles.

Alveolar ducts

The alveolar ducts are attached to the end of each respiratory bronchiole. Each duct has approximately 100 alveolar sacs, each containing 20–30 alveoli. Gaseous exchange can only occur in the alveoli, which come into direct contact with the capillaries of the cardiovascular system.

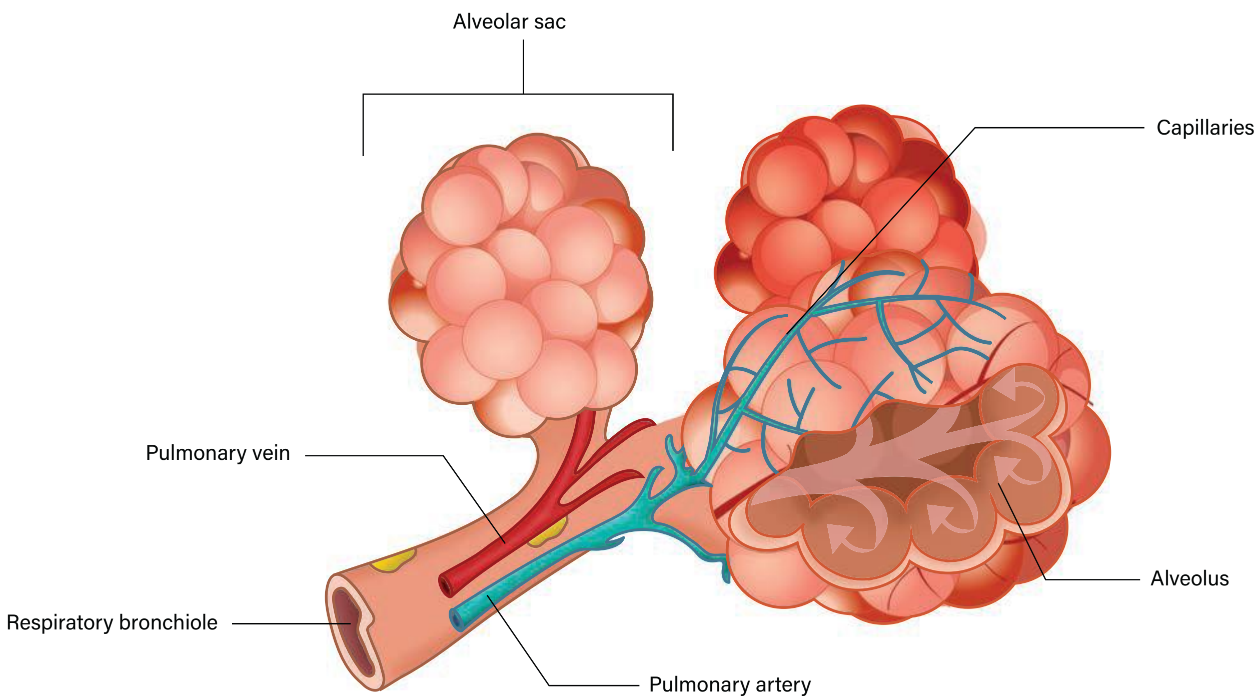


FIGURE 5.05 The respiratory bronchiole leading to an alveolar sac consisting of multiple alveoli

DID YOU KNOW?

There are about 300 million alveoli in each lung, and their combined surface area is approximately 75 m^2. This allows for rapid diffusion of gases into and out of the alveoli and surrounding capillaries.

intercostal muscles
The 11 sets of muscles located between each rib that help form and move the chest wall

diaphragm
A dome-shaped muscular partition that is located at the base of the thoracic cavity. It is composed of skeletal muscle and is attached to the lower ribs, spine and sternum

inspiration
The phase of ventilation in which air enters the lungs, initiated by contraction of the respiratory muscles

expiration
The phase of ventilation during which air is expelled from the lungs, caused by relaxation of the respiratory muscles

tidal volume (TV)
A measurement of the volume of air inhaled and exhaled per breath

respiratory rate
The number of breaths taken per minute, sometimes referred to as respiratory frequency

Inspiration and expiration

We breathe in actively by contracting our **intercostal muscles** and the **diaphragm**. When the intercostal muscles contract, the ribs move upwards and outwards, while the diaphragm contracts downwards. These actions increase the size of the thoracic cavity and the space within the lungs, causing the pressure within the lungs (intrapulmonary pressure) to decrease to less than that of air outside the body. Gases always move from areas of higher pressure to lower pressure, so air moves into the lungs quickly. This is known as **inspiration**.

Expiration, on the other hand, is passive and occurs in response to the intercostal and diaphragm muscles relaxing. When this happens, the ribs drop and the diaphragm adopts its relaxed dome-like shape in the thoracic cavity. The space inside the lungs decreases, while air pressure increases until it exceeds that of air outside the body and air is exhaled or expired.

The amount of air inhaled and exhaled per breath is known as the **tidal volume (TV)**. Pulmonary ventilation (or minute ventilation) refers to the volume of air moved into and out of the respiratory tract each minute. This can be calculated using the following equation:

Minute ventilation (V_E) = respiratory rate × tidal volume

At rest, minute ventilation = 12 breaths/min × 0.5 L/breath = 6.0 L/min.

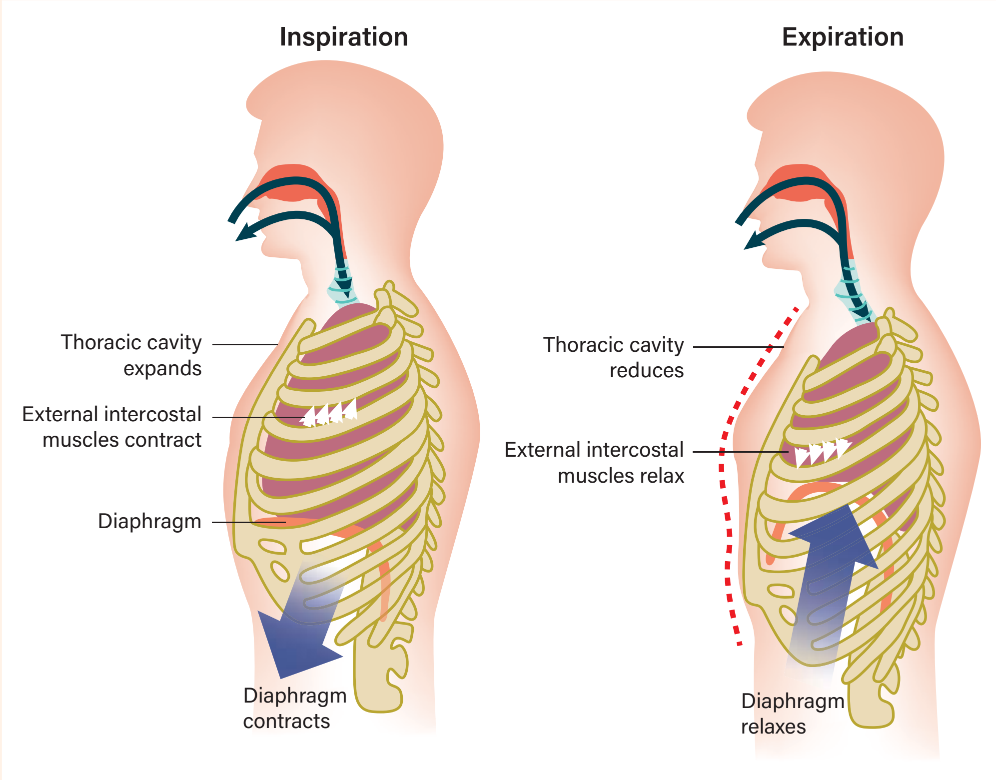


FIGURE 5.06 Inspiration and expiration create pressure changes in the lungs, causing air to move into and out of the respiratory tract respectively.

REAL WORLD APPLICATIONS

Lung capacity

Men generally have a larger lung capacity than women, so their resting tidal volumes tend to be greater. The average tidal volume for men is 600 mL, and the average for women is 500 mL. Just as a stroke volume tends to peak sub-maximally, tidal volume does the same. They both have a finite capacity. As oxygen demands increase, greater amounts are delivered from the lungs by increasing the respiratory or breathing rate.

DID YOU KNOW?

Inspiration occurs when nerves stimulate the inspiratory muscles (the external intercostals and diaphragm), causing them to contract. This stimulation lasts for approximately two seconds, and this process is considered 'active.' Following this, the inspiratory muscles relax and expiration occurs. Expiration is a passive process.

5.1 CHECK-IN QUESTIONS

1 **Outline** why inspiration is considered to be active while expiration is a passive process.
2 You may have experienced a situation when food has 'gone down the wrong way.' Clearly **discuss** what happens to allow this to occur, and how your respiratory system responded.
3 Smoking and vaping have been associated with irreversible damage to the alveoli in the lungs. **Propose** how this affects the surface area available for gaseous exchange, and describe the effect this will have on someone's ability to perform daily tasks as well as to participate in sport.
4 Have you ever gone to the snow and found it more difficult to breathe? **Explain** how breathing in colder air when skiing or snowboarding places greater stress on the respiratory system.

Assessment
5.1 Check-in questions

Command terms

outline
Provide an overview or the main features of an argument, point of view, text, narrative, diagram or image

propose
Suggest or put forward a point of view, idea, argument, diagram, plan and/or suggestion based on given data or stimulus material for consideration or action

5.2 GASEOUS EXCHANGE AT THE LUNGS AND MUSCLES

In this module you will learn about:
- gaseous exchange at the lungs and muscles
- how the brain senses gaseous changes and regulates breathing

and learn to:
- describe the process of gaseous diffusion from high to low pressures
- describe how the cardiovascular and respiratory systems work closely together.

The cardiovascular and respiratory systems work closely to take up and transport gases throughout the body – primarily, oxygen and carbon dioxide. Oxygen is vital to the functioning of every cell in our body and is required to produce aerobic energy. This process is sometimes called aerobic respiration, and involves breaking down blood glucose, stored muscle glycogen and fatty acids into adenosine triphosphate (ATP) with the presence of oxygen. This results in the byproducts water and carbon dioxide, as well as heat production. The body needs to eliminate the carbon dioxide and excess heat, while the water is retained and used in multiple ways to maintain **homeostasis**.

homeostasis
Physiological processes that keep the body's internal environment stable and balanced

LEARNING HACK

ATP is a compound consisting of an adenosine molecule bonded to three phosphate groups – hence the name adenosine triphosphate. It is present in all living tissue. The breakage of one phosphate linkage (to form adenosine diphosphate, or ADP) provides energy for muscular contractions and other biological processes.

anaerobic
Any function or biological process that occurs in the absence of oxygen

LOOKING FORWARD / LOOKING BACK

Energy systems

Chapter 1 and Units 3&4 – Chapter 6

Earlier in Chapter 1 you learnt about different types of muscles, contractions and how they allow movements to occur. In *Nelson Physical Education Units 3&4* you will learn about the three energy systems and how they work together to supply energy under aerobic and **anaerobic** conditions.

Gas exchange

An important function of the respiratory system is to perform gas exchange. Ventilation provides air to the alveoli so gas exchange can occur. At the respiratory membrane, where the alveoli and capillary walls meet, gases move across the membranes, with oxygen entering the bloodstream and carbon dioxide exiting it. In essence, the two different gases move in opposite directions. It is through this mechanism that blood is oxygenated and carbon dioxide, a by-product of aerobic respiration, is removed from the body.

Gas exchange occurs at two sites in the body:

- the lungs, where oxygen is picked up and carbon dioxide is released at the respiratory membrane. This is sometimes referred to as external respiration, because it involves the exchange of gases with the external environment and occurs at the alveoli
- the muscles and tissues, where oxygen is released and carbon dioxide is picked up. This is sometimes referred to as internal respiration, because it involves the exchange of gases within the body.

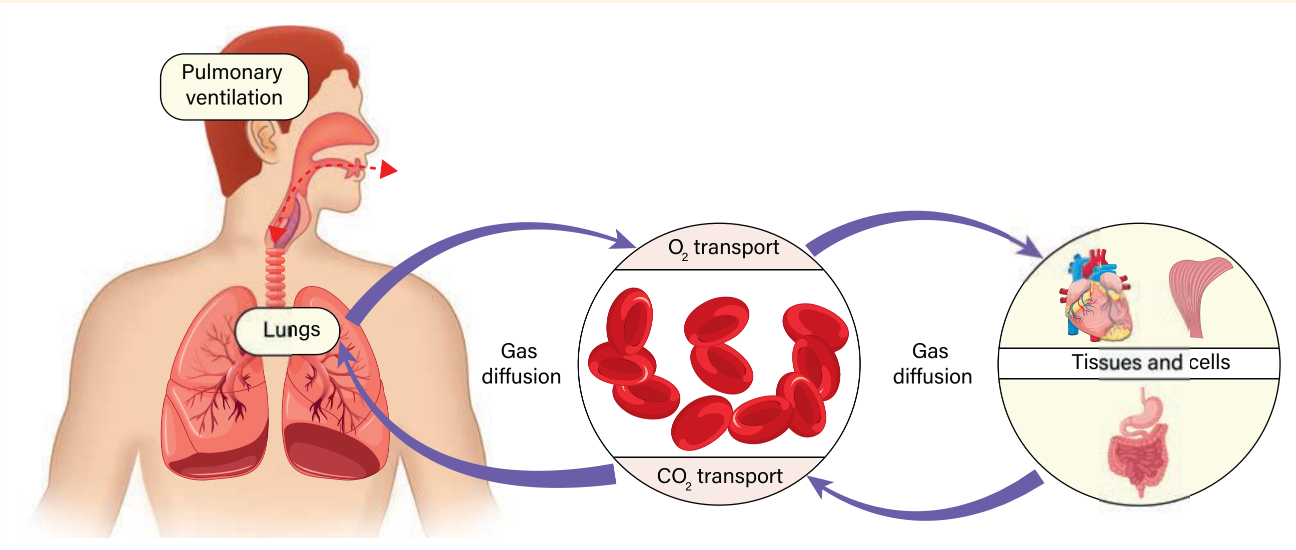


FIGURE 5.07 Gaseous exchange occurs at the lungs and muscles/tissues, with gases moving from high to low pressure either side of a membrane.

Energy is not required to move oxygen or carbon dioxide across the alveoli/capillary membranes at the lungs or capillary/muscle membranes at the muscles. Gases follow pressure gradients that allow them to diffuse or move from areas of high pressure to low pressure. The rate of gaseous diffusion is also linked to the surface area of the membrane, the solubility of gases and the distance the gases must travel.

External respiration (at the lungs)

The pulmonary arteries carry deoxygenated blood from the right side of the heart to the lungs, where they branch and eventually become pulmonary capillaries. These pulmonary capillaries form the respiratory membrane with the alveoli. As the blood is pumped through this capillary network, gas exchange occurs at the **alveolar/capillary interface**. Most of the oxygen that enters the pulmonary capillaries is picked up by red blood cells and attaches to haemoglobin. Carbon dioxide is released in the opposite direction, from the blood to the alveoli to be exhaled. Oxygenated blood is pumped back to the heart through the pulmonary veins, and is then pumped to the rest of the body, enabling aerobic respiration at muscles and other tissues.

alveolar/capillary interface The blood–air barrier or air–blood barrier (alveolar–capillary barrier or membrane) situated in the gas-exchanging region of the lungs

Oxygen is not very soluble in blood, but there is a significant difference in the pressure of oxygen in the alveoli compared to the blood in pulmonary capillaries. This difference of twice or even three times the pressure results in a very strong pressure gradient, which causes oxygen to rapidly cross the respiratory membrane from the alveoli into the blood.

The pressure difference of carbon dioxide between the alveolar air and the blood of the capillary is not as great as that for oxygen, being slightly higher in the capillary than the alveoli. However, carbon dioxide is twenty times more soluble than oxygen in both blood and alveolar fluids. As a result, the amount of oxygen and carbon dioxide that diffuse and exchange across the respiratory membrane are similar.

DID YOU KNOW?

Oxygen is not the major gas found in the air we breathe. Air is 78 per cent nitrogen, 21 per cent oxygen and 0.04 per cent carbon dioxide, with other gases making up the rest. Air is normally 1–3 per cent water vapour (by volume).

Video
In focus: Gaseous exchange

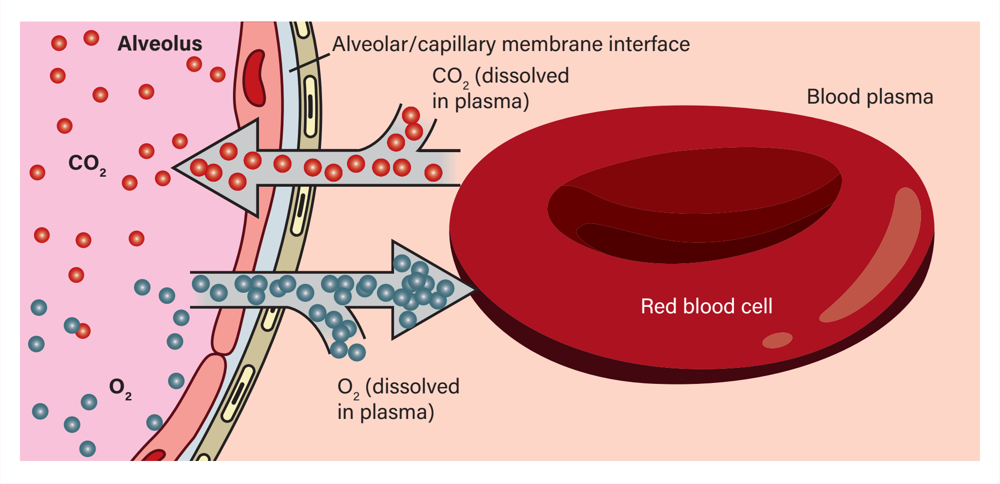


FIGURE 5.08 During external respiration oxygen diffuses from the alveoli to the capillary, while similar amounts of carbon dioxide diffuse out of the capillary into the alveoli to be exhaled. **Note:** Oxygen is mainly transported by red blood cells, but also in blood plasma.

Internal respiration (at muscles and tissues)

Internal respiration involves gas exchange occurring inside our body at muscles and tissues. As with external respiration, this also occurs via pressure differences in oxygen and carbon dioxide on either side of a membrane/interface. This time, the pressure gradients are the opposite to those occurring at the respiratory membrane. The pressure of oxygen in muscles

internal respiration Gaseous exchange that occurs at the muscles and tissues of the body and tissues is low, because oxygen has been extracted and used for cellular respiration to produce ATP. However, the pressure of oxygen in capillaries is high, having been 'reloaded' at the lungs. This pressure difference causes oxygen to be released from haemoglobin, diffuse out of the blood, cross the membrane, and enter muscles and tissues.

Cellular respiration continuously produces carbon dioxide, and its pressure is higher in the muscle/tissues than in the surrounding capillaries. This pressure difference causes carbon dioxide to diffuse out of the muscle/tissue, cross the membrane and enter the blood. It is then carried back to the lungs, mainly bound to haemoglobin or otherwise dissolved in plasma. This blood is pumped back to the heart, then to the lungs to be oxygenated once again during external respiration, and the whole cycle repeats itself.

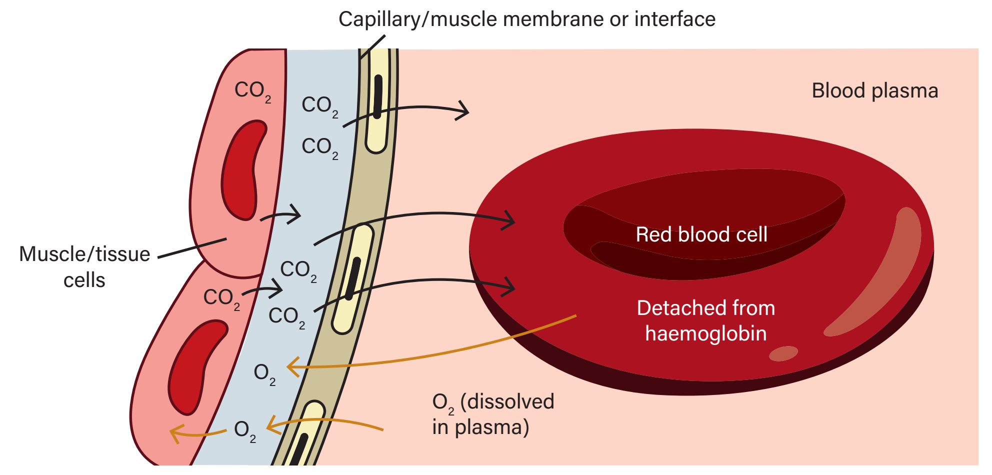


FIGURE 5.09 During internal respiration oxygen diffuses from the capillaries to the muscles/tissues, while similar amounts of carbon dioxide diffuse out of the muscles/tissues into the capillaries to be pumped back to the heart and lungs.

LOOKING FORWARD

Acute responses to exercise

Units 3&4 – Chapter 5

When considering acute responses to exercise in Chapter 5 of *Nelson Physical Education Units 3&4*, you will consider how the body's three major systems (cardiovascular, muscular and respiratory) operate at rest and respond to varying exercise levels.

Weblinks
Gas exchange
Alveoli: Gas exchange

SIGNPOST

Watch these two videos showing gaseous exchange and the structures of the respiratory system:

- 'Gas exchange' on the Stile Education channel on YouTube.
- 'Alveoli: Gas exchange' on the Science Sauce channel on YouTube.

Regulation of breathing

Breathing is controlled by a respiratory control centre located in your brain stem that constantly monitors the levels of oxygen and carbon dioxide in the bloodstream and adjusts breathing rates to maintain balance and homeostasis in the body. When a person performs activities that require additional oxygen, the oxygen levels in their blood decrease, while the carbon dioxide levels increase. The respiratory control centre of the brain senses that the levels are incorrect and increases both the heart rate and respiratory rate to make up the difference.

The breathing control centre is assisted by oxygen and carbon dioxide sensors located in the aorta, which monitor concentration levels of these gases as blood leaves the heart. If oxygen saturation falls, ventilation accelerates to increase the volume of oxygen inspired. When levels of carbon dioxide increase, hydrogen ions (H+) are formed. An increase in H+ concentration in the blood stimulates increased ventilation rates. This also occurs when lactic acid is released into the blood following high-intensity exercise.

LOOKING FORWARD

Accumulation of H+

Units 3&4 – Chapter 7

In Chapter 7 of *Nelson Physical Education VCE Units 3&4* you will explore a range of factors that cause fatigue. Accumulation of H+ is one of these.

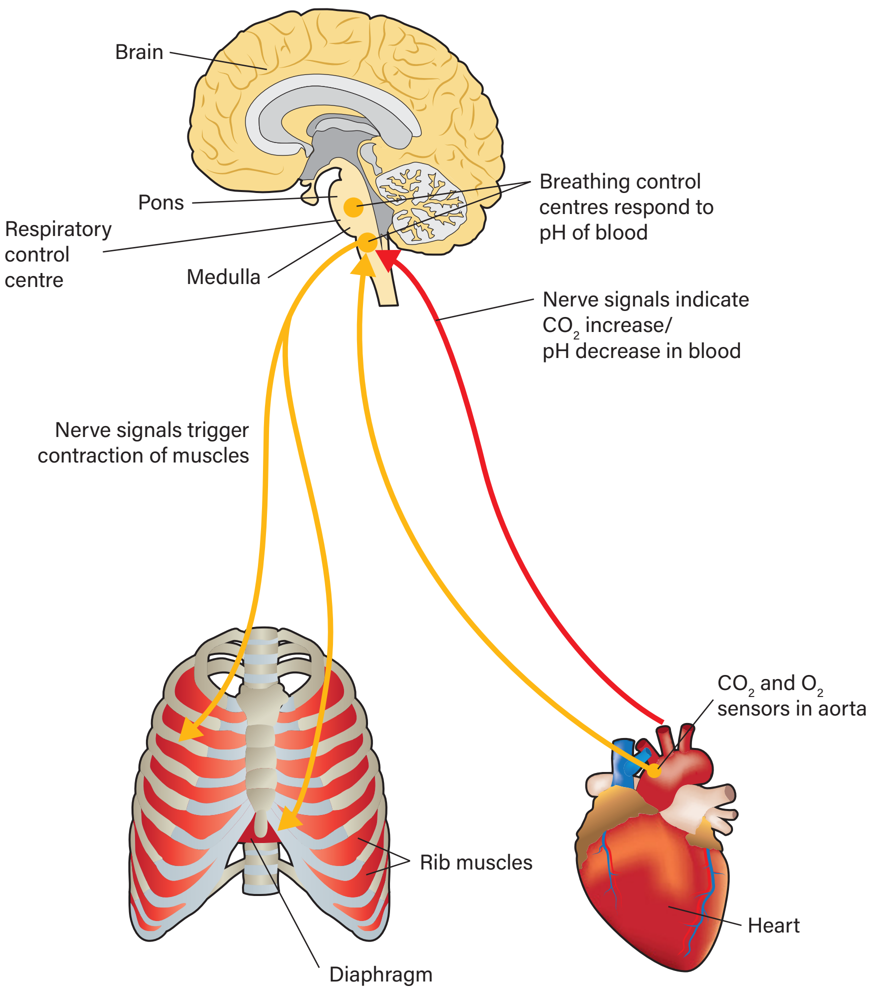


FIGURE 5.10 The respiratory control centre located in the brain combines with sensors at the aorta to monitor CO_2 and O_2 levels to ensure that the body's oxygen demands can be met quickly.

Deeper and more frequent breathing occurs due to increased firing of inspiratory nerves and the increased recruitment of motor units within the intercostals and diaphragm. Our lungs are prevented from excess inspiration due to stretch receptors within the bronchi and bronchioles, which send impulses to the brain when stimulated, resulting in an increase in expiration. Breathing frequency is also increased during exercise because the expiratory centre is activated and stimulates the expiratory muscles, the abdominals and the internal intercostal muscles, making expiration an active process and increasing its rate.

LOOKING BACK
Neural control
Chapter 1

In Chapter 1 you learnt about neural control on muscles and how recruiting more motor units results in stronger contractions.

DID YOU KNOW?

The build-up of carbon dioxide makes the blood acidic and decreases pH. This, more than a lack of oxygen, is what prompts the respiratory control centre to signal the lungs to increase breathing rates.

ABOVE AND BEYOND THE STUDY DESIGN

Asthma, p. 190

Assessment
5.2 Check-in questions

5.2 CHECK-IN QUESTIONS

1. **Outline** the difference between internal and external respiration.
2. During exercise there is an increase in gaseous exchange at the lungs. Referring to pressure gradients, clearly **discuss** why the rate of gaseous exchange increases in direct response to exercise intensity.
3. When H+ accumulates in the blood, ventilation increases. How does consuming more oxygen help the body return to homeostasis?
4. Hyperventilation occurs when we start to breathe rapidly, and sometimes occurs when people are anxious. This results in increased oxygen levels and lower levels of carbon dioxide in the body, sometimes causing people to feel light-headed and even faint. **Propose** why this happens, considering how the respiratory system responds to hyperventilation.

Command term

discuss
Present a clear, considered and balanced argument or prose that identifies issues and shows the strengths and weaknesses of, or points for and against, one or more arguments, concepts, factors, hypotheses, narratives and/or opinions

5.3 THE CARDIOVASCULAR AND RESPIRATORY SYSTEMS AT REST AND EXERCISE

In this module you will learn about:

- how oxygen is taken up by the respiratory system and transported by the cardiovascular system
- change to the cardiorespiratory system resulting from excess post-exercise oxygen consumption (EPOC)

and learn to:

- describe and explain oxygen deficit, steady state and EPOC
- link availability of oxygen to energy system contribution to energy supply.

At rest

When a person is at rest, oxygen supply is equal to oxygen demand, and the body is said to be in a **steady state**. This results in the right amount of oxygen being transferred to the person's blood when they inhale, and the right amount of carbon dioxide being exchanged and exiting the blood when they exhale. Table 5.1 reveals ventilation at rest, and how this changes during exercise. Recall that tidal volume has a finite capacity and once reached will not increase – for example, it peaks at 40–50% maxHR and then does not increase any further, despite increased oxygen demands.

steady state
A situation where oxygen supply is able to meet oxygen demand

by-product
A substance that is produced as a result of a chemical reaction

linear relationship
Occurs when two variables have a direct connection – for example, if the value of *x* is changed, *y* must also change in the same proportion

TABLE 5.1 Ventilation at rest and various exercise intensities

State	Respiratory rate (breaths/min)	Tidal volume (L/breath)	Minute ventilation (L/min)
Rest	12	0.5	6.0
40–50% maxHR exercise	25	2.5	62.5
85–95% maxHR exercise	60	2.5	150.0

During exercise

During exercise, two major body systems come into action: the cardiovascular and respiratory systems. Essentially, the respiratory system brings oxygen into the body to produce energy, and removes carbon dioxide, the **by-product** of energy production. The cardiovascular system pumps the oxygen throughout the body to tissue and the working muscles.

To cope with the extra oxygen demand from the muscles, breathing needs to increase from resting levels of about 12–15 breaths per minute (6–8 litres of air), up to about 25–60 breaths per minute (60–150 litres of air) during exercise. There is a direct **linear relationship** between exercise intensity and both heart rate and respiratory rate. This means that as exercise intensity increases, both of these variables will also increase. During decreases in intensity, these will lower at the same time and eventually return to resting levels once recovery has been completed.

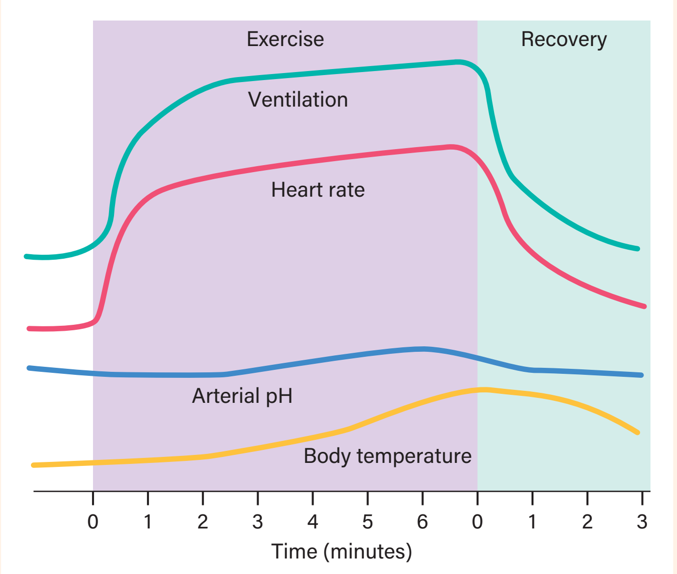


FIGURE 5.11 Changes in heart rate, ventilation, pH and body temperature in response to exercise

As oxygen demands increase during exercise, so too does the gas exchange requirement at the lungs. Respiratory rate and tidal volume increase (up to finite capacity), contributing to increased ventilation and uptake of oxygen at the lungs. As discussed earlier, the volume of gas that moves across a tissue is proportional to the area available for diffusion and the difference in pressure across the membrane.

oxygen deficit
A situation when the body's oxygen consumption exceeds the intake of oxygen – i.e. oxygen demand exceeds oxygen supply

At the commencement of exercise and also when workloads are increased, the demand for oxygen exceeds the body's ability to supply it and a period of **oxygen deficit** occurs. If an athlete works submaximally, oxygen demand will level off and they will experience steady state. This occurs when oxygen supply can meet oxygen demand, and is commonly experienced when jogging, rowing, cycling or swimming at a comfortable and steady pace.

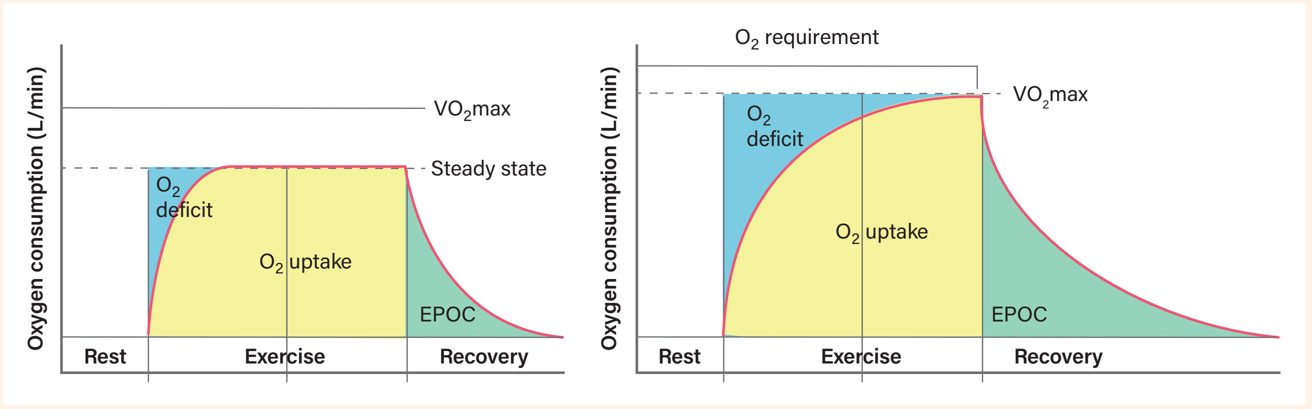


FIGURE 5.12 Oxygen consumption at rest, submaximal and maximal exercise intensities and associated recovery

Source: W. McArdle, F. Katch, & V. Katch (2007), *Exercise Physiology: Energy, Nutrition and Human Performance*, 6th edn, Chicago: Lippincott Williams & Wilkins.

VO_2 maximum
The maximum amount of oxygen that can be taken in, transported and utilised per minute

When exercise intensity increases, there comes a point where oxygen supply can no longer meet demand, and another deficit occurs. At highest intensities, a point is reached where the maximum amount of oxygen that can be taken in, transported and utilised – known as **VO_2 maximum** – is reached. This intense exercise cannot be sustained for extended periods, as the body will not be able to supply sufficient oxygen to meet these high demands and fatigue will soon set in.

Video
In focus: VO_2 max during a ramp treadmill test

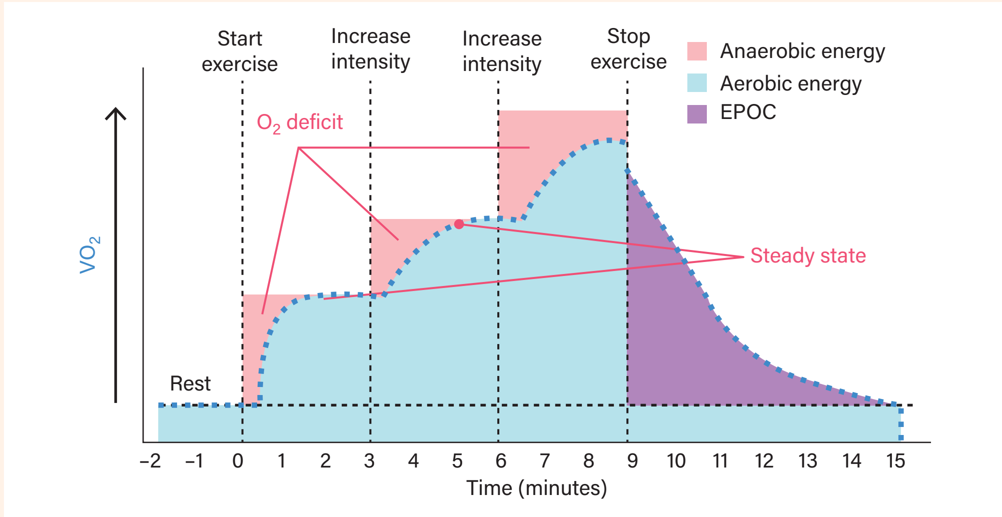


FIGURE 5.13 Oxygen consumption during a ramp test performed on a treadmill where speeds are increased periodically. Note the multiple steady states and oxygen deficits that coincide with increased demand for oxygen that cannot be met initially.

Oxygen consumption during recovery

When exercise, training or competition ceases, oxygen demands drop and oxygen consumption levels gradually return to resting levels. The post-exercise period where oxygen consumption remains above resting levels is known as oxygen debt, or **excess post-exercise oxygen consumption (EPOC)**. People who participate in regular aerobic activities or undertake aerobic-based training will see a faster return to resting levels of oxygen consumption than those who have lower levels of aerobic training and associated adaptations.

When we exercise, more alveoli are recruited for gas exchange. As a result, the surface area available for gas exchange increases, and thus the rate of diffusion of gases such as oxygen and carbon dioxide will also increase.

Exercise results in increased stroke volume (limited capacity), heart rate and contractility, which all contribute to increased **cardiac output**. This results in more blood being sent to the lungs to pick up more oxygen and expel more carbon dioxide, as a by-product of cellular respiration. As exercise intensity increases, more pulmonary capillaries are recruited, further increasing the rate of gaseous exchange at the lungs. Recruitment of pulmonary capillary beds that had relatively low blood flow at rest, and an improvement in alveolar–capillary membrane conductance due to thinning caused by increased pulmonary capillary **perfusion**, greatly speeds up the rate of gaseous exchange.

excess post-exercise oxygen consumption (EPOC)
The period during recovery from exercise when oxygen consumption remains above resting levels

cardiac output
Cardiac output = Stroke volume × Heart rate

perfusion
The flow of blood or fluid to tissues and organs, primarily via the circulatory system

SIGNPOST

Watch the video 'Observe how a red blood cell travels from the heart to the lungs and other body tissues to exchange oxygen and carbon dioxide' on the Britannica website.

Weblink
Observe how a red blood cell travels from the heart to the lungs

Video
In focus: Active vs passive recoveries and effects on EPOC

Assessment
5.3 Check-in questions

5.3 CHECK-IN QUESTIONS

1 **Discuss** why it takes longer to reach steady state when exercising at 75% maxHR compared to 50% maxHR.
2 **Explain** how increased oxygen demand by muscles can be met once tidal volume reaches its finite capacity.
3 During exercise, more blood is directed to working muscles as well as to the lungs. **Discuss** the role greater blood flow to the lungs plays in picking up more oxygen and giving off more carbon dioxide during exercise.
4 Steady state is common in most endurance events, such as marathons and triathlons.
  a **Explain** why steady state makes up such a large portion of these endurance events.
  b Apart from the first few minutes of these events, clearly **discuss** when oxygen deficit might otherwise occur.

LEARNING HACK

Lactate inflection point (LIP) is the highest aerobic intensity possible, when maximal amounts of lactate production are matched by lactate removal. This is sometimes referred to as the maximal lactate steady state. This is the fastest someone can run, swim, cycle etc. without needing to slow down due to the build-up of fatiguing by-products.

5.4 REGULAR AEROBIC EXERCISE AND ENHANCED FUNCTIONING OF THE CARDIOVASCULAR AND RESPIRATORY SYSTEMS

In this module you will learn about:
- benefits associated with meeting physical activity guidelines and regular participation in aerobic exercise
- long-term adaptations occurring at the cardiovascular and respiratory systems by participating in regular aerobic-based activities and training

and learn to:
- link cardiorespiratory adaptations to improved lifestyle and training outcomes.

Participating in regular physical activity and limiting sedentary behaviour is central to achieving good health and psychosocial wellbeing. Regular activity supports brain development, bone strength, muscle control, balance and coordination, and helps to achieve and maintain a healthy weight. It can also positively affect sleep patterns, mental health, concentration, self-esteem and confidence.

Participation in sufficient levels of physical activity is also important for cardiovascular, respiratory and musculoskeletal health, and plays a critical role in the prevention and treatment of non-communicable diseases such as heart disease, type 2 diabetes and some cancers.

LOOKING FORWARD

Physical activity guidelines

Chapter 10

In Chapter 10 you will learn about the physical activity guidelines that are recommended for different age groups. In Chapter 13 you will be required to design a personalised physical activity plan to promote physical activity and reduce sedentary behaviour.

Enhancing the capacity and functioning of the cardiovascular system

Participating in moderate to vigorous physical activity (70–85% maxHR) for a minimum of 20 minutes at least three times per week will result in the following beneficial cardiovascular changes.

Increased stroke volume

The left ventricle will increase in size, allowing it to receive more blood and then squeeze out more blood per systole. This contributes to an increased cardiac output, resulting in more blood, oxygen, fuels and nutrients being transported to working muscles and more carbon dioxide and other wastes being removed from the muscles.

Because more blood can be ejected per beat, the heart does not need to work as hard to supply muscles at rest, resulting in lower resting heart rates. Stroke volume finite capacity also lifts, from 40–50% maxHR up to 60–70% maxHR, meaning the heart rate doesn't need to increase to meet increased demands. The heart becomes more efficient and does not need to work as hard to meet exercise demands. As a result, the rate of perceived exertion (RPE) decreases for equivalent types of exercise and activity.

LEARNING HACK

RPE = rate of perceived exertion. This is a subjective measure of how hard someone is working.

Increased ventricle thickness

The heart is a powerful muscle. Aerobic exercise 'strengthens' this muscle, and in particular the ventricles – especially the left ventricle because of its systemic blood flow (as opposed to pulmonary blood flow in the right ventricle). This results in greater contraction force, which also increases stroke volume and cardiac output.

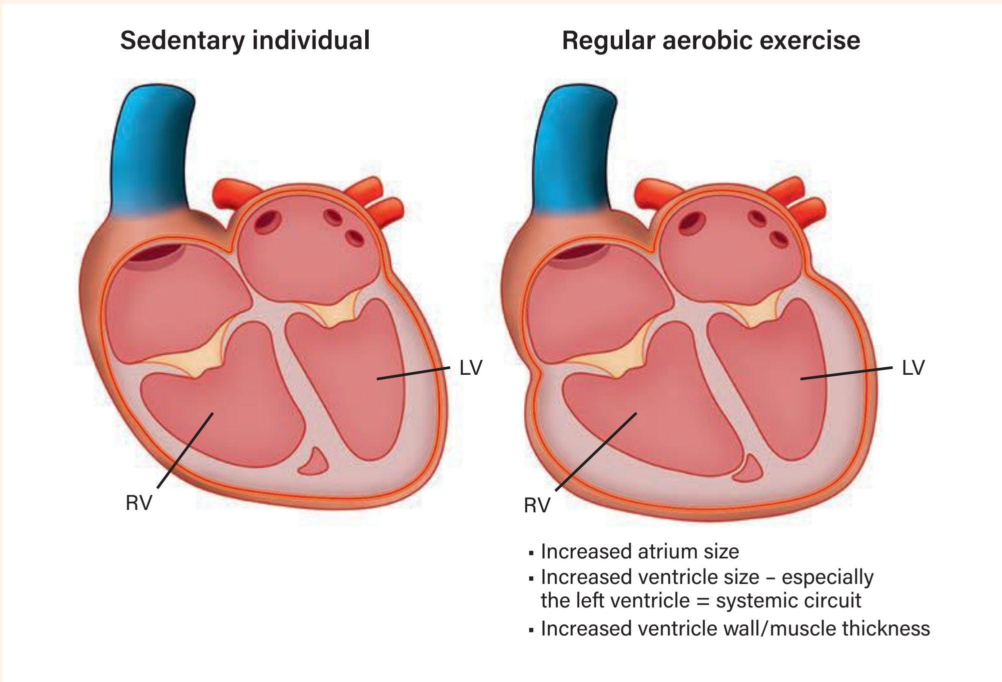


FIGURE 5.14 Changes to the heart structure as a result of participation in regular aerobic-based exercise

Improved oxygen extraction

As the cardiovascular system becomes stronger, more oxygen is transported to working muscles and a larger proportion of this is extracted from the capillaries, resulting in a higher arteriovenous oxygen difference (a-VO_2 diff). With more oxygen being available to working muscles, exercise can occur either at higher intensities aerobically or at moderate intensities with less oxygen and energy – basically, exercise becomes much easier.

LEARNING HACK

a-VO_2 diff is a measure of the oxygen difference in the arterioles compared to the venules after blood has travelled through the capillaries surrounding muscles. The arteriovenous oxygen difference is considered to be either a cardiovascular or muscular event – it is not part of the respiratory system.

Increased blood volume

Having more red blood cells increases the oxygen-carrying capacity of blood, and so increases the supply of oxygen to working muscles. More plasma increases the ability of fuels to be transported to muscles and wastes to be removed from them. Increased plasma levels also act to maintain homeostasis and prevent the body from overheating – this is a significant thermoregulatory benefit. More plasma also reduces the vascular resistance of arteries and arterioles.

Decreased systolic blood pressure

As well as helping reduce stress on the heart, meaning more fuels and oxygen are available for muscles contributing to exercise, decreased systolic blood pressure reduces the risk of cardiovascular disease such as hypertension, stroke or heart attack. Aerobic-based exercise also reduces the amount of 'bad cholesterol' – low-density lipoproteins (LDL) – and increases the levels of 'good lipids' – high-density lipoproteins (HDL). The build-up of fats and cholesterol on arterial walls is called plaque. This plaque causes arteries to narrow, become less elastic and reduce blood flow. This condition is known as **atherosclerosis**. If plaque becomes dislodged it may block blood flow altogether and result in a stroke or heart attack. A cardioprotective benefit arises from having less plaque build-up on the inside of arteries. Elasticity is maintained or increased as well as increasing the ability to remove existing plaque to create larger amounts of blood able to be transported to the heart and other muscles.

atherosclerosis
A condition resulting from the arteries becoming narrow due to a build-up of plaque on the artery walls

REAL WORLD APPLICATIONS

Atherosclerosis vs arteriosclerosis

The terms 'atherosclerosis' and 'arteriosclerosis' are often used interchangeably, but they're different conditions. Atherosclerosis happens when your arteries become narrow due to a build-up of plaque. Arteriosclerosis is a condition in which your artery walls thicken, harden and become less elastic. Atherosclerosis is a type of arteriosclerosis. Both conditions can occur if higher blood pressure and potential health risks are left untreated.

Increased vascularisation

Along with increased blood volumes, there is also an increase in the amount of blood vessels, especially capillaries, which are responsible for exchange of gases, transfer of fuels and removal of wastes. When combined with a greater redistribution of blood to exercising muscles, increased capillary density significantly enhances perfusion.

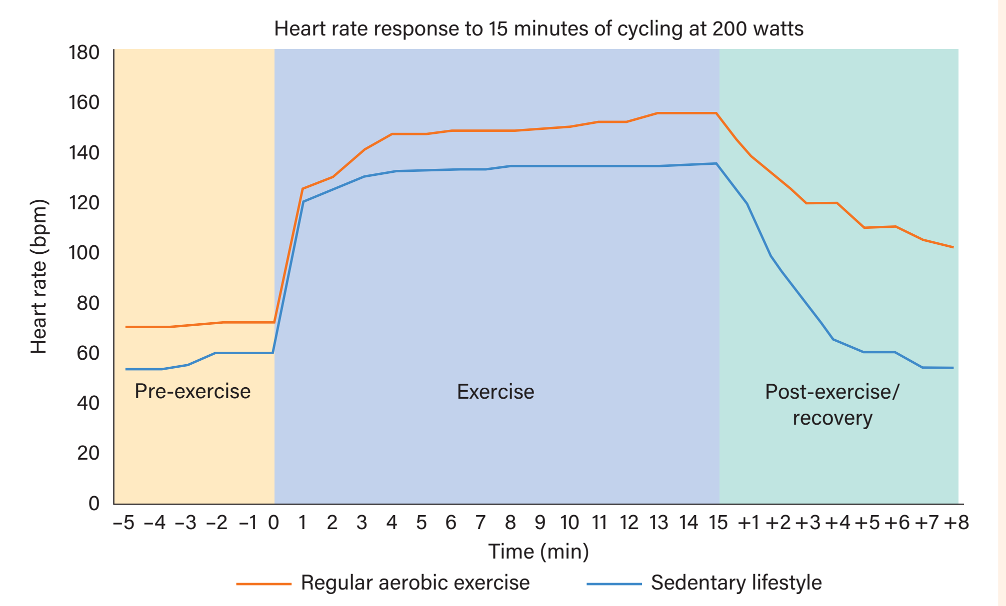


FIGURE 5.15 Heart rate response during sub-maximal exercise for two 20-year-old males. One participates in regular aerobic training, while the other does not meet the physical activity and sedentary behaviour guidelines for adults.

FIGURE 5.16 Working out with others has been proven to result in higher levels of exercise, and is often a good motivator when starting a training program. Many cardiovascular and respiratory changes occur when including aerobic-based exercises such as skipping in regular workouts.

DATA ANALYSIS

The following two graphs reveal the difference in blood flow and arteriovenous oxygen in response to increasing workloads. Subjects had both these variables measured while running on a treadmill that was programmed to increase its speed every minute. The running speed corresponded to the volume of oxygen consumed, and this has been used to indicate workload.

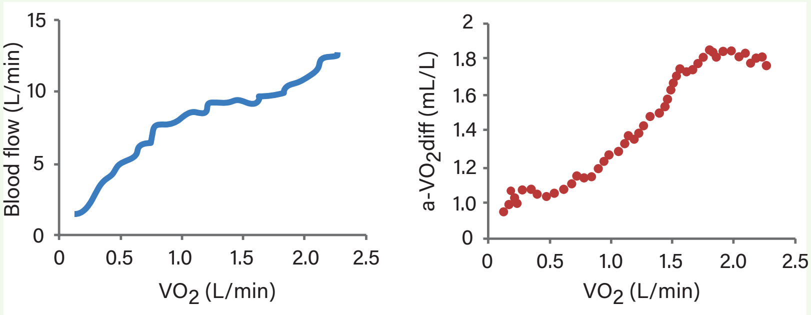


FIGURE 5.17 The relationship between blood flow (left) and oxygen use (right) during graduated exercise

Source: L. Ferreira, S. Koga & T. Barstow, 'Dynamics of noninvasively estimated microvascular O_2 extraction during ramp exercise', *Journal of Applied Physiology,* 1 December 2007, vol. 103, no. 6. Copyright © 2016 The American Physiological Society.

1 **Describe** any trends that are evident when comparing oxygen consumption, arteriovenous oxygen difference and blood flow.

2 Why does the a-VO_2 diff plateau towards the end of the test while blood flow continues to increase linearly?

Command term

describe
Provide characteristics, features and qualities of a given concept, opinion, situation, event, process, effect, argument, narrative, text, experiment, artwork, performance piece or other artefact in an accurate way

>

Command term

explain
Give a detailed account of why and/or how with reference to causes, effects, continuity, change, reasons or mechanisms; make the relationships between things evident

3. If the a-VO_2 diff graph represents the response of an untrained 20-year-old male who can get to level 5 on the beep test, draw a new set of axes to show the response of a trained 20-year-old male who can get to level 14 on the beep test. Assume both are running at the same incremental pace throughout the test.
4. As a-VO_2 diff increases throughout the test, what must be happening to gas exchange between the alveoli and capillaries at the lungs as well as in the muscle cells and surrounding capillaries? **Explain** why you believe this to be different from resting conditions.

COLLABORATIVE TASK
Prac activity

Heart rate and respiratory response to exercise

AIM

To collect and analyse data relating to the range of acute effects that physical activity has on the cardiovascular and respiratory systems.

EQUIPMENT

One heart-rate monitor (smart watch with digital readout is okay) and stopwatch per subject, and access to a basketball/netball court

METHOD

Students will ideally work in pairs – one will be the subject, the other will record heart rate and respiratory rate every minute. Roles will then be swapped. Record the subjects' pre-exercise levels of heart rate and respiratory rate.

Subjects will be required to select two zones they would like to run continuously for three minutes up and back (width-ways) on a basketball/netball court. Record heart rate as well as respiratory rate every minute for the duration of the run, including three minutes of passive recovery from the activity.

After both subjects have completed their first run (allowing recovery in between while they swap roles), they will repeat the procedure for their second chosen zone. For example, Subject 1 chooses Zone 2, their classmate chooses Zone 3. They both perform and record each others' heart rates and respiratory rates and then complete their second choice, e.g. subject 1 chooses Zone 4 and their classmate chooses Zone 5.

Note: The subject needs to remain stationary at the end of each minute while their partner observes the rise and fall of their chest for five seconds (this will be used to record an approximate respiratory rate when multiplied by 12). It is recommended that this be practised during rest to ensure student recorders know what to look for, how to use stop watches and so on.

The table below illustrates five HR training zones.

Zone	Intensity	% of maxHR	Description
1	Very light	50–60	Equivalent to an easy walk and often used as an active recovery
2	Light	60–70	Equivalent to an easy run that could continue at this intensity for an extended period, e.g. a jog while maintaining conversation
3	Moderate	70–80	Equivalent to running pace that can be sustained for 10 minutes, but conversation is starting to become more difficult
4	Hard	80–90	Equivalent of a fast run where breathing becomes heavier and work rate cannot be sustained for more than 5–10 minutes
5	Maximum	90–100	Equivalent of a very fast run that cannot be sustained for longer than 1–2 minutes, e.g. sprinting

Complete the three minutes of continuous running followed by three minutes of passive recovery and then record all parameters in a table, as shown below. This data should be processed/graphed.

Time	Zone: Heart rate	Respiratory rate	Zone: Heart rate	Respiratory rate
Pre-exercise				
1 min				
2 min				
3 min				
Recovery				
1 min				
2 min				
3 min				

DISCUSSION

1 **Discuss** any relationship between heart rate, exercise intensity (Zone) and respiratory rate.

2 Is there any evidence that steady state has occurred during the test? **Discuss** why this has or has not been achieved during the test and how the cardiovascular and respiratory systems contribute to this.

3 **Compare** your recovery heart rate and respiratory rate to that of another classmate and **discuss** why any differences might exist in the rate with which these return to pre-exercise levels.

Command term

compare
Recognise similarities and differences and the significance of these similarities and differences

SIGNPOST

Watch the video 'a-v O_2 difference' on the KINprof channel on YouTube. This excellent video clip clearly explains a-VO_2 diff, how it is calculated, and how it varies under different exercise conditions.

Weblink
a-VO_2 difference

Enhancing the capacity and functioning of the respiratory system

Participating in moderate to vigorous physical activity (70–85% maxHR) for a minimum of 20 minutes at least three times per week will result in the following beneficial respiratory changes.

Increased lung elasticity/capacity

Lungs increase their ability to expand, enabling a greater quantity of air, and oxygen, to move in and out (this is a similar adaptation to the increase in stroke volume in the cardiovascular system).

Increased alveolar surface area and size

This greatly increases the surface area available for gaseous exchange to take place. Coupled with the increase in a-VO_2 difference, the exchange of oxygen and carbon dioxide improves as the pressure gradient between each becomes larger. This occurs because the increase in oxygen being extracted from the capillaries by muscles and the increase in carbon dioxide produced both contribute to a larger difference/gradient between the blood and tissues.

Increased tidal volume

Stronger diaphragm and intercostal muscles increase the amount of air that can be inspired per breath, because the thoracic cavity increases. Having a greater tidal volume increases ventilation. This brings more oxygen into the lungs and also allows for greater exchange of carbon dioxide to occur.

Improved strength and endurance of respiratory muscles

Improved strength and endurance of respiratory muscles results in an enhanced ability to breathe in more air, as the thoracic cavity increases more during inspiration. Having greater endurance allows the diaphragm and intercostal muscles to contract for longer with less fatigue. Thus, activities become easier to perform because breaths are fuller and more air is inspired and expired per breath. Where previously you would have needed to stop a run, netball match or swim, or continue at a drastically reduced intensity/pace, improved capacity and functioning allows continued participation for longer with less fatigue.

Increased capillarisation at the lungs

More capillaries are formed in the lungs over time, allowing more blood to flow in and out of the lungs. This improves the uptake of oxygen, as there is a greater surface area for blood to bind with haemoglobin, and also increases the amount and rate of gaseous exchange. More carbon dioxide can also be removed from the body.

All of these changes to the cardiovascular and respiratory systems make it easier to perform daily tasks such as climbing stairs, participating in exercise and sports and undertaking recreational pursuits such as surfing, golf or mountain biking. Both systems become more efficient and use less energy to meet the exercise demands of the body.

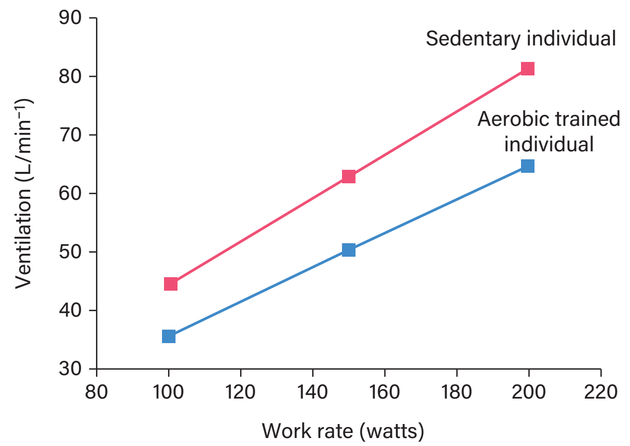


FIGURE 5.18 Participation in regular aerobic-based exercise results in lower ventilation during rest and sub-maximal exercise as the respiratory system becomes more 'efficient.'

LOOKING FORWARD

Improving cardiovascular and respiratory function

Units 3&4 – Chapter 15

In Chapter 15 of *Nelson Physical Education VCE Units 3&4* you will be taken through a range of training methods and chronic adaptations to the cardiovascular and respiratory systems that bring about improvements in performance.

5.4 CHECK-IN QUESTIONS

1 Tidal volume and stroke volume both increase in response to participation in regular aerobic-based physical activity. How do these work together to provide more oxygen to working muscles?
2 **Outline** how having 'stronger' respiratory muscles (the diaphragm and intercostals) leads to improved ventilation.
3 **Explain** what is meant by the statement 'the respiratory system becomes more efficient' when discussing the benefits of participating in regular aerobic-based exercise.
4 Aerobic conditioning leads to more oxygen being transported to working muscles, along with higher capillary density around the muscles. How do these combine to increase the arteriovenous oxygen difference during exercise?
5 How does having lowered blood pressure contribute to improved availability of oxygen for working muscles and also result in exercise becoming more comfortable or possible at a lower RPE?

Assessment
5.4 Check-in questions

ABOVE AND BEYOND THE STUDY DESIGN

MODULE 5.2, p. 178

Asthma

Asthma is a medical condition that affects the airways. From time to time, people with asthma find it harder to inhale and exhale, because the airways in their lungs become narrower in any of the following ways.

Airways tighten up

Inside the wall of each airway there is a thin layer of muscle. When it contracts, it makes the airway narrower. Reliever medicines work by relaxing these muscles in the airways.

Airways thicken up

The lining of the tubes gets swollen and inflamed, leaving less space to breathe through. Preventer medicines work by reducing the inflammation that causes the swelling.

Airways fill up

The inside of the tubes can get blocked by mucus. Preventer medicines reduce mucus.

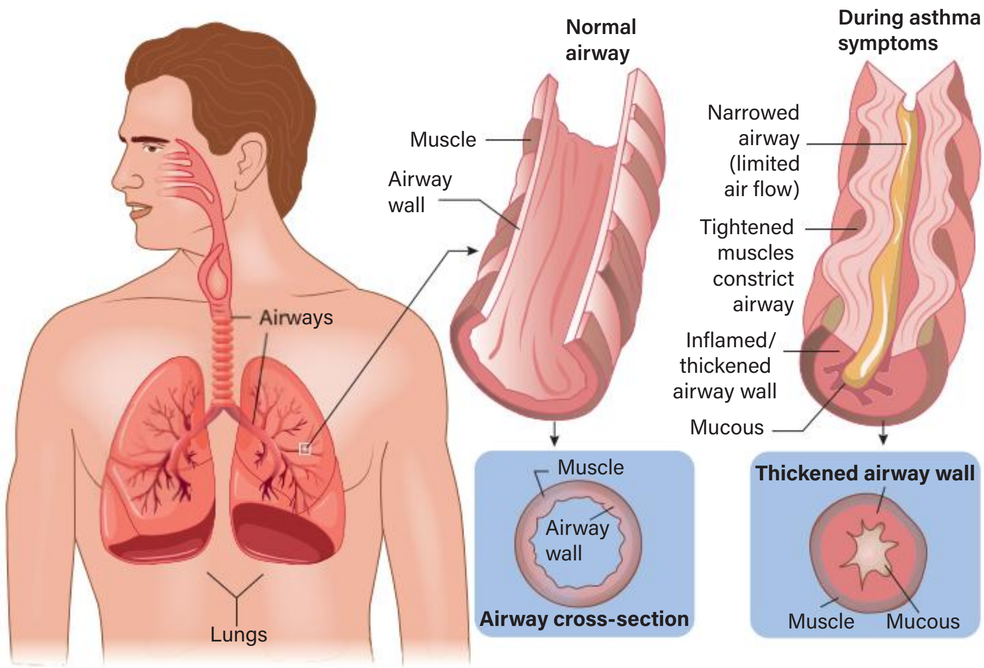


FIGURE 5.19 A normal airway versus an asthma-affected airway

Sometimes all three of these asthma-related changes to the airways occur at the same time. As well as causing serious discomfort, this is potentially life threatening unless treated effectively.

Having asthma should not restrict your ability to exercise or be physically active. If you feel uncomfortable during or after exercise, you should ask your doctor to investigate whether the management of your condition could be improved. In fact, many athletes have asthma and are able to compete at the highest level when their condition is well-managed.

Your doctor may prescribe medicine to control your symptoms. Inhaled steroids such as Ventolin, a drug commonly used by people with asthma, are the most important controller medication you can take. These act as bronchodilators, which stop the air passages (mainly the bronchi and bronchioles) from constricting and reducing the amount of air that reaches the alveoli.

SIGNPOST

Watch the video 'How asthma affects your lungs' on the Asthma + Lung UK channel on YouTube to see how the respiratory system is affected by asthma.

Weblink
How asthma affects your lungs

DID YOU KNOW?

Most asthma medicines are taken as inhalers or 'puffers.' Asthma medications are usually grouped into 'preventers' and 'relievers.' Preventers (e.g. Symbicort) are used daily to prevent asthma symptoms, while relievers (e.g. Ventolin) are used when necessary to relieve symptoms. Preventers can take several days or even weeks to work, so they're not for the quick relief of symptoms. To work properly, preventers need to be used every day, even when you have no symptoms.

CASE STUDY Marathon runner and asthma sufferer

KJELD HANSEN, DENMARK, HAS ASTHMA AND COMPLETED THE NEW YORK MARATHON

'It is hard to motivate yourself to train when your 100% is no match for a non-asthmatic person. My asthma sometimes felt as if I was breathing through a whistle. If you try to run and whistle at the same time, you'll feel what I felt.'

'During training for the marathon, I felt my confidence grow. I followed my treatment regime carefully and exercised at least 3 times a week. By following my treatment plan, I was able to get rid of my asthma symptoms. The marathon training also felt amazing – I was able to push myself to new levels and see improvements day-by-day.'

Batchelder/Alamy Stock Photo

FIGURE 5.20 Many people with asthma participate in aerobic-based activities such as the New York marathon with positive outcomes.

CHAPTER SUMMARY

Resource
Self-assessment checklist

Video
Masterclass: Chapter 5

5.1 The structure and function of the respiratory system

- Breathing involves gaseous exchange through a respiratory cycle involving inspiration and expiration of air.
- The respiratory system has the following main structures – nose, mouth, pharynx, larynx, trachea, bronchi and lungs.
- The respiratory muscles are the diaphragm and the intercostals (between ribs).
- Inspiration occurs when the respiratory muscles actively contract to increase the chest cavity, thus decreasing pressure.
- Expiration occurs passively when the respiratory muscles relax, forcing air out of the body.
- The primary function of the respiratory system is to supply oxygen to the body cells, tissues and organs and remove carbon dioxide from these areas.

5.2 Gaseous exchange at the lungs and muscles

- Gaseous exchange at the respiratory level can only occur in the alveoli, which come into direct contact with the capillaries of the cardiovascular system.
- Gaseous exchange at the lungs and muscles occurs due to pressure differences between gases on either side of membrane. Gases will move from high pressure to low pressure into and out of the body.
- Respiration at the lungs is considered external, while respiration at the muscles is considered internal.
- The amount of air breathed in per breath is known as tidal volume. This has a finite capacity.
- Ventilation = tidal volume (TV) × respiratory rate (RR)
- A direct linear relationship[p exists between exercise intensity and ventilation.
- Breathing is controlled by a respiratory control centre in the brain stem that constantly monitors the levels of oxygen and carbon dioxide in the bloodstream.

5.3 The cardiovascular and respiratory systems at rest and exercise

- When the brain senses that levels of carbon dioxide are high, it increases both the heart rate and respiratory rate to increase oxygen uptake and supply to muscles and other tissues.
- The amount of energy produced while oxygen demand is higher than oxygen supply at the start of exercise and during increases in work rate, is known as oxygen deficit.
- Steady state occurs when oxygen supply equals oxygen demand. This occurs at rest and also during exercise up to a moderate intensity.
- While the body recovery from exercise, oxygen levels remain above resting levels. This is known as excess post-exercise oxygen consumption (EPOC).
- During exercise, more blood is directed to the lungs and working muscles in an effort to take up and transport more oxygen and remove higher amounts of carbon dioxide.

- Exercise results in increased stroke volume, heart rate and contractility, which all contribute to increased cardiac output.
- As exercise intensity increases, more pulmonary capillaries are recruited, further increasing the rate of gaseous exchange at the lungs.
- Exercise results in the lungs expanding and alveoli surface area increasing significantly to increase the rate of gaseous exchange.

5.4 Regular aerobic exercise and enhanced functioning of the cardiovascular and respiratory systems

- Participation in regular aerobic-based activities as per the activity guidelines or as part of a personalised training program results in the cardiovascular and respiratory systems improving their efficiency in several ways.
- Respiratory adaptations/improvements:
  - Increased lung elasticity/capacity
  - Increased alveolar surface area and size
  - Increased tidal volume
  - Improved strength and endurance of respiratory muscles
  - Increased capillarisation at the lungs
- Cardiovascular adaptations/improvements:
  - Increased stroke volume
  - Increased ventricle thickness
  - Improved oxygen extraction (a-VO_2 diff)
  - Increased blood volume
  - Decreased systolic blood pressure
  - Increased vascularisation

CHAPTER REVIEW

Assessment
Chapter 5 Review

1 **Identify** the respiratory response that occurs once we start exercise such as going for a jog.

A Increased heart rate

B Decreased resting heart rate

C Increased gaseous exchange

D Decreased fuel stores

2 Why is the ventilation of a marathon runner at maximal intensity going to be higher than that of a netball centre at maximal intensity?

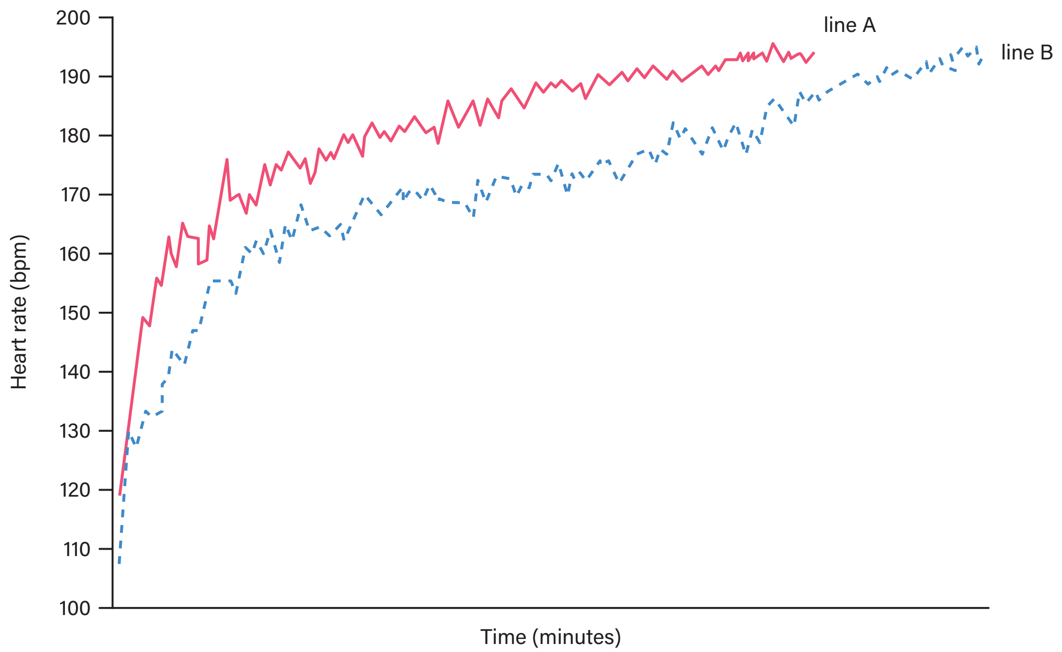
3 Participating in regular aerobic-based exercise that meets the activity guidelines results in steady state being achieved earlier when swimming laps at the local pool. **Explain** how this occurs.

4 **Discuss** how surface area greatly affects the rate of gaseous exchange at the lungs and what happens after months of aerobic exercise to improve this.

5 People who have higher levels of aerobic fitness recover from exercise, training and competition quicker than those who have lower levels of aerobic fitness. **Propose** why this may be the case, from a cardiovascular and respiratory perspective.

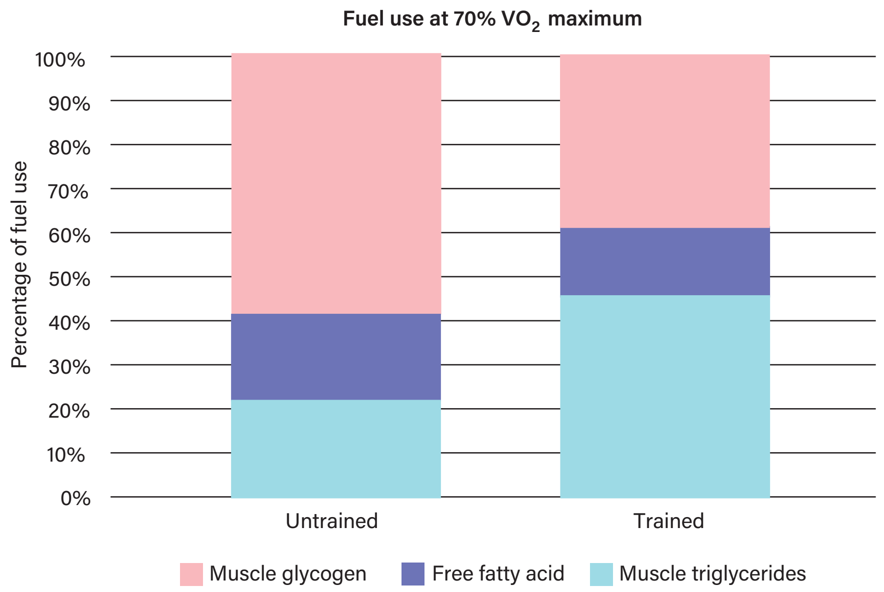
6 Referring to the data in the following graph, identify which line – line A or line B – shows the test result after the aerobic-based training program. **Justify** your response by referring to two cardiovascular and/or respiratory changes that would explain the improved test result.

Heart rate response to aerobic power fitness test before and after participating in an aerobic-based training program



7 The Ironman Triathlon consists of a 3.86-km swim, a 180.25-km bicycle ride and a 42.20-km marathon, raced in that order. Races generally last eight hours for world-class performers.
List one acute response and describe how it results in increased oxygen uptake during exercise.

8 The graph below shows the changes in fuel use for a cross-country runner before and after a 12-week training program.



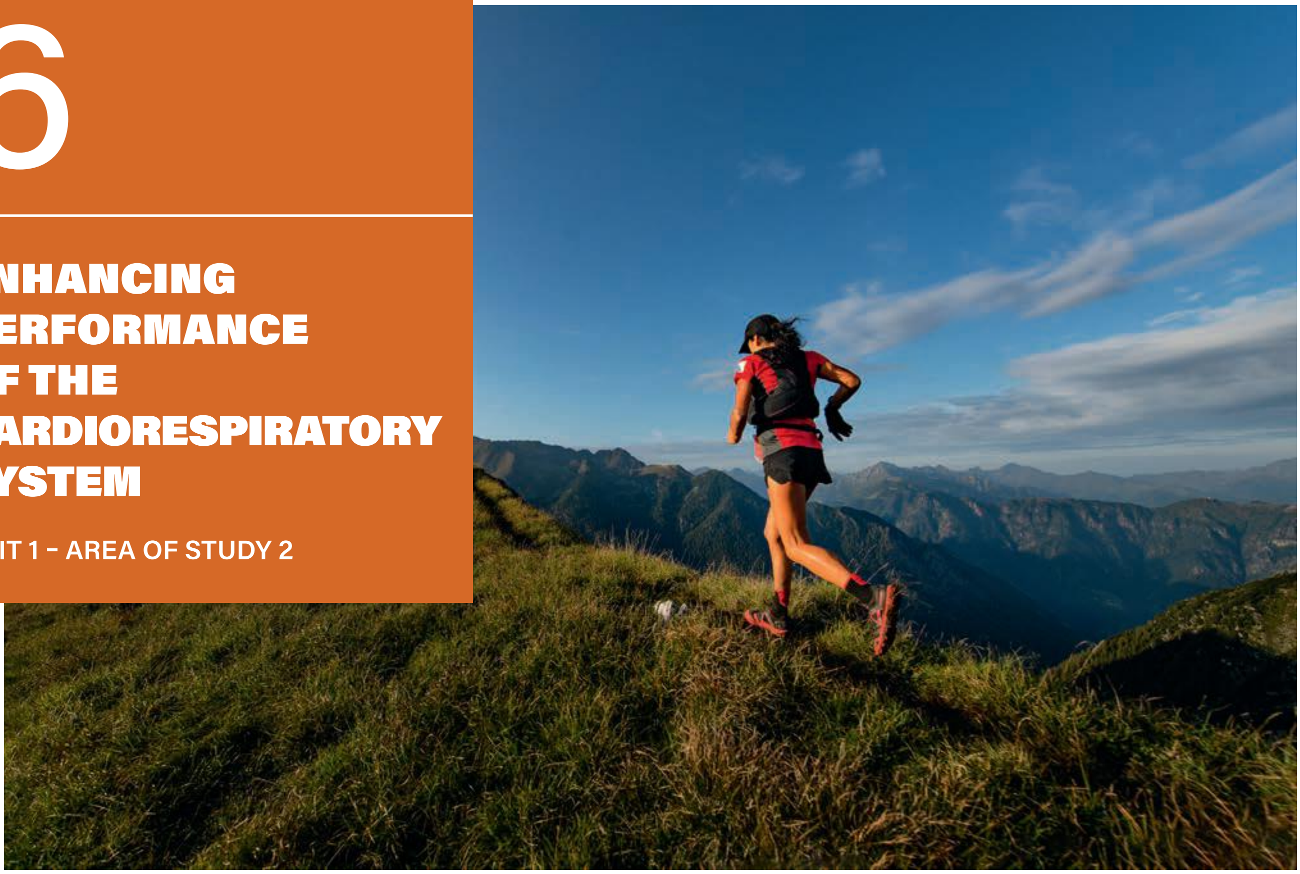
Source: Victorian Curriculum and Assessment Authority

Predict the variation in the tidal volume and respiratory rate of the trained athlete compared to an untrained athlete, during a 60-km cross-country race.

CHAPTER 6

ENHANCING PERFORMANCE OF THE CARDIORESPIRATORY SYSTEM

UNIT 1 – AREA OF STUDY 2



michelangeloop/Adobe Stock

FIGURE 6.01 Athletes use strategies such as altitude training to enhance their cardiorespiratory system.

Quizzes

Chapter 6 Pulse check

6.1 Check-in questions

6.2 Check-in questions

6.3 Check-in questions

Chapter 6 Review

Videos

Masterclass: Chapter 6

6.2 In focus: Altitude training

Resources

Chapter 6 Self-assessment checklist

Nelson MindTap

To access resources above, visit **cengage.com.au/nelsonmindtap**

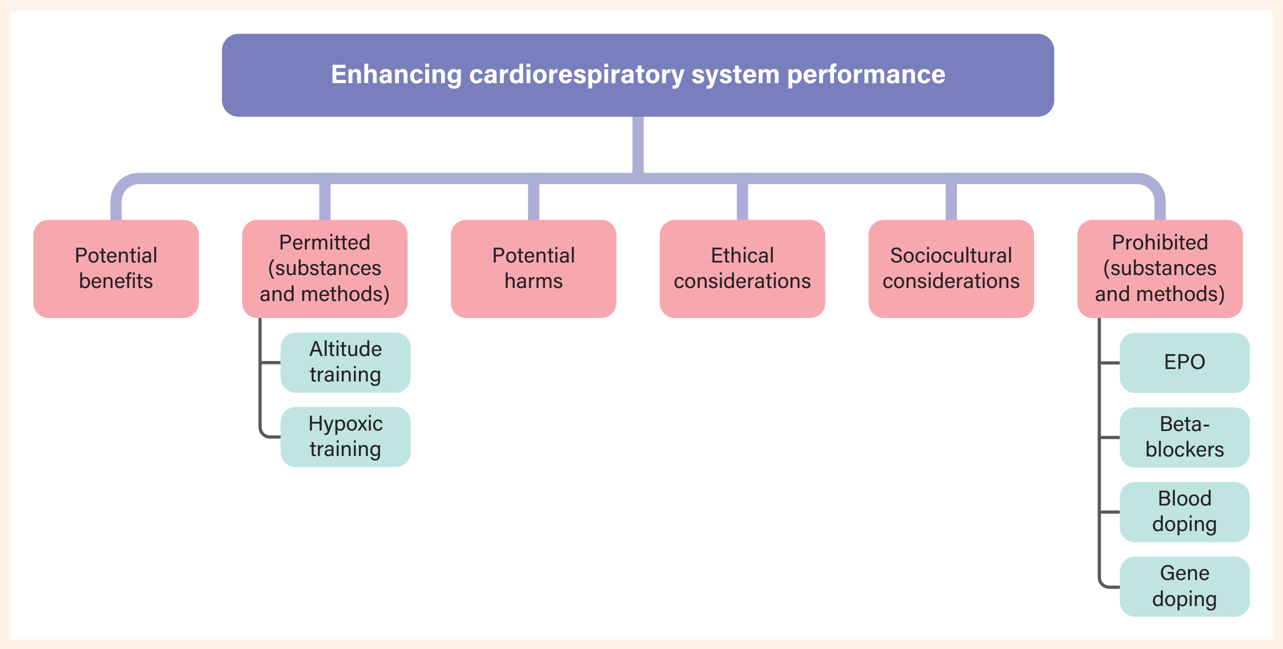
KEY KNOWLEDGE

- » potential benefits and harms of permitted and prohibited substances and methods that enhance performance of the cardiorespiratory system, such as altitude training, erythropoietin (EPO), beta-blockers, and gene and blood doping
- » ethical and sociocultural considerations associated with the use of permitted and prohibited performance-enhancing substances and methods

KEY SKILLS

- » investigate and evaluate the effects of a range of performance-enhancing substances and methods on the cardiorespiratory system from a physiological perspective
- » explore the ethical and sociocultural considerations relating to the use of permitted and prohibited performance-enhancing substances and methods

Source: VCAA VCE Physical Education Study Design (2025–29)



Video
Masterclass: Chapter 6

beta-blockers
A type of medication that slows down cellular activity including heart rate

doping
The use of prohibited substances or methods to unfairly improve sporting performance or mask presence in the body to gain an advantage over competitors

Assessment
Chapter 6 Pulse check

In Chapter 6 you will review why certain substances and methods are permitted or prohibited, and explore the ethical and sociocultural considerations relating to the use of ergogenic aids. With a focus on the cardiorespiratory system, you will evaluate permitted strategies such as altitude training and hypoxic environments, as well as those that are prohibited, such as erythropoietin (EPO), **beta-blockers** and gene and blood **doping**. These strategies will be explored from a physiological perspective, and you will need to explain the potential benefits and harms of each. Real world applications will form an important part of this chapter as you investigate why substances and methods are used for performance enhancement.

PULSE CHECK

Take the pulse check quiz to check your prior knowledge and understanding of the concepts covered in this chapter.

1 **Identify** three sports where having a highly trained cardiorespiratory system may be of benefit.

2 What does it mean when sporting codes state that players and athletes are expected to act with integrity?

3 Brainstorm why a substance or method may be prohibited by the World Anti-Doping Agency.

4 Rapid fire anything you know about altitude training: who, what, how, why?

5 **Explain** how an increase in red blood cells could enhance the capacity and functioning of the cardiorespiratory system.

6.1 ENHANCING PERFORMANCE OF THE CARDIORESPIRATORY SYSTEM

In this module you will learn about:
- the role of the World Anti-Doping Agency (WADA) and Sport Integrity Australia and the criteria for determining if a substance is on the Prohibited List
- ethical and sociocultural considerations associated with the use of permitted and prohibited performance-enhancing substances and methods

and learn to:
- determine the difference between a permitted and prohibited substance or method.

In Chapters 4 and 5 you studied the structure and function of the cardiovascular and respiratory systems. These chapters explored the role of each system during rest and at higher intensities, such as those experienced when exercising or playing sport. They explored how the two systems interact to take in and transport oxygen to working muscles, and investigated how undertaking regular aerobic exercise can result in adaptations in the body to enhance the capacity and functioning of these systems.

This chapter builds on your knowledge and understanding of how these systems combine and work to explore a range of performance-enhancing substances and methods, known as ergogenic aids. You will review why an ergogenic aid might be permitted or prohibited, and explore ethical and sociocultural considerations regarding the use of performance-enhancing strategies.

Before we look at specific performance-enhancement strategies, it is important we review how and why substances and methods are classified as permitted or prohibited, and identify the governing bodies of global and national sport that work to ensure safety and fair play for all athletes.

World Anti-Doping Agency (WADA)

The World Anti-Doping Agency (WADA) works to achieve worldwide dope-free sport. WADA was established in 1999 to build consistency between anti-doping organisations around the world. WADA created the World Anti-Doping Code, which was most recently updated in 2021 and aims to, among other things, protect the right of athletes to participate in dope-free sport in order to promote fairness, health and equality. Figure 6.02 shows some key moments in the journey to dope-free sport in Australia and around the world.

Other key roles of WADA include: scientific research; education of governing bodies, coaches and athletes; and ensuring compliance with the anti-doping code. WADA set the rules on which substances and methods are permitted, and which are prohibited. Read more about WADA later in the chapter when exploring beyond the study design.

1999	The International Olympic Committee convenes the first World Conference on Doping in Sport, resulting in the Lausanne Declaration on Doping in Sport. The World Anti-Doping Agency (WADA) is established as an independent agency funded equally by the sport movement and governments of the world.
2004	WADA introduces the World Doping Code ('The Code') to ensure that athletes around the world, in any sport, all adhere to the same basic anti doping rules.
2006	The Australian Sports Anti-Doping Authority (ASADA), tasked to protect Australia's sporting integrity through the elimination of doping, replaces the Australian Sports Drug Agency.
2009	A revised Code comes into force. It is supported by five international standards to ensure a uniform approach to anti doping around the world.
2015	A revision of The Code comes into effect.
2020	The Australian Sports Anti-Doping Authority (ASADA), the National Integrity of Sport Unit and the nationally focused integrity functions of Sport Australia combine to form a new agency called Sport Integrity Australia.
2021	A revision of The Code comes into effect on 1 January 2021.

FIGURE 6.02 A historical reflection of the key moments in the fight for dope-free sport

Sport Integrity Australia

Sport Integrity Australia is Australia's national anti-doping organisation, and is responsible for the design and implementation of a sophisticated program that meets both Australian legislation and international requirements. Among other roles, Sport Integrity Australia provides advice and assistance to counter the use of prohibited substances and methods in sport.

Permitted substances and methods

permitted
Substances and methods that can be used in training and/or competition according to WADA

Chapter 3 outlined **permitted** and prohibited substances and methods that enhance the musculoskeletal system, and also discussed why these are permitted or prohibited. The same concept applies to the cardiorespiratory system. A permitted substance or method may have a slight performance advantage, but does not pose a health risk to the athlete and does not violate the spirit of the sport.

batch testing
Laboratory testing of a batch of produce to determine that the batch is free of prohibited substances

Many over-the-counter nutritional supplements such as protein bars or vitamins may appear to be permitted, as there are no prohibited substances in the ingredients list. However, Sport Integrity Australia advises that no supplement is safe, as many products can become contaminated with prohibited substances during production and processing. If athletes do choose to use a supplement, they are encouraged to use only **batch tested** products displaying one of the stamps shown in Figure 6.03. Sport Integrity Australia has put together a clip explaining how to check if your supplement is batch tested, which you can view in your MindTap resources.

FIGURE 6.03 To ensure a supplement isn't contaminated, athletes should only use batch-tested products that have a label from a recognised certifier.

Weblinks
How To Check if your Supplement is Batch Tested

Supplements: a cautionary tale

SIGNPOST

Watch a short clip explaining how to check if your supplement is batch tested by Sport Integrity Australia.

Watch the video 'Supplements: a cautionary tale' by Sport Integrity Australia. This video features a personal story from marathon runner Cassie Fien, who tested positive and received a nine-month ban after taking a nutritional supplement.

DID YOU KNOW?

The 'spirit of the sport' is defined as 'the ethical pursuit of human excellence through the dedicated perfection of each athlete's natural talents.'

Prohibited substances and methods

To be on the **Prohibited** List, a substance or method must meet two of three following criteria:

- It has the potential to enhance, or it does enhance performance in sport.
- It has the potential or represents an actual risk to the athlete's health.
- It violates the spirit of sport.

Sport Integrity Australia, 2024

prohibited
Substances and methods that cannot be used in training and/or competition according to WADA

A substance or method will also be included on the Prohibited List if there is evidence to suggest it has the potential to mask the use of other prohibited substances or methods.

It's important to emphasise that the use of performance-enhancing substances and methods is not only ethically questionable, but also poses serious health risks. Moreover, it undermines the principles of fair play and the integrity of sports competitions. Sports organisations have strict anti-doping policies and conduct regular testing, both in and out of competition, to maintain a level playing field and ensure the safety of athletes.

DID YOU KNOW?

Diuretics are a type of medication that increase the amount of urine the body produces. When urine is diluted, it makes it harder to detect a prohibited substance; therefore, potentially masking its use. Diuretics are always banned in sport, both in and out of competition.

SIGNPOST

Visit the Sport Integrity Australia website to find detailed information about the current list of prohibited substances and methods, athlete education and information about the anti-doping code.

Weblink
Sport Integrity Australia

Ethical considerations

Alongside the many physiological and psychological benefits of sports participation, sport provides an opportunity to develop life skills that are important for functioning effectively in society. These skills include collaboration, fair play, respect for others and inclusion. In short, playing sport helps develop ethical behaviour.

Ethical decision-making is important for maintaining the positive impact of sport on society. Athletes who choose to use a prohibited substance and/or method may gain a significant performance advantage which raises both ethical and moral questions.

Some important considerations for ethical decision-making when it comes to using performance-enhancing strategies include the following:

- Honesty: is there transparency when using this strategy?
- Fairness: can all athletes in this sport access this strategy?
- Safety: are there any health risks?
- Is using this strategy good role modelling?

WILLIAM WEST/AFP/Getty Images

FIGURE 6.04 The Matildas consistently demonstrate a positive and supportive team culture.

Sociocultural considerations

Our values, beliefs and behaviours are heavily influenced by the people around us. **Sociocultural** factors that impact our values include gender, family, peers and socio-economic status, as well as our community and cultural norms.

In this section we will explore how these factors can impact our beliefs and behaviour and look at case studies where sociocultural factors have had a large influence on athlete behaviour.

sociocultural
Of or relating to the interaction of social and cultural elements such as family, peers, community, gender, socio-economic status, cultural beliefs and traditions

LOOKING FORWARD
Sociocultural factors

Chapter 8

In Chapter 8 you will explore the impact of sociocultural factors on physical activity participation and behaviour.

Weblink
Clean freak

SIGNPOST

To find out how Sport Integrity Australia advises athletes to stay clean, watch the video 'Clean Freak' on the Sport Integrity Australia channel on YouTube.

Peers

When belonging to a sporting team, you are surrounded by people who often have similar goals and ideas about training and performance. Many professional teams spend a large amount of time together. Additionally, athletes in teams are guided by coaches, trainers and healthcare professionals who have one overarching goal – to help athletes and teams perform at their best. While most teams and organisations have positive cultures, there have been cases where the desire to win at all costs has been more important than fair play.

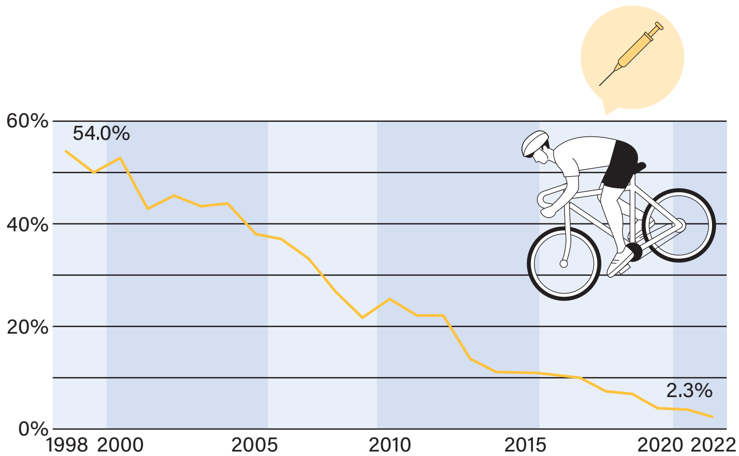
The Tour de France has long been associated with doping. Many of the substances and methods that athletes have used aimed to increase the oxygen carrying capacity of the blood, to enhance endurance for this gruelling race, which spans 23 days and over 3400 kilometres. Famously – or perhaps infamously – Lance Armstrong, who won the tour seven times, admitted to doping in 2013. He was stripped of his titles after more advanced retrospective testing returned a positive result, demonstrating the use of many prohibited

Doug Pensinger/Getty Images Sport/Getty Images

FIGURE 6.05 Cyclist Jan Ullrich won the Tour de France in 1997, and has since admitted to doping.

strategies. In 2023, German cyclist Jan Ullrich admitted to doping a year before he won the tour in 1997. He remains staunch in his defence, saying that everyone else was doing it, demonstrating the extent of peer influence on behaviour. He also said that unless he was doping, he had no chance, insisting that he was a fair person who only used prohibited strategies to keep up with others.

French cycling website cyclisme-dopage.com mapped cyclists who have tested positive, refused to take a test or admitted to doping during their cycling career. The results are displayed in Figure 6.06.



* Includes riders who tested positive, refused to take a doping test, admitted to having doped or have been sanctioned for doping at least once in their career, not necessarily at the Tour de France.

FIGURE 6.06 The percentage of Tour de France riders who have violated anti-doping regulations between 1998 and 2022

Community role models

The use of performance-enhancing substances and methods has moved beyond the professional sporting world. More recreational athletes are now seeking ways to improve their experience, whether through nutritional supplementation such as creatine, or recovery strategies such as cryotherapy or massage.

The shift of information distribution, particularly through social media, means that elite athletes are more accessible and therefore their beliefs, behaviours and actions can be scrutinised, judged and imitated. Elite athletes are role models and can influence the beliefs and behaviour of children and young people. If young people see professional athletes using prohibited performance-enhancement strategies, they may believe that is these strategies are acceptable and appropriate.

Some athletes take a strong and visible stance on anti-doping, mindful of their influence on young people. Medium-pace bowler Zoe Cooke, who plays for Queensland in the Women's National Cricket League, was part of WADA's Play True Day in 2023. On this day, female players came together to promote clean sport. As Zoe said, 'It's part of the Australian sporting mentality, you work hard, you do it cleanly, it's that simple.'

Albert Perez/Getty Images Sport/Getty Images

FIGURE 6.07 Cricketer Zoe Cooke is vocal in her stance on clean sport.

Socio-economic status

The amount of money an athlete can spend on equipment and clothing impacts the choices they make. Many biomechanically efficient and effective pieces of equipment are expensive, and the use of these links back to ethical decision-making. If something is not accessible for all athletes, is it fair?

Recently, there has been a lot of media attention on super shoes – shoes that are designed with special foam and a carbon fibre plate (CFP), designed to decrease energy expenditure and increase economy while running. A study conducted by Nike employees found that for the 18 runners tested, the super shoes reduced the energy cost of running by an average of 4 per cent compared with established marathon racing shoes. Other independent studies have found similar results.

The cost of super shoes starts at about $250, raising questions about how fair the use of these products is for athletes, particularly those in sub-elite categories who don't have sponsorships. Read more about the controversy surrounding technological advances in the case study below.

Nattawit Khomsanit/Dreamstime LLC; Joaquin Corbalan/Dreamstime LLC

FIGURE 6.08 The expensive Nike Vaporfly led the way in carbon fibre plate technology.

CASE STUDY A HISTORY OF TECHNOLOGICAL CHALLENGES

While the criteria for banning performance-enhancing substances and methods is clear, this becomes more challenging when it comes to technology in equipment and clothing. The dilemma regarding the CFP shoes is not unprecedented. For a long time, World Athletics has monitored controversial shoe designs. In the 1960s the 200 and 400 metre world records were broken within the space of two weeks with both athletes wearing a Puma-designed shoe termed the 'brush shoe,' which had 68 small needle-like spikes that improved grip and stability on a racetrack, compared to a standard shoe which has six to eight spikes. Just prior to the 1968 Olympics these shoes were banned, and the world records were deemed null and void. The World

Kohjiro Kinno/Sports Illustrated/Getty Images

FIGURE 6.09 The Puma brush shoe

Athletics Federation has implemented strict policies around shoes, producing a 17-page document to support and educate athletes in their shoe choice. Importantly, the Federation states that tailor made, individualised shoes are not permitted and do not comply with their attempt to create a level playing field where all shoes worn are freely available for purchase.

Similarly, FINA (now known as World Aquatics) produced a 26-page document detailing approved swimwear. This was prompted after multiple world records were smashed in the mid-2000s, when Speedo created LZR swimsuits using imitation shark skin. It was claimed that this material increased the flow of oxygen around the body, reducing drag and increasing buoyancy. The swimsuits were deemed to provide an unfair advantage and so were banned from 1 January 2010.

TORU YAMANAKA/AFP/Getty Images

FIGURE 6.10 Speedo's LZR swimsuits were banned in 2010.

Using sports equipment to gain an unfair advantage over competitors is known as technological doping. WADA considers the use of this equipment to be performance enhancing, and against the spirit of the sport, as it provides an unfair advantage. Finding a happy place between technological advancement and technological doping will continue to be a focus for sporting organisations as they work to ensure fair play and ethical participation and performance.

QUESTIONS

1 **Identify** the performance benefit of the Puma brush shoe.
2 **Identify** two performance benefits of the Speedo LZR swimsuit.
3 **Define** what is meant by technological doping.
4 Why are tailor-made shoes not permitted by the World Athletics Federation?
5 **Explain** why the world records set while wearing the brush shoe were deemed null and void.
6 **Discuss** how sporting organisations might differentiate between technological advancement and technological doping.

Reasons for using prohibited substances and methods

People may use performance-enhancing substances or methods in sport or recreation for various reasons. In sport, many of these are considered unethical, violate the spirit of the sport and are used in spite of the fair play rules that sporting organisations have put in place. The reasons athletes may be tempted to use these substances and methods include:

- performance enhancement
- dissatisfaction with current performance status
- peer/coach pressure
- culture within a club, sport or peer group
- keeping up with other athletes
- financial incentive
- the belief that they will not be caught
- a 'win at all costs' mentality
- lack of education
- fame and role model status.

ABOVE AND BEYOND THE STUDY DESIGN

Exploring WADA, p. 218

COLLABORATIVE TASK

Investigating the history of anti-doping

AIM

To investigate the history of anti-doping

METHOD

- Use the MindTap resources to review the history of doping.
- Working in pairs, select six of the most important events that have contributed to anti-doping rules.
- Draw these out on a timeline.
- Investigate any case studies or athletes that contributed to the milestone and list dot points outlining why they had an impact on this rule or event.
- Share your timeline with another pair in the class and discuss differences and similarities.

DISCUSSION

Discuss why you thought each of the milestones was so important, why class members had different milestones, and any interesting case studies that informed the process of developing anti-doping policy and procedure.

Weblink
Anti-doping

SIGNPOST

To see a timeline of some key milestones in anti-doping history, go to the Anti-doping page on the Sport Integrity Australia website.

6.1 CHECK-IN QUESTIONS

1 **State** the criteria a substance and/or method must meet to be prohibited.
2 **Explain** why the World Anti-Doping was created.
3 **Discuss** why Sport Integrity Australia does not recommend athletes use nutritional supplements.
4 a **Identify** three reasons why an athlete may use a prohibited substance and/or method.
b Select one of the reasons above and **explain** why an athlete should not use this substance and/or method, using ethical decision-making.

Assessment
6.1 Check-in questions

Command term

explain
Give a detailed account of why and/or how with reference to causes, effects, continuity, change, reasons or mechanisms; make the relationships between things evident

6.2 PERMITTED SUBSTANCES AND METHODS

In this module you will learn about:
- potential benefits of permitted substances and methods that enhance performance of the cardiorespiratory system, such as altitude training

and learn to:
- investigate and evaluate the effects of a range of performance-enhancing substances and methods on the cardiorespiratory system from a physiological perspective.

Permitted substances and methods are those that may have a slight performance advantage but do not compromise the health of the athlete or violate the spirit of the sport.

Video
In focus: Altitude training

Altitude training

Altitude training typically involves an athlete spending a period of time training at locations elevated 2000 metres or more above sea level. There is less oxygen available to the working muscles at these altitudes, so athletes experience a natural increase in the production of red blood cells to cope with the low oxygen (hypoxic) environment. This increase in red blood cells has performance benefits for a short time when returning to lower altitude environments. While individual responses vary dramatically, altitude training has been popular with endurance runners and cyclists, who will benefit from a stronger cardiorespiratory system with the capacity to deliver more oxygen to working muscles, as well as in sports such as Australian Rules football.

altitude training
Training undertaken at an altitude significantly higher than sea level

Research is ongoing about the best time to return to sea level when competing. Endurance capacity often begins to decline about three weeks after returning to sea level; this is known as **deacclimatisation**. One of many reasons scientists believe this occurs is due to constant cellular turnover, particularly red blood cells, the loss of which reduces the endurance capacity of the athlete.

deacclimatisation
The loss of adaptations following altitude training

To obtain the adaptations required to see a measurable increase in performance, it is recommended that athletes spend at least two weeks, preferably a month, training at altitude. This has some practical complications, including access to training facilities and time spent away from family, as well as physiological implications such as altitude sickness as the body adjusts to the low-oxygen environment.

To overcome some of these issues, as well as to increase practicality, some training facilities simulate lower oxygen levels artificially in 'altitude chambers', allowing athletes to train under high-altitude conditions without the need to travel to natural elevations.

FIGURE 6.11 Many athletes make an annual visit to high-altitude locations as part of their training periodisation.

Considerations

While WADA has determined that altitude training poses no significant health risk to athletes when performed correctly, athletes have been known to suffer fatigue and altitude sickness, and can have trouble maintaining higher intensities when training, as initially their capacity to take in, transport and utilise oxygen has decreased.

Although altitude training is a permitted method, there are still ethical questions to consider as altitude training requires access to a low-oxygen environment, something which not all athletes are able to afford.

LOOKING FORWARD
Adaptations to training

Units 3&4, Chapter 15

In Unit 4 you will participate in different training methods that can be used to target aerobic power. You will explore the adaptations that are made to training and the associated performance benefits.

Hypoxic environments

To combat some of the challenges faced with altitude training, the concept of 'live high, train low' has been widely embraced. In this approach, athletes use a chamber, tent or house that simulates the low-oxygen environment in an attempt to produce similar adaptations and performance enhancements as altitude training. An athlete will spend up to 20 hours a day, including time spent sleeping, in the hypoxic environment, venturing out to train in their normal environment. This negates the health and training issues associated with altitude training. The Australian Institute of Sport (AIS) has developed an altitude house, which you can find out more about in the MindTap resources. Refer to the interview with four-time Olympian Jeff Riseley on page 216 to find out more about how he incorporated this sort of practice into his regime.

Products that simulate altitude are available for athletes and the general population, whether that means hiring a tent for use in the home or checking into an altitude hotel! It is claimed that as a result of using these products, not only is red blood cell production enhanced, but pulmonary diffusion and capillarisation also increase to enhance maximal aerobic power.

The elevation training mask (ETM) is another product that has gained popularity for its lower cost and accessibility. An ETM is an adjustable mask that can be used to restrict oxygen flow during inspiration. While it doesn't directly simulate the partial pressure of oxygen in altitude training, the ETM alters ventilation patterns to stress the respiratory system, resulting in some similar adaptations to those experienced with altitude training. Figure 6.12 summarises results from a study on the impact of ETMs on physiology and performance.

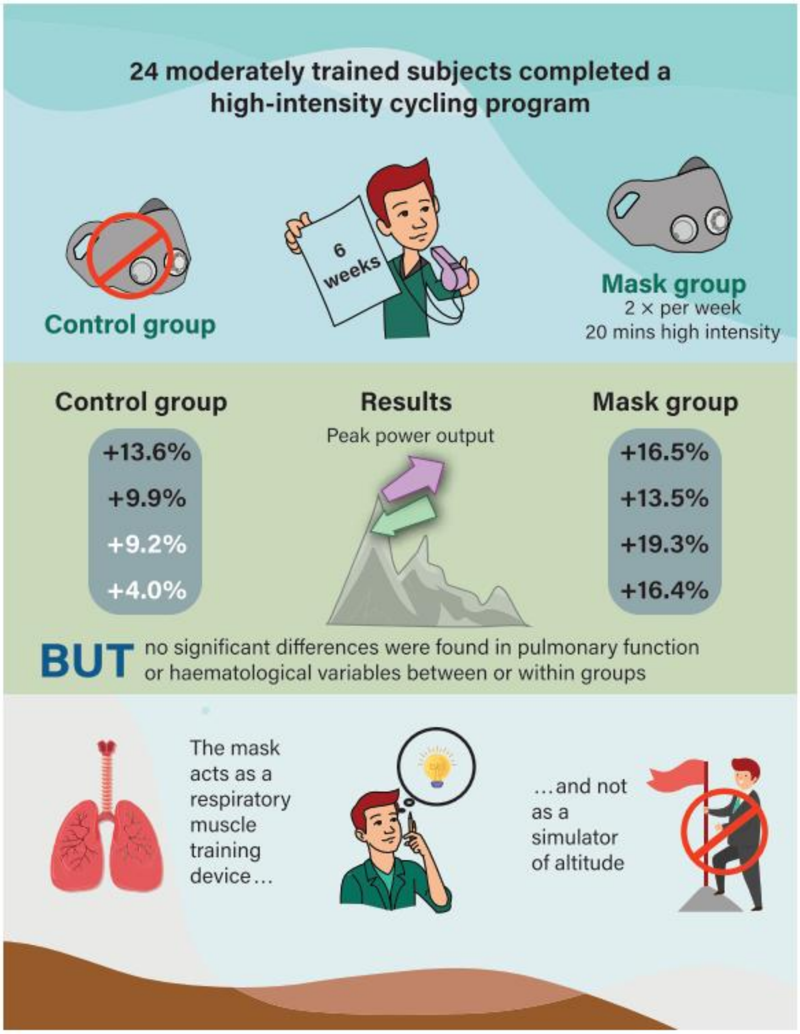


FIGURE 6.12 The impact of elevation training masks on physiology and performance

Considerations

Like altitude training, hypoxic environments are permitted by WADA but are expensive, creating ethical questions around access for all athletes.

ANGELA WEISS/AFP/Getty Images

FIGURE 6.13 Athletes use a hypoxic tent to achieve adaptations while sleeping.

SIGNPOST

To explore the AIS Altitude House, watch the video, 'Living High and Training Low with AIS' Altitude House' on the Australian Sports Commission's channel on YouTube.

Weblink
Living high and training low with AIS' Altitude House

TABLE 6.1 Summary of permitted substances or methods

Method	Potential benefits to the cardiorespiratory system	Considerations
Altitude training	• Increases red blood cell production • Increases oxygen carrying capacity of the blood • Increases aerobic power	• Can be expensive • Involves lengthy time away from home • Can have side effects including: » altitude sickness » fatigue » difficulty maintaining training intensities
Hypoxic 'live high train low'		• Can be expensive • Involves lengthy time periods in a simulated chamber

Assessment
6.2 Check-in questions

6.2 CHECK-IN QUESTIONS

1. How long must someone undertake altitude training in order to experience performance benefits?
2. **State** the component of blood that increases its oxygen carrying capacity.
3. **Explain** why training intensities are compromised when an athlete commences altitude training.
4. **Explain** why some people in sport may consider altitude training to provide an unfair advantage.
5. **Discuss** why athletes may prefer to use the 'live high, train low' strategy rather than to live and train at altitude.

Command term

state
Give a specific name or value or other brief answer without explanation or calculation

6.3 PROHIBITED SUBSTANCES AND METHODS

In this module you will learn about:
- potential benefits and harms of prohibited substances and methods that enhance performance of the cardiorespiratory system, such as erythropoietin (EPO), beta-blockers, and gene and blood doping

and learn to:
- investigate and evaluate the effects of a range of performance-enhancing substances and methods on the cardiorespiratory system from a physiological perspective.

When studying prohibited substances and methods, you will discover that some are prohibited at all times, both in and out of competition, while others are only prohibited in competition. Additionally, some substances and methods are prohibited in some sports, where they are likely to provide a performance advantage, but not in others, where they provide no advantage and may even be detrimental to performance.

DID YOU KNOW?

There are hundreds of items listed on the WADA International Standard Prohibited List and the list is constantly evolving. The list is issued in September or October of each year and the rules come into effect on 1 January of the following year.

Manipulation of blood components

Components of blood, including red blood cells, can be manipulated by blood transfusion or the introduction of a synthetic version of erythropoietin.

Erythropoietin (EPO) is a hormone that is naturally produced in the kidneys. It acts on the bone marrow to increase red blood cell production. Synthetic EPO can be injected to stimulate the natural red blood cell production process. As with the permitted strategies discussed in the previous section, when red blood cells are increased, the body's capacity to transport oxygen to the working muscles increases, increasing aerobic power and endurance capacity. Sports where there has been evidence of EPO use include cycling, marathon running and, more recently, triathlon.

erythropoietin (EPO) A polypeptide hormone naturally produced in the kidneys or produced synthetically

There are health risks associated with the use of EPO. By increasing red blood cell production and decreasing blood plasma, EPO use can lead to an increase in the viscosity (thickness) of the blood. This puts extra load on the cardiovascular system, increasing the risk of blood clotting, heart attack and stroke. Anecdotally, some athletes claim they get up in the middle of the night to cycle on a stationary bike to reduce the risk of clotting.

Because EPO is a naturally occurring hormone in the body that can also be increased via permitted methods such as altitude training, it is difficult to detect if higher levels are the result of doping. Since the early 2000s, elite athletes have been tracked via their biological passport, which

Alex Bierens de Haan/Getty Images Sport/Getty Images

FIGURE 6.14 American triathlete Collin Chartier admitted to using EPO.

uses frequent blood testing to monitor changes to indirectly detect EPO doping. While there has been some promising advancement in detection technology, this remains an area of focus for scientists.

blood doping
The misuse of techniques to manipulate components of the blood, which are then introduced into the body

Blood doping is a method of introducing blood or red blood cells into the cardiovascular system. This may be through the removal and then reintroduction of an athlete's own blood, known as autologous doping, or through the introduction of red blood cells from a donor, known as homologous doping. As with EPO, blood doping may have performance advantages in sports where a high aerobic power is required, such as marathon running, cycling and rowing.

Potential harms of EPO and blood doping include:

- hypertension
- stroke
- heart disease
- liver and kidney failure
- transmission of blood-borne disease from use of needles or donor red blood cells.

DID YOU KNOW?

The over-the-counter cost of a prescribed needle of EPO was $2100 in 2024.

ABOVE AND BEYOND THE STUDY DESIGN

Synthetic oxygen carriers, p. 219

nenetus/Adobe Stock

FIGURE 6.15 Beta-blockers are banned in archery, where a steady hand can provide a performance advantage.

Beta-blockers

Beta-blockers interact with the cardiovascular system by blocking the effects of adrenaline, reducing heart rate and widening blood vessels. This makes them a common and effective treatment for high blood pressure. Because they reduce the number of times the heart beats, they can enhance performance by lengthening the time between beats. There is a slight tremor in the body when the heart beats, which means beta-blockers may enhance performance in sports that require a steady hand by giving an athlete longer between each beat to perform skills. This includes skills such as releasing a bow in archery or shooting a dart. There is also evidence to suggest beta-blockers can reduce anxiety, supporting an optimal arousal zone.

Beta-blockers are banned in competition for sports including:

- archery
- darts
- billiards
- pistol shooting.

The potential harms of using beta-blockers include:

- hypotension
- altered blood sugar levels
- asthma attacks
- cardiac failure.

Gene doping

Scientists have found that it is possible to manipulate the DNA of cells in the body to alter genetic expression in animals and humans. When used to treat and potentially cure genetic diseases and some cancers, this process is known as gene therapy. However, it is possible that this science could be used to manipulate genes to enhance performance. Such alterations may include EPO and human growth hormone manipulation.

The non-therapeutic use of genes, genetic elements and/or cells that have the capacity to enhance athletic performance is prohibited under WADA rules and is known as **gene doping**.

WADA has set up a gene and cell doping advisory group to explore the science behind gene doping, and are developing increasingly advanced tests to detect its use.

gene doping
The non-therapeutic use of genes, genetic elements and/or cells that have the capacity to enhance athletic performance

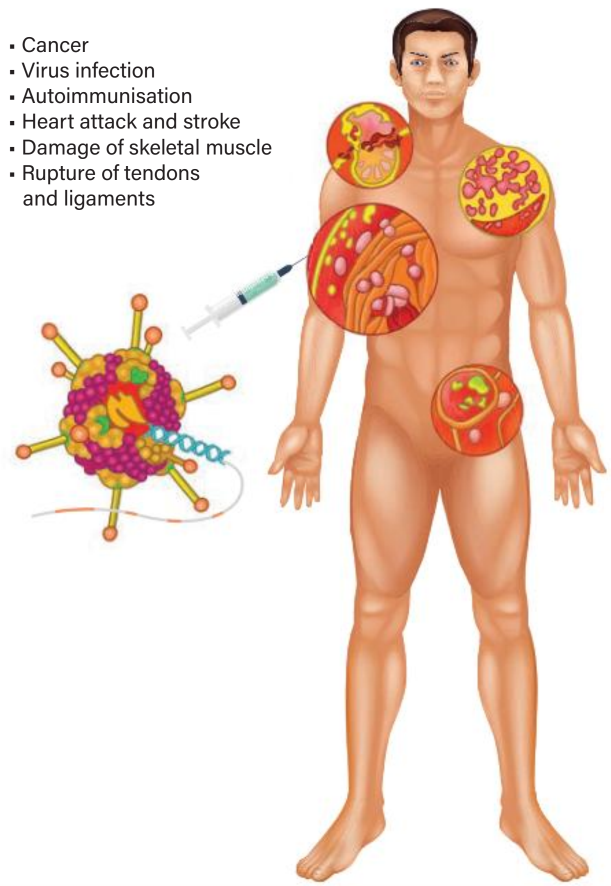


FIGURE 6.16 The potential harms of gene doping

SIGNPOST

Watch the video, 'CRISPR: What is the future of gene editing?' on the Al Jazeera English channel on YouTube for a detailed explanation of the process and dangers of gene editing from a medical and ethical point of view.

Weblink
CRISPR: What is the future of gene editing?

WORKED EXAMPLE

QUESTION

©VCAA VCAA PE Exam 2011, Section B, Question 3b, c and e

Cyclists in the Tour de France have in the past used erythropoietin (EPO) to artificially manipulate their haematocrit and haemoglobin counts.

1 What is EPO and how does it physiologically enhance the performance of an elite distance cyclist? 3 marks

It is alleged that cyclists using EPO will set their alarm each night to wake them in the middle of their sleep. They then ride for 10 minutes, on a stationary bike, before returning to their beds to resume sleep.

2 Outline a potential harm associated with the use of EPO and explain how the strategy given above is designed to alleviate the problem. 3 marks

Hypoxic tents are a legal practice which may produce a similar physiological benefit to EPO.

3 Describe how an athlete may utilise a hypoxic tent as part of their preparation for an event. 2 marks

Sample responses

The first sentence explains what EPO is and sets up the rest of the answer by explaining that it can be synthetically produced.

1 Erythropoietin (EPO) is **a hormone** / that is naturally produced in the body and can also be **synthetically produced** (1 mark). It stimulates the production of red blood cells (1 mark). This increases the **oxygen carrying capacity of the blood** allowing the cyclist to deliver more oxygen to be used by the working muscles, thus allowing the **cyclist to ride at a higher intensity aerobically** (1 mark).

Stating that it increases the oxygen carrying capacity of the blood supports the explanation of its physiological benefit.

Specifically referring to the performance outcome in cycling gets the performance mark.

The harm of increased thickness is linked to the component of blood that has been increased.

2 A potential harm of EPO is **an increase in blood thickness (viscosity)** due to **increased red blood cells** (1 mark). When heart rate drops during sleep, the blood can clot and result **in stroke cardiac failure** (1 mark). Cycling at night **decreases this risk by increasing heart rate** and circulation, which **decreases the risk of clotting** (1 mark).

The harm continues to be outlined by identifying the result of increased thickness.

Explaining how cycling decreases this risk has been linked to the physiological responses of cycling – increasing heart rate.

The strategy is described by explaining what it 'looks like' in everyday life.

3 The athlete **will sleep** in a hypoxic tent and then **train in their normal environment –** live high, train low (1 mark). The body will adapt **by producing more red blood cells, increasing the cyclist's oxygen carrying capacity** (1 mark).

The performance link to event preparation is clearly explained.

COLLABORATIVE TASK
Class discussion

Enhanced Games

AIM

To discuss the ethical considerations of the Enhanced Games

METHOD

1 Visit the Enhanced Games website, and explore the website for insights into the Games.
2 Investigate viewership of the Paralympics/Olympics and the Enhanced Games.
3 Document the world record and the Enhanced Games record for the following sports:
   - athletics: 100- and 200-metre sprint
   - swimming: 50-metre freestyle.

DISCUSSION

1 Was there a significant difference in any of the results?
2 What do you think about the Enhanced Games claim: '*The Enhanced Movement believes in the medical and scientific process of elevating humanity to its full potential, through community of committed athletes.*'
3 What do the Enhanced Games say they are doing to keep athletes safe?
4 What influence might these games have on recreational and junior athletes?
5 Do you think there should be an Enhanced Games?

Weblink
Enhanced Games

Quinn Rooney/Getty Images Sport/Getty Images

FIGURE 6.17 Australian swimmer James Magnusson is one of the most well-known athletes to support the Enhanced Games.

REAL WORLD APPLICATIONS

Ask an expert – Jeff Riseley

Jeff is an Australian middle distance runner who won six national titles in the 800 and 1500 metres. He is a four-time Olympian.

Lucas Dawson/Getty Images Sport/Getty Images

FIGURE 6.18 Jeff Riseley is a four-time Olympian who represented Australia in middle distance running.

As an elite athlete and four-time Olympian, what do you consider your greatest athletics achievement to be?

Having the resilience to come back from Achilles surgery and make my fourth Olympics at 34 years of age and make the semi-final of the 800 m. I considered retirement a number of times, but wanted to go out of the sport on my own terms and have the feeling of being able to compete against the best in the world again. Not many people gave me any chance of doing so. While challenging, it was a great feeling to achieve my ultimate goal.

As an athlete, what sort of education did you have around prohibited/permitted substances/practices?

We had yearly education resources and courses and would receive communication of any changes to the Prohibited List. There was a period in 2014 where there was a surge in new companies producing supplements and using athletes as ambassadors to promote them. It coincided with a spike in doping cases due to contaminated supplements. Sporting bodies responded by providing a lot of information. This, alongside the pressure for companies to batch test to give athletes an assurance that their supplements were WADA approved, helped alleviate the problem and now positive cases are much more rare.

What sort of permitted substances/practices did you use for your sport?

It's not really a case of permitted substances or practices but more using science and research to help training and recovery. I would often use altitude training camps and altitude tents to help improve my endurance by increasing the amount of red blood cells and oxygen carrying capacity. We'd use these modalities at specific times of the year around our training and competition.

Nutrition was another really important part of the recovery process and making sure we got enough carbohydrates and protein to refuel after a hard workout. Recovery boots, hot and cold baths and massage was also used from a recovery point of view.

Bicarb soda and beetroot juice was popular but the science was something that I didn't believe in enough to implement into my training or competition practices.

You mentioned live high and train low – 14/16 hours in a tent at home. How many weeks did you do this for and when during the year?

We would use the altitude tent up to two times a year for a three-week period for 14–16 hours a day. It would usually depend on the year and competitions we were working towards. The altitude tent gave us the flexibility to still get the benefits of altitude but also giving us more flexibility in our training. Altitude training is normally at isolated parts of the world without often having access to a track and is typically used for the long aerobic training blocks in the periodisation of the year.

Can you talk a little about your experience of training at high altitude. How did you adjust your training load?

Altitude training has its problems. The reduced amount of oxygen affects your ability to recovery between training sessions and easy runs. It's important to get the training intensity right, otherwise you don't obtain the training adaptations that you are looking for and are at a higher risk of overtraining syndrome.

Approximately how many drug tests do you estimate you had over your career? Or per year?

It varied from year to year. You were either tested after a competition – that often depended on the results in that race – or randomly tested at home or a place you choose to be for an hour each day. Over a year it would be 4–6 times, but other more high profile athletes would be tested more.

You mentioned you had blood taken for your biological passport at every major Olympic Games, Comm Games, worlds. Any others?

Blood tests for biological passports were typically aimed at endurance athletes because of the benefits of manipulating components of blood to that event. Blood was taken before every major championship, as well as other random times of the year so that they could track your tests and look for any abnormalities.

There are different views on ethical decision-making when using performance enhancement. What is your view? How did this inform your training?

With the advancement of science and research there will always be different views on what is ethical. I used professional sport scientists from the Victorian Institute of Sport to inform any of the different modalities I used in my training program. Personally, I tried to put all my energy into training and controlling the things I could, which resulted in being able to have a long career because I built habits into my life that allowed me to train and compete consistently.

TABLE 6.2 Summary of prohibited substances or methods

Method	Potential benefits to the cardiorespiratory system	Potential harms
Manipulation of blood		
EPO	• Increases red blood cell production • Increases oxygen carrying capacity of the blood • Increases aerobic power	• Blood clotting • Hypertension • Stroke • Heart disease/attack • Liver and kidney failure • Transmission of disease from needles or donor red blood cells
Blood doping	• Increases red blood cell level • Increases oxygen carrying capacity of the blood • Increases aerobic power	
Beta-blockers	• Reduces heart rate	• Hypotension • Altered blood sugar levels • Asthma attacks • Cardiac failure
Gene doping	• Alters genetic expression • Can increase EPO production • May enhance aerobic power	• Cancer • Virus infection • Autoimmunisation • Stroke • Muscle, tendon and ligament damage

6.3 CHECK-IN QUESTIONS

1 **Identify** two methods athletes can use to manipulate components of blood.
2 **Explain** why beta-blockers may enhance performance in sports such as pistol shooting.
3 **Investigate** why gene doping is difficult to detect in traditional drug testing procedures.
4 Referring to the criteria for prohibited practices and substances, **discuss** why altitude training is permitted but EPO is prohibited.

Assessment
6.3 Check-in questions

Command term

investigate
Observe, study or carry out an examination in order to establish facts and reach new conclusions

ABOVE AND BEYOND THE STUDY DESIGN

MODULE 6.1, p. 206

Exploring WADA

In Chapter 3 you looked at the role of WADA and its role in creating the list of prohibited items. Now you will explore the WADA code and the doping control process.

World Anti-Doping Code

We know that WADA created the World Anti-Doping Code to protect the right of athletes to participate in dope-free sport to promote fairness, health and equality. Under the World Anti-Doping Code, there are 11 possible anti-doping violations:

- presence of a prohibited substance in an athlete's sample
- use or attempted use of a prohibited substance or method
- refusing to submit a sample
- failure to provide whereabouts three times
- tampering or attempting to tamper with a sample
- possession of prohibited substance or method
- trafficking
- administration or attempted administration
- complicity
- prohibited association
- acting to discourage reporting.

If an athlete is found guilty of violating the rules they may be **sanctioned**. Depending on the severity of the violation, this may include a lengthy ban on competition and training.

sanction
A punishment for someone who violates the rules

Testing

If an athlete meets the testing criteria, they will be placed on the National or Registered Testing Pool. The criteria include but are not limited to: being a member of national teams/squads, returning from injury or having a sudden dramatic increase in performance. Testing of an athlete can occur at any time, in or out of competition. A doping control officer may come to a training venue or to an athlete's home. When approached by a doping control officer, athletes are required to give a sample of urine, blood or both. The officer takes the sample to a laboratory, where it is tested.

Weblink
What to expect from the doping control process

SIGNPOST

For an explanation of what you can expect from the doping control process, watch the video, 'What to expect from the Doping Control Process' on the Sport Integrity Australia channel on YouTube.

Athlete whereabouts

Athletes are required to register their information on a system known as ADAMS (Anti-Doping Administration and Management System). This helps Sport Integrity Australia know where the athlete is to ensure a smooth and fair testing process. If an athlete is on the Registered Testing Pool, they are required to log a 60-minute window every day, guaranteeing the doping control officer access to the athlete at some point during that hour. While athletes must nominate their whereabouts for three months at a time, details can be updated daily through an app to ensure flexibility. Figure 6.19 details the requirements of athletes in the two pools.

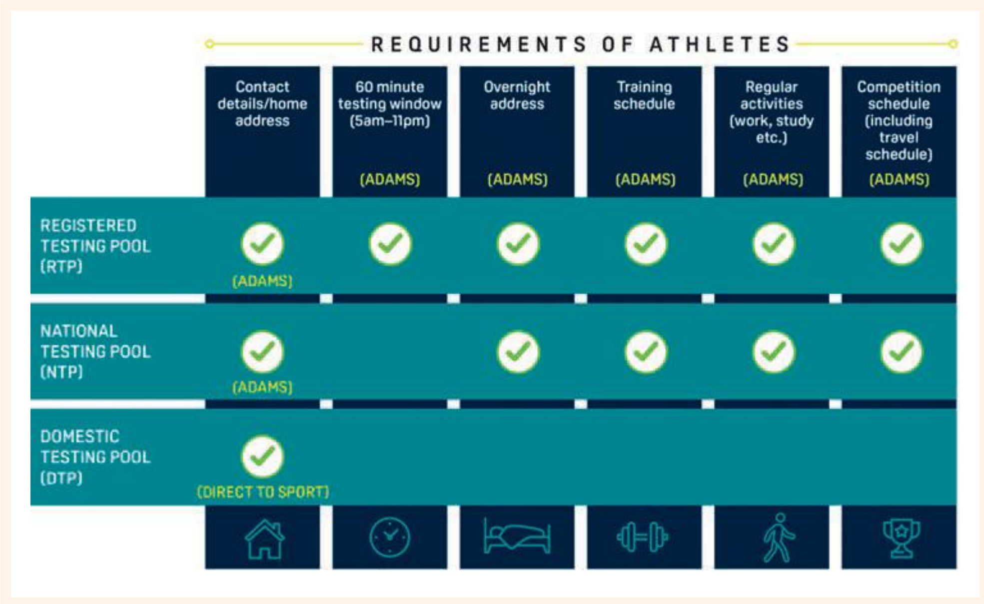


Image courtesy of Sport Integrity Australia | Accurate as at 14/04/24 for athletes registered in an Australian testing pool

FIGURE 6.19 The requirements of athletes in the Registered or National testing pools

ABOVE AND BEYOND THE STUDY DESIGN

Therapeutic use exemptions

Athletes can apply for a therapeutic use exemption (TUE) if they require the use of a prohibited substance or method for a diagnosed medical condition. The use of the substance or method must not provide any performance enhancement other than returning the athlete to normal health, and the process must be approved by a medical professional. For example, an athlete who requires the use of Ventolin to manage asthma will apply for and be granted approval to use their medication via a TUE.

MODULE 6.3, p. 212

Synthetic oxygen carriers

The creation of artificial or synthetic oxygen carriers (SOCs) has been an important scientific development. SOCs were initially created to be used in crisis situations to overcome the challenges of homologous blood transfusions, including a short shelf life, supply and the possibility of transferring blood-borne diseases. Scientists have had varying success in producing haemoglobin-based oxygen carriers, which can improve oxygen carrying capacity. One product has approval for use in South Africa and Russia, and another has approval for veterinarian use in the USA and Europe. The use of SOCs is prohibited by WADA, but this is a space to watch over the next 10 years!

SIGNPOST

Read the Australian Academy of Science's explanation of SOCs on their website.

Weblink
Australian Academy of Science - SOCs explanation

CHAPTER SUMMARY

Resource
Self-assessment checklist

Video
Masterclass: Chapter 6

6.1 Enhancing performance of the cardiorespiratory system

- The World Anti-Doping Agency (WADA) was established in 1999 to foster consistency between anti-doping organisations around the world.
- Sport Integrity Australia is Australia's national anti-doping organisation.
- Doping in sport is the occurrence of one or more violations of the anti-doping rules as set out in the World Anti-Doping Code.
- A permitted substance or method is one that can be used in training and competition according to WADA.
- A prohibited substance or method cannot be used in training and/or competition according to WADA.
- To be on the Prohibited List, a substance or method must meet two of three criteria:
  1. It has the potential to enhance, or it does enhance performance in sport.
  2. It has the potential or represents and actual risk to the athlete's health.
  3. It violates the spirit of the sport (this definition is described in the introduction to the Code).
- Sociocultural factors are those of or relating to the interaction of social and cultural elements including family, peers, community, gender, socio-economic status, cultural beliefs and traditions.

6.2 Permitted substances and methods

- Altitude training is training undertaken at an altitude significantly higher than sea level.
- Altitude training increases red blood cell production to enhance the oxygen carrying capacity of the blood.
- While there are no significant risks to an athlete's health during altitude training, they may experience dizziness and fatigue and be unable to train at the intensities required.
- Hypoxic tents or chambers are used to live high, train low to negate some of the challenges associated with altitude training.
- Erythropoietin (EPO) is a polypeptide hormone naturally produced in the kidneys or produced synthetically that increases red blood cell production.

6.3 Prohibited substances and methods

- The synthetic use of EPO is prohibited.
- Blood doping refers to the misuse of techniques to manipulate components of the blood. Blood doping is prohibited.
- Beta-blockers have the potential to slow down heart rate and are prohibited in sports such as archery, where a steady hand provides a performance advantage.
- Gene doping is the non-therapeutic use of genes, genetic elements and/or cells that have the capacity to enhance athletic performance.

CHAPTER REVIEW

1 Physiological responses to altitude training include:
   A increasing bone marrow concentration and therefore increasing red blood cells.
   B decreasing blood plasma to allow for a greater volume of red blood cells.
   C increasing white blood cells, platelets, red blood cells and blood plasma.
   D increasing production of EPO and therefore the production of red blood cells.

2 **State** the three WADA criteria that determine if a substance or method is permitted or prohibited.

3 **Identify** some ethical questions that athletes must consider before using a performance-enhancing substance or method.

4 **Explain** why the benefits of altitude training only last for a short time after returning to sea level.

5 **Discuss** why beta-blockers are banned during archery competitions.

6 Using EPO as an example, **explain** how and when gene doping could be used and describe its performance advantages.

7 Research and give an example of how an athlete might use a TUE.

8 Using the graph on page 203, **discuss** some reasons why the percentage of Tour de France riders violating anti-doping regulations dropped between 1998 and 2022.

9 Select one reason athletes might use prohibited substances and methods and research a case study of an athlete who has used them for this reason. **Investigate** the performance-enhancement benefit as well as the health risk. Share this on a class collaborative tool.

Assessment
Chapter 6 Review

discuss
Present a clear, considered and balanced argument or prose that identifies issues and shows the strengths and weaknesses of, or points for and against, one or more arguments, concepts, factors, hypotheses, narratives and/or opinions

UNIT 1 REVIEW

INTEGRATED EXTENDED RESPONSE QUESTIONS

These questions have been developed to allow you to draw on the knowledge and skills that you have developed across both Areas of Study in Unit 1. The responses require you to incorporate the concepts found in each Area of Study, draw on practical examples and integrate theoretical and practical concepts.

Question 1 (12 marks)

Thi is 30 years old and has been running 3–4 times per week for many years. She usually runs 5 kilometres, but she will occasionally sign up for a 10-kilometre fun run. As she prepares for the run, she will increase the distance that she runs leading up to the event.

At the start of each run, Thi notices a number of changes to her cardiorespiratory system.

a **Identify** two changes to the cardiorespiratory system that Thi will experience at the start of her run. (2 marks)

b What role do the skeletal and cardiovascular systems play in the production and function of red blood cells? (2 marks)

c **Identify** and **describe** the role of the hamstring, quadricep and gluteal muscles in hip flexion and extension during running. (3 marks)

d Exercise has been shown to reduce the risk of musculoskeletal and cardiorespiratory illness. **Evaluate** one long-term benefit to the musculoskeletal system and one long-term benefit to the cardiorespiratory system of exercising regularly. (5 marks)

Question 2 (9 marks)

Jeremy is 18 years old and a regional-level cyclist who is looking to ride at a national level and hopefully one day compete in the Tour de France. Jeremy trains five days a week, mainly focusing on his endurance rides (60–120 minutes), with some higher intensity efforts throughout the ride to develop his capacity to surge through short, explosive efforts when required. Another cyclist at Jeremy's club has suggested that Jeremy could get the boost he needs from a prohibited substance.

Based on your knowledge of the musculoskeletal and cardiorespiratory systems and of performance-enhancing substances and methods, provide Jeremy with all the information he needs to decide on the best way to achieve his goal of competing at the Tour de France.

Your response must address the following points:

- permitted and prohibited performance-enhancing substances and methods
- potential benefits and harms to the musculoskeletal and/or cardiorespiratory systems
- ethical and sociocultural considerations.

Question 3

(8 marks)

Analyse the data from the 'Warm-up – raise' collaborative task on page 78 (Chapter 2) and the 'Heart rate response to exercise' activity on page 144 (Chapter 4). Use the information gathered to **explain** the relationship between the cardiovascular and warm-up activities. Your response should include refence to data from the practical activities and a discussion of the:

- purpose of a warm-up
- role of the cardiovascular system
- relationship between the purpose of a warm-up and the cardiovascular system.

Question 4

(8 marks)

Select an exercise or sport of your choice and, using a specific movement or skill from that activity, explain how the muscular, skeletal and cardiorespiratory systems function and interact to produce movement. With specific reference to the action identified and performance in the activity, **discuss** the:

- bones, joints and muscles involved in the action
- role of each of the systems
- interaction of the musculoskeletal and cardiorespiratory systems.

UNIT 2

PHYSICAL ACTIVITY, SPORT, EXERCISE AND SOCIETY

master1305/Adobe Stock

UNIT 2

- explores different types of physical activity and the role that participation and sedentary behaviour play in student health and wellbeing, as well as in other population groups and contexts.
- explores different types of physical activity promoted within and beyond their community.
- provides an appreciation of the movement required for health benefits and the consequences of physical inactivity and sedentary behaviour.
- expects students to analyse data to investigate perceived barriers and enablers, and explores opportunities to enhance participation in physical activity.
- explores and uses the social-ecological model to critique a range of individual- and settings-based strategies that are effective in promoting participation in regular physical activity.
- facilitates the creation and participation in a personal plan with movement strategies that optimise adherence to physical activity and sedentary behaviour guidelines.
- investigates a range of contemporary issues associated with physical activity, sport and exercise that affect access, inclusion, participation and performance.

CHAPTER

7

PHYSICAL ACTIVITY TYPES AND THE BENEFITS OF BEING ACTIVE

UNIT 2 – AREA OF STUDY 1

loreanto/Adobe Stock

FIGURE 7.01 Dog owners are more likely to be active than non-dog owners.

Quizzes

Chapter 7 Pulse check

7.1 Check-in questions

7.2 Check-in questions

7.3 Check-in questions

7.4 Check-in questions

Chapter 7 Review

Videos

Masterclass: Chapter 7

7.1 Understanding sedentary behaviour – Jo Salmon

7.4 In focus: Social benefits of being active

7.4 In focus: The relationships between physical activity and mental health

Resources

Chapter 7 Self-assessment checklist

Nelson MindTap

To access resources above, visit **cengage.com.au/nelsonmindtap**

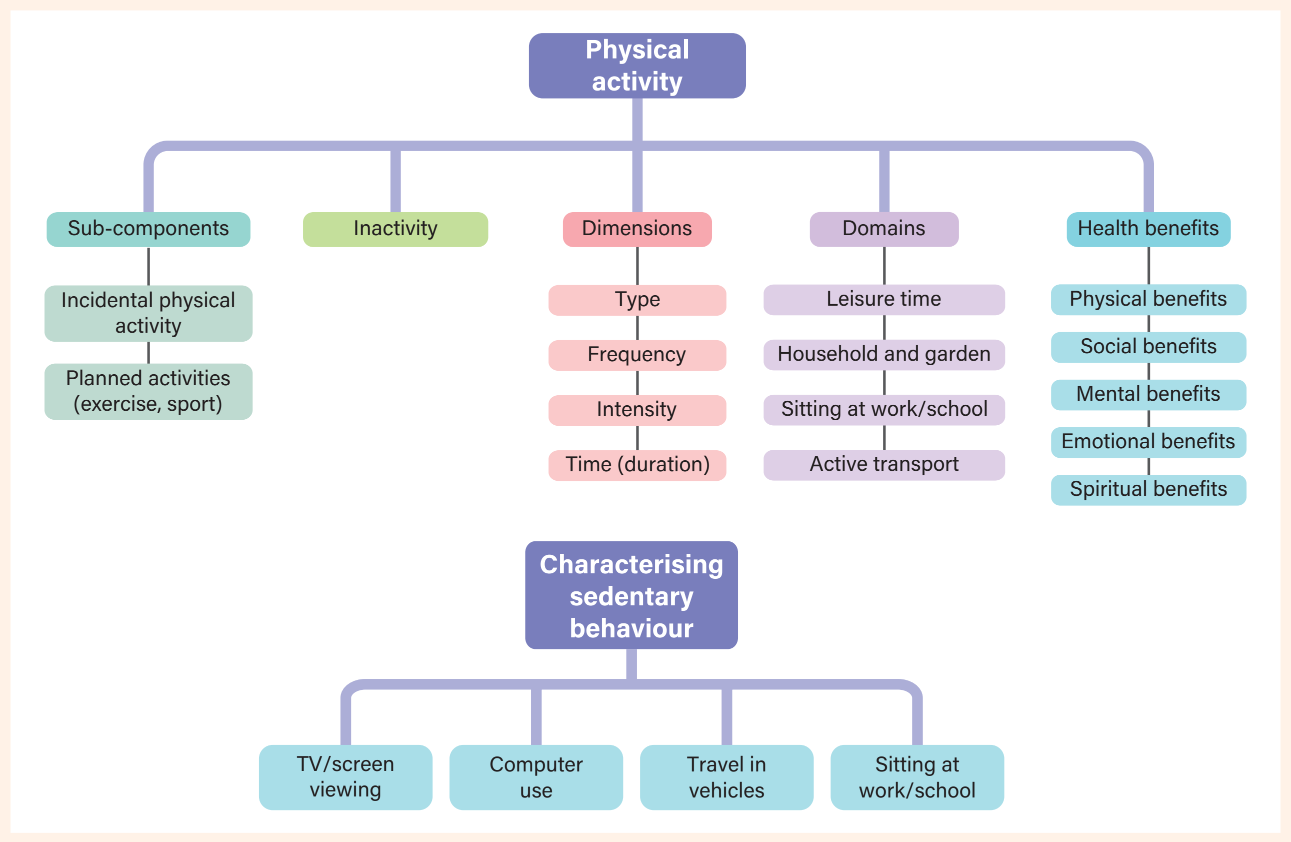
KEY KNOWLEDGE

- types of physical activity such as play, games, sports (formal and informal), transportation, chores, exercise and recreational activities
- physical, social, mental, emotional and spiritual benefits of regular participation in types of movement

KEY SKILLS

- participate in and explain different types of movement experiences including a variety of culturally diverse and inclusive physical activities
- participate in a variety of movement experiences to reflect on and record information related to the physical, social, mental, emotional and spiritual benefits of physical activity

Source: VCAA VCE Physical Education Study Design (2025–29)



Video
Masterclass: Chapter 7

Assessment
Chapter 7 Pulse check

Physical activity is an area of study that encompasses all movement. It is associated with many benefits and is influenced by a range of factors.

PULSE CHECK

Take the pulse check quiz to check your prior knowledge and understanding of these concepts.

1 Provide examples of physical activity in sport, recreation and play. How are they different?

2 What is meant by the term 'incidental physical activity'? Identify three examples.

3 **Describe** one example of active transport and comment on whether this is part of your weekly routine.

4 **Discuss** two social benefits of participating in regular physical activity for a 17-year-old.

5 **Explain** the difference between an emotional benefit and a spiritual benefit of physical activity.

7.1 UNDERSTANDING THE NATURE OF PHYSICAL ACTIVITY

In this module you will learn about:

- types of physical activity such as play, games, sports (formal and informal), transportation, chores, exercise and recreational activities
- the nature of sedentary behaviour
- dimensions of physical activity including type, frequency, intensity and duration
- the domains of physical activity such as leisure time, occupation/work, home and transportation

and learn to:

- participate in and explain different types of movement experiences, including a variety of culturally diverse and inclusive physical activities.

sport
Physical involvement in organised games or activities within an accepted set of rules

incidental activity
Any activity that builds up in small amounts during the day, such as housework and walking for transport

Physical activity is defined by the World Health Organization (WHO, 2024) as 'any bodily movement produced by skeletal muscles that requires energy expenditure'. Some people think **sport** is something different, but it is simply a subcomponent of physical activity. Other subcomponents include exercise, lifestyle activities and games (see Figure 7.02).

Physical activity may also be classified as structured or **incidental activity**. Structured physical activities tend to be planned, such as participating in organised sport, going to the gym or going for a bike ride. Most people engage in a combination of incidental and structured physical activity that contributes to their overall physical fitness and wellbeing.

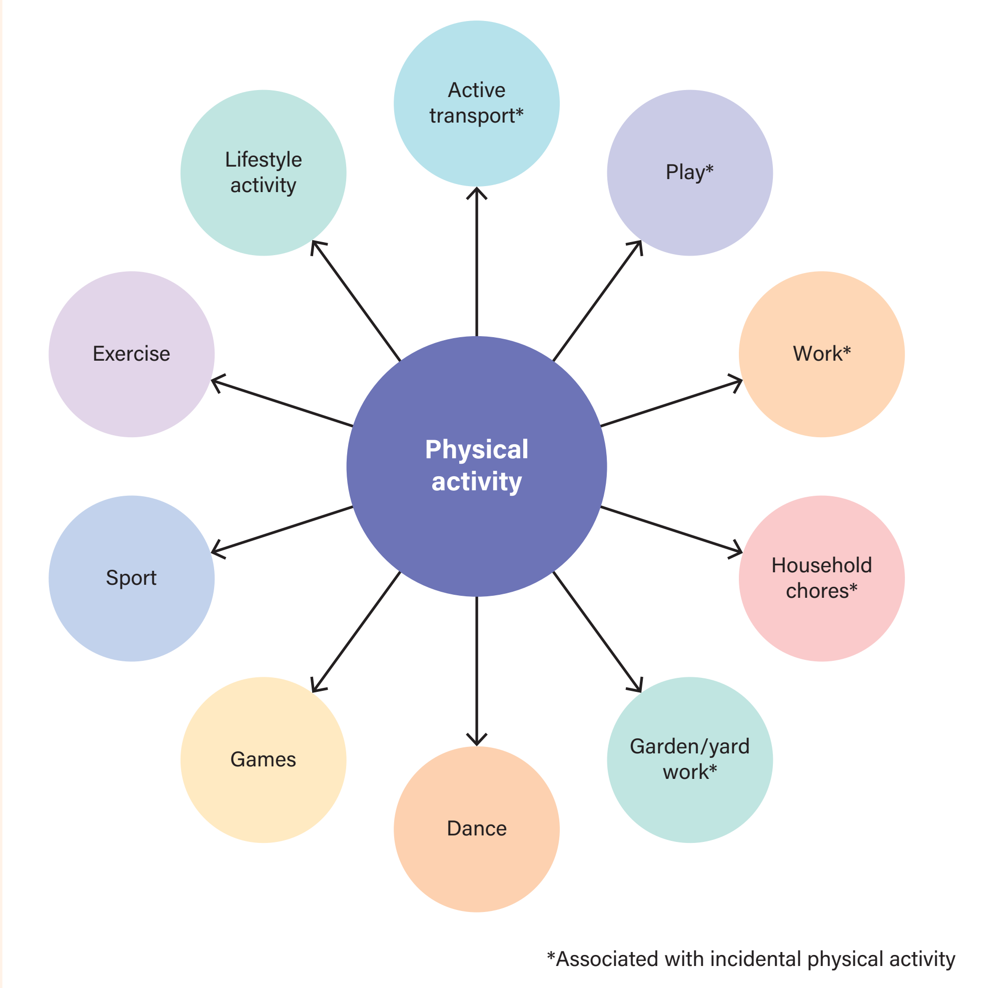
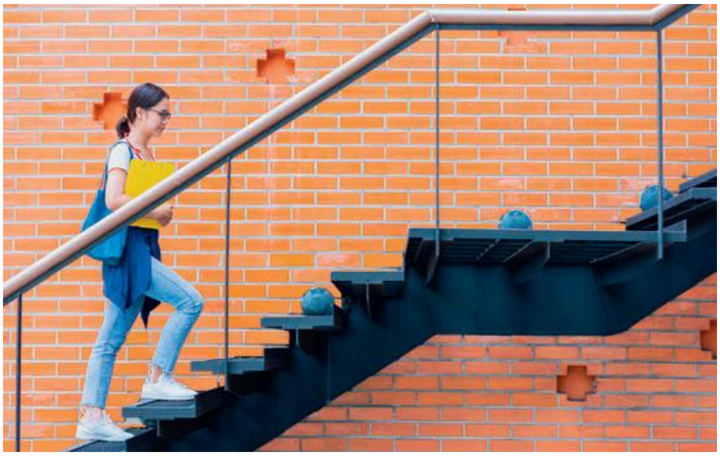


FIGURE 7.02 Subcategories of physical activity

Incidental physical activity

Incidental physical activity is unstructured activity accumulated throughout the course of the day. An example is walking instead of riding a bike or catching public transport, and using the stairs instead of the lift at a shopping centre. Incidental activity can occur during daily activities such as doing the housework, working in the garden or when you play with your pets. Often, physical activity is not the primary goal, it's just something that occurs as a consequence of this behaviour. For example, the primary goal may be to make a video on social media, but the associated behaviour is creating a dance, or the primary goal might be to go to your next class, but in the process, you may walk 250 metres.



Quality Stock Arts/Shutterstock.com

FIGURE 7.03 Walking up stairs instead of using the lift is a healthy incidental activity.

REAL WORLD APPLICATIONS

Incidental physical activity adds up while you shop

It's amazing how many steps you can accumulate while shopping without even realising it. For example, you will incidentally accumulate thousands of steps walking up and down each aisle in a supermarket, as well as when moving between the aisles, walking to the check-out and to and from the car/public transport. Before you know it you will have added well over 1000 steps towards your daily goal. In some of the larger stores like Costco or Bunnings, if you went up and down most aisles, you could easily add over 3000 steps to your daily step total. This is an accessible way to increase your steps, even if you don't necessarily need or want to purchase something.

TABLE 7.1 Subcategories of physical activity classified as incidental activities

Physical activity subcategory	Description	Examples
Household chores/gardening  Pixel-Shot/Shutterstock.com	Completing household chores results in higher energy expenditure than being at rest.	Sweeping, vacuuming, scrubbing floors, mopping, hanging out washing, digging, mowing, raking leaves
Active transport  NassornSnitwong/Shutterstock.com	Any form of human-powered transport to get to and from specific destinations, such as the post office, local shop, work or school, by active mode. This results in much higher energy expenditure than a sedentary alternative, such as travelling in a vehicle or using an electric scooter or e-bike.	Walking to the train station, riding a bicycle to work or school, riding a scooter, skateboarding or roller-skating to the local park or shop, non-mechanised wheelchairing
Occupational (work) activity  Monkey Business Images/Shutterstock.com	Some occupations are very active and result in significantly higher energy expenditure than desk jobs. Many tradespeople, labourers, farmers, rangers etc. are quite active as part of their everyday activities at work.	Carrying bricks on a building site, digging trenches beside a road, removing trees, rounding up cattle on horseback, delivering mail by bicycle
Play  iStock.com/FatCamera	Play generally consists of no formal rules, may be spontaneous or sporadic in nature, with no set time or defined playing area. Winning is not the priority, so there is a sense of fun, rather than pressure. Anyone can play.	Building a sandcastle, playing tag or chasey, throwing a frisbee or tennis ball, hitting a ball against a wall, juggling

active transport
Any form of human-powered transportation to get to and from work, school or specific destinations

DID YOU KNOW?

Riding an e-bike uses approximately 20–25 per cent less energy expenditure than riding a traditional non e-bike. There are still many benefits to riding an e-bike, however, as it still uses more energy than sitting still on the couch.

Sergii Figurnyi/Shutterstock.com

FIGURE 7.04 Amsterdam is the bike-riding capital of the world.

Weblink
How Amsterdam became a bicycle paradise

SIGNPOST

Read the article (including a video), 'How Amsterdam became a bicycle paradise' on the Dutch Review website to learn about how Amsterdam in the Netherlands became a bicycle paradise and the most renowned active transport capital of the world. Almost a quarter of the population cycles daily, which has had a massive impact on public health as well as reducing traffic congestion.

Structured/planned physical activity

Community and school-based physical education programs often involve exercise and sport – two common subcategories of physical activity that are structured or planned. **Sport** is an activity involving physical exertion and skill as the primary focus of the activity, with elements of competition and social participation, where rules and patterns of behaviour govern the activity (formal and informal).

sport
Activity with a primary focus on physical exertion and skill, with elements of competition and social participation, where rules and patterns of behaviour govern the activity (formal and informal)

exercise
Activity that is planned, structured and repetitive to improve or maintain health and/or fitness (including training)

TABLE 7.2 Subcategories of physical activity classified as planned activities

Physical activity subcategory	Description	Examples
Exercise  PeopleImages.com – Yuri A/ Shutterstock.com	Involves planning and structure and requires physical effort to sustain or improve health or fitness. To gain improvements or to maintain fitness outcomes requires purposeful repetition, and the exercise must be a regular part of a person's weekly routine.	• Going to the gym for a workout or to participate in a boxing class, spin class or Pilates • Walking for exercise or going for a bike ride to improve fitness • Using dumbbells at home to complete your upper body workout • Doing sit-ups and push-ups and stretching

Physical activity subcategory	Description	Examples
Recreation and leisure  fizkes/Shutterstock.com	**Recreational activities** are those activities that stimulate the mind and body, whereas leisure activities are meant to be restful. Some recreational activities, such as fishing, shopping, reading, talking on the phone or spending time on social media, are also considered functional activities. Over the past decade there has been growing interest in extreme sports and high-risk activities such as skateboarding, surfing, mountain biking, paragliding and rock climbing.	Dance, hobbies, games, music, sports, playing computer games (a more active example of this would be playing Nintendo Switch Sports or Ringfit)
Organised sport  iStock.com/YakobchukOlena	Organised sport is a physical activity that provides active diversion involving bodily exertion and structured competition. For sport to be classified as organised, it generally meets one or several of the following criteria: • structured or highly organised • involves skills or set plays • involves competition, and winning is important • has set rules that must be abided by and the inclusion of officials or umpires to enforce those rules • involves vigorous physical activity • requires training and preparation, often coordinated by coaches.	• Intra-school sport (within school), interschool sport (between different schools), community sport, social competitions (e.g. mixed netball or touch football) • Club sport at local level • Can extend from community club level to district, state, national or international level • Athletes competing in the world championships or the Olympics are competing in organised sport in its highest form of organisation and standard at an international level

recreational activity
Activity that diverts, amuses or stimulates the body and mind through enjoyment and relaxation

trubavink/Adobe Stock

FIGURE 7.05 Surfing can be classified as both a physical activity and a sport.

COLLABORATIVE TASK
Prac activity

Pickleball

Pickleball is considered an organised sport which can be formal, but can also be played informally and classified as a lifelong activity played across the lifespan. Pickleball can be played within community or school sport, or even at home in your driveway or yard. Pickleball, which originated in the USA, is the fastest-growing sport is the USA and is also showing a rapid increase in formal participation within Australia.

Participate in a Pickleball class. Visit the Pickleball Victoria or Pickleball Australia website or another Pickleball website to check out videos and other resources that will introduce you to the Pickleball concept, rules and tips.

pics721/Shutterstock.com

FIGURE 7.06 Pickleball uses small paddles, placing far less strain on the body and making it a far more accessible and safe physical activity for all ages when compared to traditional tennis.

Weblink
Pickleball Victoria

LOOKING FORWARD
Health benefits of pickleball

Later in this chapter we will explore health benefits of physical activity. Consider the health benefits of participating in pickleball regularly.

Regular physical activity

Throughout VCE Physical Education you will refer to physical activity, exercise and sedentary behaviour guidelines. Physical activity guidelines, both nationally and internationally, encourage participation in regular physical activity. In fact, you can't meet physical activity guidelines unless you are regularly active. Regular physical activity is activity performed on most days of the week, preferably every day.

DID YOU KNOW?

The term 'sedentary' is derived from the Latin *sedere*, meaning 'to sit.' Sedentary behaviour incorporates almost all sitting-based activities.

LEARNING HACK

It is important to note that although the terms inactivity and sedentary behaviour are often used interchangeably, they are not the same thing.

LOOKING FORWARD

Physical activity and sedentary behaviour guidelines

Chapter 10

Chapter 10 provides an outline of the physical activity exercise and sedentary behaviour guidelines.

Inactivity

moderate-intensity physical activity
Physical activity performed at a level that causes the heart to beat faster and some shortness of breath, while the person can still talk comfortably. An intensity that may last between 30 and 60 minutes

Inactivity means not engaging in any regular physical activity beyond daily activities, or a lack of **moderate-intensity physical activity**. Physical inactivity is defined as a person undertaking 'insufficient' physical activity to achieve measurable health outcomes. People who do not do sufficient physical activity have a greater risk of cardiovascular disease, colon and breast cancers, type 2 diabetes and osteoporosis. Regular physical activity improves mental and musculoskeletal health, which we will explore later in this chapter. It also and reduces other risk factors such as overweight, high blood pressure and high cholesterol, and many other factors that contribute to the burden of disease.

DID YOU KNOW?

Although playing computer games is generally considered sedentary behaviour, the amount of energy expended while playing certain Nintendo sports and exercise games, such as Nintendo Ringfit, is between two and three times higher than that expended while watching television (at rest). Although exergaming is not as good for you physically as participating in the actual physical activity itself, something is most certainly better than nothing.

Sedentary behaviour

Sedentary behaviour is defined as the amount of time per day spent sitting or lying down (other than sleeping). For example, activities such as watching television or playing electronic games, driving a vehicle, working at a computer and reading. Being sedentary means staying in the same place and expending low amounts of energy. While many inactive people spend many hours engaged in sedentary behaviour, highly active people can also be highly sedentary.

MET
Stands for metabolic equivalent. 1 MET is the amount of energy you expend at rest, and 2 METs is twice the energy expenditure of resting levels

Sedentary behaviours include activities that require up to 1.5 **METs** to perform, where 1 MET (metabolic equivalent) is the amount of energy you expend at rest, and 2 METs is twice the energy expenditure of resting levels. More vigorous physical activity requires proportionately higher oxygen consumption, so activities can be quantified in terms of multiples of the resting oxygen consumption. For example, jogging expends 8 METs. Higher levels of sedentary behaviour are associated with poorer health outcomes, including an increased risk of type 2 diabetes. It is important to minimise the amount of time spent sitting each day, and to break up periods of time spent being sedentary as often as possible.

LOOKING FORWARD

Reducing sedentary behaviour

Chapter 11

In Chapter 11 we will explore a range of strategies to reduce sedentary behaviour that can be easily implemented within home, school, work or community settings.

SIGNPOST

Watch a video of Professor Jo Salmon talking about understanding sedentary behaviour on Nelson MindTap.

Video
Understanding sedentary behaviour – Jo Salmon

iStock.com/track5

FIGURE 7.07 Many research studies have reported that the energy expenditure associated with active gaming is a moderate-intensity equivalent to a brisk walk at 4 kilometres per hour, and expends about 4 METs.

7.1 CHECK-IN QUESTIONS

1 Which one of the following would be associated with the lowest energy expenditure?
 A Exercise
 B Sedentary behaviour
 C Sport
 D Dance
2 **Define** the terms 'physical activity', 'exercise', 'sport' and 'play.'
3 **Outline** three characteristics of lifestyle physical activities.
4 **Contrast** the terms 'inactivity' and 'sedentary behaviour.'
5 **Discuss** with the person next to you examples of incidental physical activity you engage in during a typical week around your home, school and local community.

Assessment
7.1 Check-in questions

Command terms

outline
Provide an overview or the main features of an argument, point of view, text, narrative, diagram or image

contrast
Show how things are different or opposite

7.2 DOMAINS OF PHYSICAL ACTIVITY

In this module you will learn about:

- types of physical activity such as play, games, sports (formal and informal), transportation, chores, exercise and recreational activities

and learn to:

- classify physical activities by which domain/s they are performed within.

Physical activity can take place during leisure time, at work, while performing household chores, gardening or yard work, or as a form of transport. As mentioned earlier, physical activity accumulated within the household/garden, occupational and transport domains can also be considered incidental activity because the primary purpose is to complete the chores or your job, or commute somewhere, and to do so enabled the activity.

Sam Edwards/OJO Images/Getty Images; Ground Picture/Shutterstock.com; iStock.com/xavierarnau; Mediteraneo/Adobe Stock

FIGURE 7.08 Domains of physical activity

Leisure-time activity domain

Leisure-time activity is considered any activity that is over and above that which occurs within the workplace. Leisure-time physical activity is performed during recreational, non-working spare time, when a person has the freedom to choose an enjoyable activity or pastime. Examples of leisure-time activities are golf, tennis, walking the dog, basketball and karate.

LOOKING FORWARD
Physical activity surveys

Chapter 10

In Chapter 10 you will learn about physical activity surveys. Most physical activity surveys focus on physical activity performed during leisure time.

Household/gardening domain

Household tasks that you carry out around the house and garden provide an important source of physical activity. These include tidying up, making your bed, scrubbing, sweeping, vacuuming, washing windows, raking leaves or grass clippings, digging, taking the bins out, mowing and painting. For many older people, this is an essential source of physical activity that provides an opportunity to develop strength, flexibility, balance and muscular endurance and helps them avoid a loss of basic functioning.

Occupational/work domain

This is the physical activity that a person performs regularly as part of their work or occupation. Some people, such as labourers, gardeners, cleaners, personal trainers and physical education teachers, have highly active jobs, while others, such as those who have desk jobs, are highly sedentary. Some examples of occupational activities include walking long distances, sweeping, lifting, packing boxes, digging, carrying bricks or wood and tending to animals.

REAL WORLD APPLICATIONS

Occupational physical activity

Harley is an apprentice landscape gardener. During a typical day he uses a combination of machinery and hand tools to create new landscapes in community parks and private gardens. He builds garden beds, retaining walls, paths and water features, lays turf and plants trees, all of which requires a significant amount of physical activity. By the end of the day Harley has generally accumulated between 17 000 and 25 000 steps, and on some days has quite tired muscles, depending on the nature of the tasks performed that day. Most of the time Harley has no need nor time to go to a gym, so he complements his occupational physical activity with some dips and abdominal work in the morning when he gets out of bed.

FIGURE 7.09 Landscape gardeners can accumulate large amounts of occupational physical activity. What are some other active occupations?

Active transport domain

Active transport is any form of human-powered transportation used to get to and from specific destinations, such as to the shops or school, usually across a reasonable distance, by walking, skating, cycling or the use of public transport. Active transport usually involves travel to a specific destination, rather than walking or cycling for exercise. More people riding bikes to work not only brings many health benefits but also reduces traffic congestion and greenhouse gas emissions. Greater levels of physical activity have also been associated with increased productivity.

ABOVE AND BEYOND THE STUDY DESIGN

Health benefits can be domain specific, p. 257

Assessment
7.2 Check-in questions

7.2 CHECK-IN QUESTIONS

1 Which one of the following domains would include physical activity performed during recreational, non-working spare time?
   A Occupational domain
   B Transport domain
   C Household/garden domain
   D Leisure-time domain
2 Physical activities such as vacuuming and washing windows could be included as examples within which two domains?
3 **Identify** four highly active professions that would enable someone to accumulate significant amounts of physical activity during work duties.
4 **Describe** another example of a physical activity undertaken during a typical week that would be performed across more than one domain.
5 Using a Venn diagram, **compare** the concept of 'Active transport' with walking or cycling for exercise.

Command term

compare
Recognise similarities and differences and the significance of these similarities and differences

7.3 DIMENSIONS OF PHYSICAL ACTIVITY

In this module you will learn about:
- dimensions of physical activity including type, frequency, intensity and duration

and learn to:
- classify physical activity intensities.

Before you go on to learn about physical activity and exercise guidelines and measurement of physical activity in Chapter 10, you need a sound understanding of the fundamental dimensions of physical activity. The dimensions of physical activity can be summarised using the acronym FITT.

F	=	Frequency
I	=	Intensity
T	=	Types of activity
T	=	Time (duration)

Activity type

There are hundreds of types of physical activities that people engage in. These can be classified in terms of the following categories, based on the physical activity pyramid (see page 240):

- lifestyle or lifetime physical activities
- active aerobic activities
- active sports and recreation
- flexibility activities
- strength and muscular endurance activities.

Rest or inactivity is a part of the pyramid, but is not a category of physical activity.

Lifestyle physical activity

J_Koneva/Shutterstock.com

Lifestyle (sometimes referred to as lifetime or lifelong) physical activities should be the most common form of daily physical activity. These activities form the base of the physical activity pyramid, and should be performed on most days of the week, if not daily. Walking is a lifestyle physical activity and is the most common physical activity people engage in, regardless of the country they live in. Other examples of lifestyle physical activities are gardening, swimming, bike riding, dancing, golf, tennis, kayaking and household chores. The checklist below outlines the key factors that characterise lifestyle physical activities. Think of 10 activities you engage in regularly, and apply the checklist shown to each one. If the activity possesses at least six of the characteristics on the list, it is likely to be an example of a lifestyle physical activity.

Characteristics of lifestyle physical activities

- ☐ If regularly performed, will result in numerous health benefits
- ☐ Should be performed daily
- ☐ Can easily integrate into everyday life and routines
- ☐ May be considered light activity when you are young, but may equate to moderate intensity when you are older
- ☐ Are easy to perform regardless of fitness or skill level, and therefore popular among adults
- ☐ Should expend more energy than being at rest
- ☐ May be performed throughout the lifespan
- ☐ Usually require minimal equipment
- ☐ Can be performed anywhere, anytime, even on holidays
- ☐ Can be performed either alone or with one or two others
- ☐ Are often of light to moderate intensity, moderate-intensity activities being more attractive than vigorous-intensity activities to most people

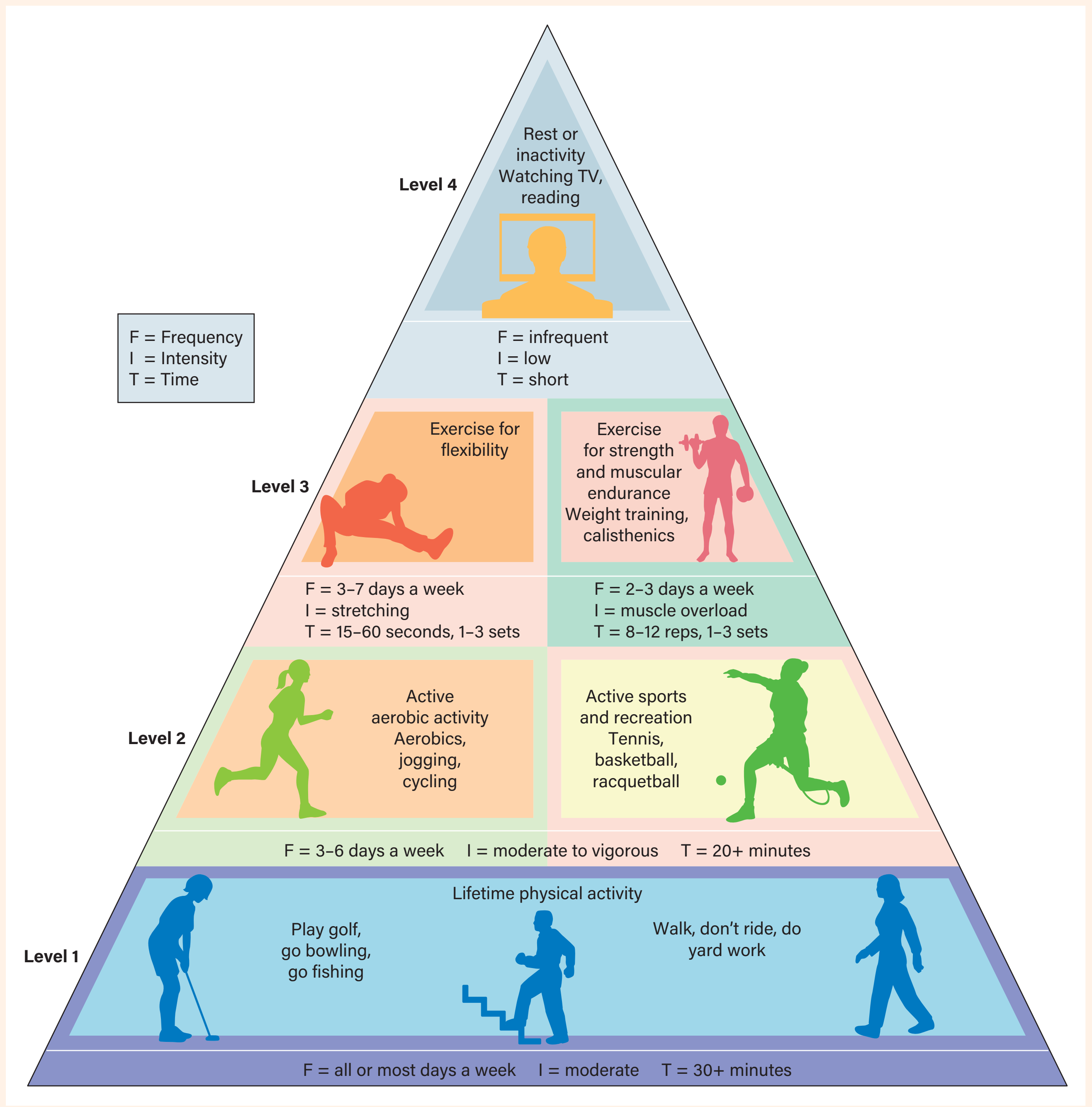


FIGURE 7.10 The physical activity pyramid

COLLABORATIVE TASK
Prac activity

Spikeball

Participate in a practical session focusing on 'Spikeball' and reflect on which characteristics, if any, from the checklist for lifestyle physical activity Spikeball would cover.

Marat Lala/Alamy Stock Photo

FIGURE 7.11 Spikeball is a dynamic physical activity that can be played with as few as two people and set up almost anywhere.

DID YOU KNOW?

High-quality and contemporary physical education programs place a huge emphasis on lifestyle physical activity programs to engage all students, rather than simply focusing on traditional team/competitive sports. Only around 30 per cent of adults participate in regular organised sport, which makes an emphasis on lifelong physical activity in programming critical.

Frequency

The number of times a person engages in physical activity within a given time frame is referred to as frequency. Frequency can also refer to the number of physical activity sessions or bouts during a day. For example, adults can meet the recommended 30 minutes per day by doing three 10-minute bouts of moderate-intensity activity. The adult guidelines recommend that people be active on most days, preferably all days, each week.

vigorous-intensity activity
Physical activity performed at a level that causes rapid heartbeat and shortness of breath. An intensity that may last up to 30 minutes and no longer than 10 minutes when exceeding 9 METs

Intensity

The intensity of an activity refers to how much effort it requires. Intensity can be classified as sedentary, light, moderate, vigorous and high, depending on how much energy is expended during the activity. The physical activity and exercise guidelines focus mainly on moderate-intensity and **vigorous-intensity activities**, which are discussed in Chapter 10.

Table 7.3 summarises the classifications of physical activity intensity in terms of MET, kcal (or kJ), perceived exertion and proportion of maximum heart rate. When you study measurement of physical activity this table will be an excellent reference.

TABLE 7.3 Classification of physical activity intensities

Intensity classification	Description	Intensity				Example activities
		METs	% VO_2 max	Perceived exertion (Borg)*	% maxHR	
Sedentary	Activities that usually involve sitting or lying, which require little movement and low energy expenditure	<1.6	<20	<6	<40	Watching television, reading, sitting in a vehicle, sitting at a computer
Low (light)	The lightest category or activity in terms of perceived and actual exertion and energy expenditure	1.7–2.9	20–39	6–10	40–54	Walking slowly, golf, gardening, household chores
Moderate	Generally consists of sustained rhythmic movements. At this level you should feel some exertion, but still be able to carry out a conversation comfortably	3–6	40–59	11–14	55–69	Bike riding moderate pace, playing tennis doubles, dancing, weightlifting
Vigorous	Participation at this level leads to a substantial increase in heart and respiratory rates	7+	60+	15+	70+	Running, swimming laps, squash

* Perceived exertion (Borg) based on category scale (6–20)

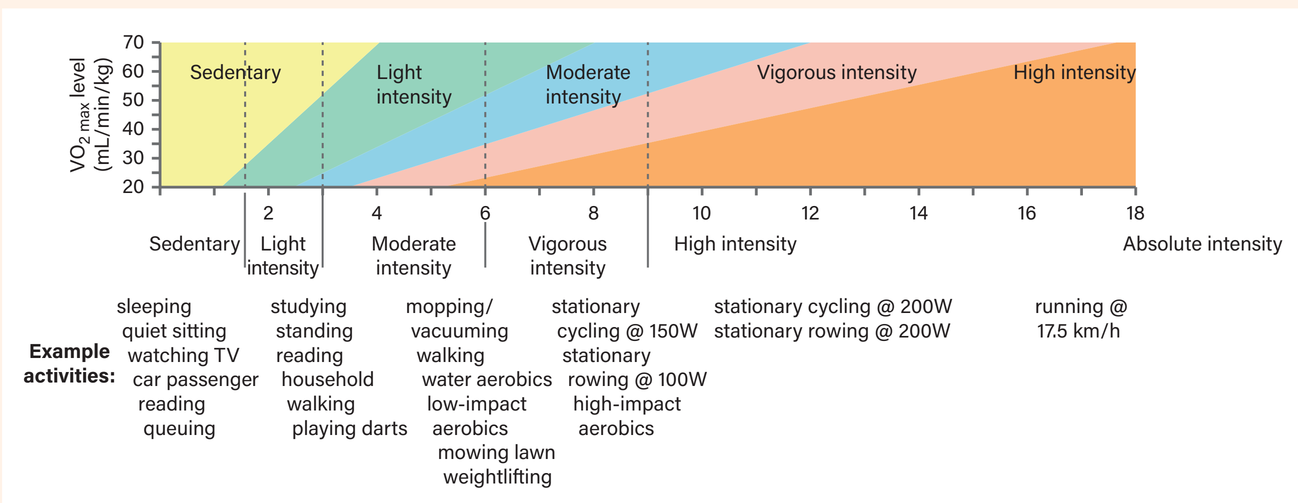


FIGURE 7.12 Physical activity intensities

Reprinted from *Journal of Science and Medicine in Sport*, vol. 13, p. 499. Kevin Norton, Lynda Norton & Daryl Sadgrove, 'Position statement on physical activity and exercise intensity terminology.'

Table 7.4 outlines four methods of determining activity intensity. The number of METs required to work at a moderate intensity declines with age.

TABLE 7.4 Methods of determining activity intensity

Method	Description
Talk test	This is a simple test. If you can talk comfortably while being active, you are working at a light or moderate intensity. If you cannot talk comfortably, you are likely to be performing at a vigorous intensity.
Perceived exertion	This a subjective estimate of how hard you feel you are working based on how your body feels. It is not always convenient to take a pulse while exercising, but perceived exertion can be assessed using tests such as the Borg Rating of Perceived Exertion or Rated Perceived Exertion (RPE). These scales are simply a perception scale to monitor and interpret the intensity of physical activity, usually an aerobic activity.
Heart rate	There is a direct linear relationship between heart rate and activity intensity. Heart rate, in beats per minute, can be measured manually or by electronic device. To work at a moderate level, heart rate should be 50–70 per cent of **maximum heart rate** (MHR). A 30-year-old should work with heart rate 95–133 bpm to be working within their moderate-intensity target zone.
Metabolic equivalent (MET)	1 MET represents the energy expended at resting levels. 4 METs represents activity expenditure four times that at rest. At rest (1 MET), an average male and female would consume approximately 250 and 200 mL of oxygen per minute, respectively. 1 MET is equal to 3.5 mL of oxygen per kilogram of body weight per minute. It is not feasible to assess how much oxygen an individual's body is using; assigning a MET equivalent can provide an estimate of intensity. The Compendium of Physical Activities provides a list of physical activities and for each assigns the energy expended during each activity by assigning METs.

maximum heart rate
Is age related and may be calculated by using the formula 220 minus age; for example, a 30-year-old's MHR would be 220 – 30 = 190 bpm

Compendium of Physical Activities

The Compendium of Physical Activities gives an estimate of the energy cost of particular activities, providing a standardised means of classifying the METs of different physical activities. Table 7.5 presents a variety of sporting, household/gardening and occupational physical activities from the Compendium of Physical Activities. Each activity has been assigned a MET value.

LEARNING HACK

Currently, VILPA, which stands for vigorous intermittent lifestyle physical activity, is not a widely used or recognised term. Instead, stick to the acronyms that are used globally to denote physical activity and intensity, such as moderate- to vigorous-intensity physical activity (MVPA), moderate-intensity physical activity (MPA) and vigorous-intensity physical activity (VPA).

TABLE 7.5 Major Headings and Specific Activity codes in the 2024 Adult Compendium

Major Heading number – Name (Total number of Specific Activity codes)		
01 – Bicycling (44)	09 – Miscellaneous (28)	17 – Walking (93)
02 – Conditioning exercises (86)	10 – Music playing (22)	18 – Water activities (87)
03 – Dancing (28)	11 – Occupation (149)	19 – Winter activities (52)
04 – Fishing and hunting (37)	12 – Running (66)	20 – Religious activities (24)
05 – Home activities (78)	13 – Self-care (11)	21 – Volunteer activities (19)
06 – Home repair (37)	14 – Sexual activity (3)	22 – Video games (8)
07 – Inactivity (17)	15 – Sports (158)	
08 – Lawn and garden (54)	16 – Transportation (12)	

Time (duration)

Duration refers to how long a person is active for within a given time period. The physical activity guidelines generally recommend that people engage in a minimum number of minutes daily on most days, depending on their age. It is recommended that people engage in moderate-to-vigorous physical activity for a minimum of 10 minutes at a time. These time periods are often referred as 'bouts' of physical activity or exercise.

Assessment
7.3 Check-in questions

7.3 CHECK-IN QUESTIONS

1 **Identify** four methods of determining physical activity intensity and provide three examples of when you have been working at this intensity.
2 **Describe** how you might use the Compendium of Physical Activity.
3 **Explain** what 5 METs refers to.
4 Think of three examples of vigorous intensity activities you engage in and justify why they would be classified as vigorous intensity.
5 If you were out on a 20-minute run and you were not able to use a wearable device to capture your intensity data, **explain** two methods you could use to determine what intensity you were working at.
6 Refer to the physical activity pyramid on page 240 and **evaluate** which sections of the pyramid you would meet, and which areas would need improvement.

Command words

evaluate
Ascertain the value or amount of; make a judgment using the information supplied, criteria and/or own knowledge and understanding to consider a logical argument and/or supporting evidence for and against different points, arguments, concepts, processes, opinions or other information

7.4 BENEFITS OF PHYSICAL ACTIVITY

In this module you will learn about:
- physical, social, mental, emotional and spiritual benefits of regular participation in types of movement

and learn to:
- participate in a variety of movement experiences to reflect on and record information related to the physical, social, mental, emotional and spiritual benefits of physical activity.

The health benefits associated with participation in regular physical activity are well documented. In fact, all types of movement experiences will have at least one physical, social, mental, emotional or spiritual benefit. Figure 7.13 summarises the well-established evidence of health benefits based on an overview of the Cochrane systematic reviews of exercise/physical activity and health outcomes (Posadzki et al., 2020).

LOOKING BACK
MUSCULAR SKELETAL CARDIOVASCULAR AND RESPIRATORY SYSTEMS

Chapter 1, Chapter 4 and Chapter 5

We explored the muscular skeletal system in Chapter 1, the cardiovascular system in Chapter 4 and the respiratory system in Chapter 5.

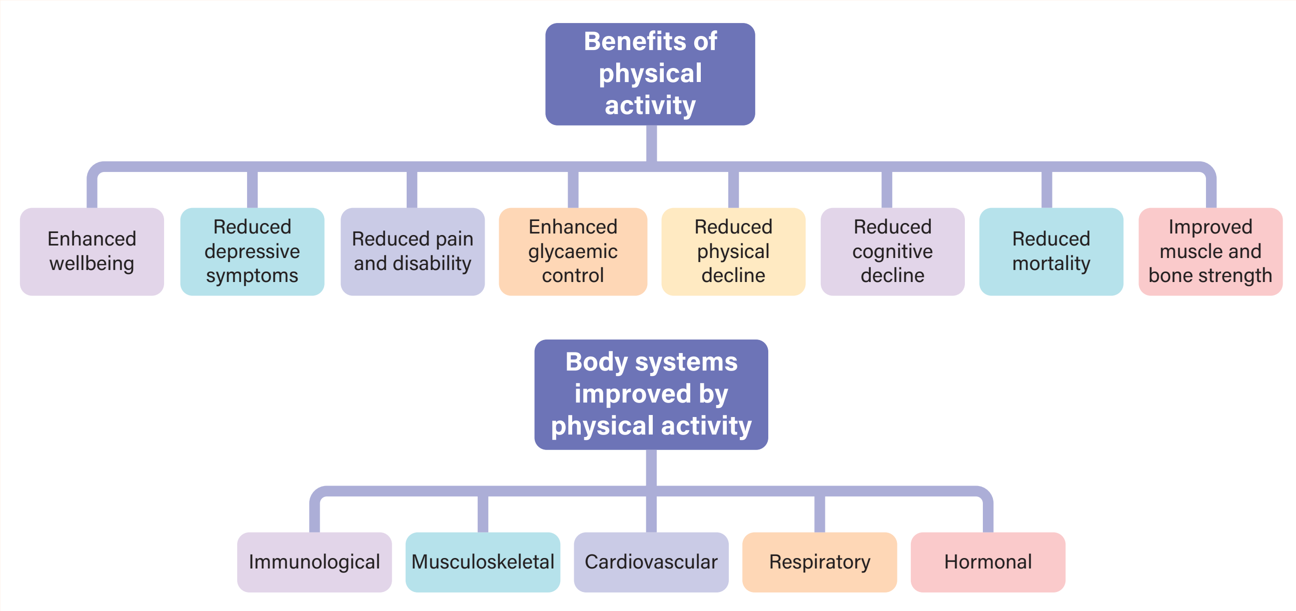


FIGURE 7.13 Benefits and body systems improved by physical activity

Physical benefits

There is a vast array of physical benefits from participation in regular physical activity.

Improved cardiovascular function

When you are regularly active, your fitness, stamina and energy increase. This is partially due to an increase in the size and strength of your heart muscle. A stronger heart is able to work more efficiently, pumping more blood with each beat. More oxygen is delivered to the brain, and muscles perform more efficiently for longer, therefore delaying fatigue. A more efficient cardiovascular system means you can work harder (i.e. walk or run further and faster) than when you were not as active. Figure 7.15 summarises the benefits to the cardiovascular system associated with participation in regular physical activity (Posadzki et al., 2020).

LOOKING FORWARD

Physical activity reduces risk of a range of diseases

Chapter 9

Physical activity and exercise are dose dependent. People who achieve cumulative levels of physical activity several times above the recommendations have a significantly reduced risk of breast cancer, colon cancer, diabetes, ischaemic heart disease and ischaemic stroke events. We will explore these in Chapter 9.

FIGURE 7.14 Regular physical activity is associated with numerous physical, social, mental and emotional health benefits.

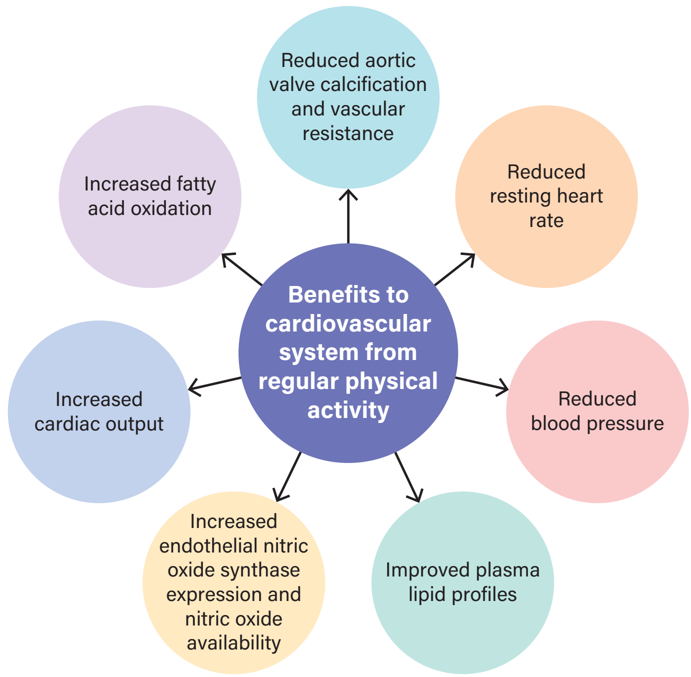


FIGURE 7.15 Benefits to the cardiovascular system from participation in regular physical activity

Improved strength and endurance

Regular exercise increases the strength and endurance of muscles. Having stronger muscles decreases the risk of injury and reduces lower back problems. Maintaining muscular strength as you age is very important for maintaining mobility and independence and slowing the rate of functional decline. Many older people struggle to open jars or to get up from chairs – these are examples of **functional decline**. Inactivity results in reduced muscle strength and mass and reduced bone mineral density (BMD), which can lead to reduced functional status, as well as falls and fractures.

functional decline
the decline in the decrement in physical and/ or cognitive functioning and occurs when a person is unable to engage in activities or daily living

Resistance to fatigue

A key benefit of regular physical activity is resistance to fatigue. Increased energy levels mean you have enough energy to get through a typical day at school or work with enough remaining to enjoy your leisure time without feeling lethargic. Increased energy levels are associated with an improved ability to cope with stress and improved **quality of life**.

quality of life
The World Health Organization (WHO) defines quality of life as an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns

Greater lean body mass and less body fat

A high level of physical activity is associated with an increase in lean body mass, made up of muscles, tendons and ligaments, and a decrease in body fat. Healthy weight range guidelines can be misleading; sometimes elite athletes, who may have a large amount of lean body mass and low body fat, are classified as overweight or obese. Sometimes the way your clothes fit or a body fat assessment is a better indicator of greater lean body mass than using the scales.

Improved flexibility

Being flexible allows you to perform a wide range of movements with a lower risk of muscular and joint injuries. Regular stretching can lead to a greater range of movement and can improve sporting performance and reduce your risk of injury.

Bone development

Participating in regular weight-bearing and high-impact activities is essential in order to maintain strong bones. Childhood and adolescence are key times to develop bone density. During this developmental period, activities such as skipping, running and gymnastics are ideal for developing large amounts of the mineral deposits responsible for bone strength. Poor bone mineral density can result in a condition known as osteoporosis, which can lead to fractures, particularly in older people.

COLLABORATIVE TASK
Prac activity

Skipping rope

As a class, participate in a range of skipping activities using a combination of short and long ropes. Monitor your heart rate:

a before the activity

b during activity

c immediately after the activity

d five minutes after stopping the activity.

Have a class discussion about the potential physical health benefits of skipping.

Soloviova Liudmyla/Shutterstock.com

FIGURE 7.16 Skipping rope has numerous potential health benefits.

CASE STUDY A WEEK IN THE LIFE OF A 12-YEAR-OLD

Madison, aged 12, is completing Year 6 of primary school. She is driven to school but has about a 500-metre walk to and from the car. During her leisure time she has a one-hour training session for tennis twice per week, and plays competition tennis on the weekend for about three hours, which includes warm-ups before each match. One night per week she also participates in stage school, which consists of 2.5 hours of acting, singing and dancing. During her leisure time at home, Madison likes to swim in her pool, bounce on her trampoline, swing on her swings and play Pickleball in the driveway with her family. Madison has physical education once per week for an hour, and sport education for two hours per week. Madison must also complete an hour of chores on the weekend. Madison also enjoys skipping rope, doing cartwheels and dancing around the house while at home and in the schoolyard during break time.

QUESTIONS

1 **Discuss** three health benefits Madison might experience based on her physical activity during a typical week.
2 **Describe** why racquet sports are an excellent option to build up strong bones for young people.
3 **Evaluate** which domains Madison accumulates physical activity in, and make a recommendation to improve her physical activity.
4 **Propose** a physical activity Madison could build into her typical week that would have spiritual benefits.
5 Madison enjoys skipping rope. **Identify** the METs associated with this physical activity and **explain** three potential health benefits of skipping rope.

Command term

propose
Suggest or put forward a point of view, idea, argument, diagram, plan and/or suggestion based on given data or stimulus material for consideration or action

FIGURE 7.17 Walking groups have grown in popularity in recent years.

Social benefits

There are many social benefits associated with participation in physical activity. Playing in a team, going to the gym to do a workout, or even walking the dog can mean interacting with other people. Walking groups are very popular, as they allow participants to walk, talk and laugh. Interacting with others increases a person's sense of connectedness within a community; the community could be within a suburb, sporting club or school. Socialising when you are active, whether with friends, family, companions, personal trainers, work colleagues or coaches, can provide the numerous benefits, as shown in Figure 7.18.

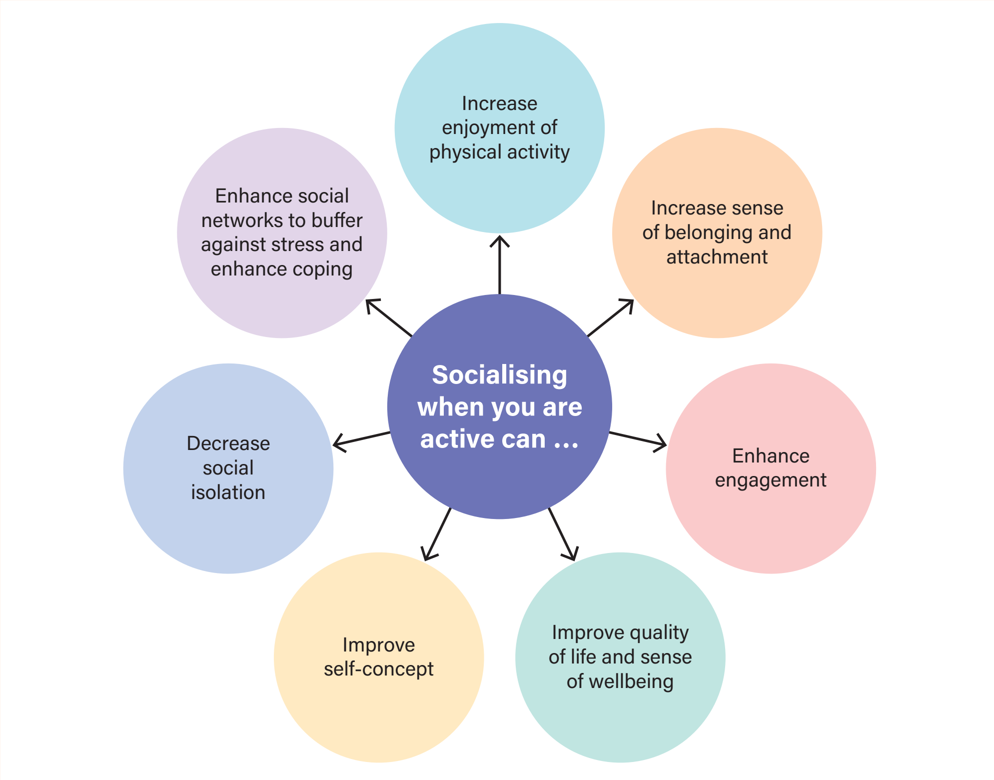


FIGURE 7.18 Social benefits of being active with others

Video
In focus: Social benefits of being active

WORKED EXAMPLE

John, aged 38 years, rides his bike to work two days per week (20 minutes each way). He works as a pool lifeguard and personal trainer at the local community recreation centre. As part of this role, he demonstrates many exercises (such as using treadmills, exercise bikes, dumbbells and other machines) to clients. In his leisure time John enjoys playing badminton twice a week for an hour, and walking his dog three days per week for half an hour. John also works out in his home gym twice a week for 30 minutes. He spends about an hour a week doing household cleaning and other tasks.

1 **a** List the domains in which John accumulates physical activity.
  b Identify a physical activity that is being performed across multiple domains.
2 Describe the physical activity type, frequency and duration for one physical activity performed by John within the leisure time domain.
3 Describe a method John could use to assess intensity while riding his bike to work.

Suggested responses:

1 **a** *Household/garden, Active transport, Occupational/work and Leisure-time domains*
Rationale: The cleaning relates to the Household/garden domain, the demonstration of exercises relates to the Occupational/work domain. Playing badminton and dog walking relates to leisure time, and riding to work is active transport.
  b *Bike riding*
Rationale: The riding to work is active transport and demonstrating use of exercise bike is within the occupational domain.

2 *John exercises (type) in his home gym at a frequency of twice a week for a duration of 30 minutes each time.*
Rationale: In this instance, type could be classified as exercise or lifelong physical activity if you selected dog walking. Duration relates to minutes and can be combined into minutes per week. Frequency is expressed as number of sessions in each week.

3 *John could measure his heart rate by wearing a watch which has this function.*
Rationale: It would be unsafe for John to take his pulse on a moving bicycle, hence the suggestion of a wearable device to capture heart rate. Alternatively, you could suggest the use of perceived exertion using a scale like Borg's or even the talking test.

CASE STUDY JUST 5 MINUTES OF PHYSICAL ACTIVITY A DAY COULD LOWER YOUR CANCER RISK

SHORT BURSTS OF DAILY ACTIVITY LINKED TO REDUCED CANCER RISK

28 JULY 2023
UNIVERSITY OF SYDNEY

Wearable technology reveals potential benefits of vigorous incidental activity

progressman/Shutterstock.com

FIGURE 7.19 Researchers found that short 1-minute bursts of physical activity totalling about 4.5 minutes daily could lower your risk of cancer.

Promising research published in 2023 suggests a total of just 4.5 minutes of vigorous activity that makes you huff and puff during daily tasks could reduce the risk of some cancers by up to 32 percent.

Published in *JAMA Oncology* and led by the University of Sydney, Australia, the study used data from wearable devices to track the daily activity of over 22,000 'non-exercisers'. Researchers then followed the group's clinical health records for close to seven years to monitor for cancer.

As few as four to five minutes of vigorous intermittent lifestyle physical activity or 'VILPA' was associated with a substantially lower cancer risk compared to those who undertook no VILPA.

Vigorous Intermittent Lifestyle Physical Activity, or VILPA for short, was coined by researchers at the University of Sydney's Charles Perkins Centre to describe the very short bursts of activity—around one minute each—we do with gusto each day. This includes activities like vigorous housework, carrying heavy shopping around the grocery store, bursts of power walking or playing high-energy games with the kids.

"VILPA is a bit like applying the principles of High-Intensity Interval Training (HIIT) to your everyday life," said lead author Professor Emmanuel Stamatakis of the Charles Perkins Centre.

He said adults who don't exercise are at increased risk of developing certain cancers like breast, endometrial or colon, but until recently the impact of less structured forms of vigorous physical activity was unable to be measured.

"We know the majority of middle-aged people don't regularly exercise which puts them at increased cancer risk but it's only through the advent of wearable technology like activity trackers that we are able to look at the impact of short bursts of incidental physical activity done as part of daily living," said first author Professor Stamatakis.

"It's quite remarkable to see that upping the intensity of daily tasks for as little as four to five minutes a day, done in short bursts of around one minute each, is linked to an overall reduction in cancer risk by up to 18 percent, and up to 32 percent for cancer types linked to physical activity."

The study is observational, meaning it isn't designed to directly explore cause and effect. However, the researchers say they are seeing a strong link and refer to previous early-stage trials showing that intermittent vigorous physical activity leads to rapid improvements in cardio-respiratory fitness, which may provide a possible biological explanation for reduced cancer risk. Other likely contributors include physical activity's role in improving insulin sensitivity and chronic inflammation.

"We need to further investigate this link through robust trials, but it appears that VILPA may be a promising cost-free recommendation for lowering cancer risk in people who find structured exercise difficult or unappealing," says Professor Stamatakis.

Professor Karen Canfell, Director of the Daffodil Centre, a joint research venture between Cancer Council NSW and the University of Sydney, said regular physical activity was an important strategy for preventing cancer, through direct physiological benefits and indirect benefits in helping to maintain a healthy weight.

"More than 1800 cancer cases diagnosed in Australia this year are likely to be the direct result of physical inactivity, while many more will be indirectly related to physical inactivity because of its association with obesity, which is also a cancer risk factor," said Professor Canfell who was not involved in the study.

"This new study shows that the more you move at a higher intensity as part of your daily living, the lower your risk of developing cancer, especially up to the 13 types associated with physical inactivity."

The international research team on the *JAMA Oncology* study includes investigators from the University of Sydney (Australia), University College London (UK), Harvard Medical School (US), University of Calgary (Canada), Maastricht University (The Netherlands), National Research Centre for the Working Environment (Denmark), The University of East Anglia (UK), Norwegian University of Science and Technology (Norway), Loughborough University (UK), and University of Adger (Norway).

What did the researchers find?

In a study sample of 22,398 people with an average age of 62 who didn't exercise in their leisure time, the researchers found;

- 2356 new cancer events (1084 in physical activity related cancer) over an average follow-up of 6.7 years
- a minimum of around 3.5mins of daily VILPA was associated with up to 18 percent reduction in cancer incidence (compared with no VILPA)
- 4.5 mins of daily VILPA was associated with up to 32 percent reduction in physical activity-related cancer incidence
- the steepest gains in cancer risk reduction were seen in people who did small amounts of VILPA compared to those who did none, however, benefits continued with higher levels of daily VILPA - particularly for physical activity-related cancers
- most VILPA (92 percent) occurred in bouts of up to 1min.

Study design

The current study analysed the impact of VILPA on overall cancer incidence, as well as for 13 cancer sites associated with physical activity; these include liver, lung, kidney, gastric cardia (a type of stomach cancer), endometrial, myeloid leukaemia, myeloma, colorectal, head and neck, bladder, breast and esophageal adenocarcinoma (cancer of the oesophagus)

The researchers used data from the UK Biobank Accelerometry Sub Study and only included those who identified as 'non-exercisers' – meaning they self-reported no leisure time exercise and no regular recreational walks.

They excluded study participants that could skew the results including due to previous cancer diagnosis or diagnosis within a year of enrolment.

Other influences such as age, smoking status, BMI, cardiovascular disease, sleep, diet and hereditary cancer risk were also taken into account.

VILPA was assessed based on the participant's activity levels as measured by wrist accelerometers worn over 7 days at study onset. This is consistent with other wearable studies as physical activity levels remain relatively stable at the population level over adulthood.

New cancer events were recorded via cancer registries, and hospitalisations or deaths attributable to cancer.

Next steps

"We are just starting to glimpse the potential of wearable technology to track physical activity and understand how unexplored aspects of our lives affect our long-term health – the potential impact on cancer prevention and a host of other health outcomes is enormous," said Professor Stamatakis.

Source: First published by Michelle Blowes, University of Sydney (2023), July 27, 2023.

QUESTIONS

1 **List** five types of cancer that are associated with low levels of physical activity.
2 **Outline** what VILPA stands for.
3 **Identify** how many minutes of VILPA per day was associated with up to 18 per cent reduction in cancer incidence (compared with no VILPA).
4 **Describe** who VILPA might be appealing to and explain why.
5 **Explain** why more research on VILPA is needed.
6 **Justify** why VILPA may be a promising alternative to duration-based recommendations for physical activity.

DID YOU KNOW?

The notion of short bursts of high-intensity physical activity underpins activities like CrossFit or Cardio Tennis.

Unai Huizi Photography/Shutterstock.com

FIGURE 7.20 Numerous mental health benefits are associated with physical activity.

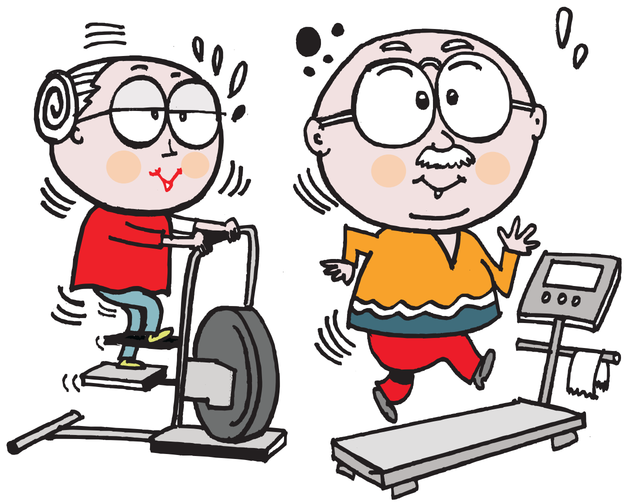
Mental health benefits

There is consistent evidence demonstrating the mental health benefits of physical activity. Engaging in physical activity reduces symptoms of both depression and anxiety, and physical activity is often prescribed as a treatment therapy in combination with other approaches. A systematic review found that people with high physical activity levels were more likely to have reduced risk of developing anxiety (Wanja et al., 2023).

Another systematic review and meta-analysis of the association between physical activity and risk of depression, which looked at 15 studies of over 191 130 people, showed that with increasing physical activity there was a reduced risk of depression (Pearce et al., 2022). In fact, research revealed that if less-active adults could achieve the minimum recommended physical activity, 11.5 per cent of depression cases could have been prevented.

Engaging in aerobic activity can also improve the quality of your sleep. Good-quality sleep is essential for all aspects of your life.

Increased physical activity is also associated with improved brain function/cognitive function. The latest evidence has shown that physical activity facilitates the **neuroplasticity** of certain brain structures and related cognitive functions. To maintain the neuro-cognitive benefits induced by physical activity, an increase in cardiovascular fitness levels must be maintained.



Alan Benge/Shutterstock.com

FIGURE 7.21 Participation in moderate- or vigorous-intensity physical activity has numerous mental and emotional health benefits.

neuroplasticity
The adaptation of the human brain to changing demands by altering its functional and structural properties. This results in learning and acquiring skills, and thereby enhances an individual's capacity to respond to new demands with behavioural adaptations

CASE STUDY COGNITIVE FUNCTION AND PHYSICAL ACTIVITY

Research has shown that regular physical activity can reverse some of the unwanted effects of a sedentary lifestyle, and delays brain ageing and degenerative conditions such as Alzheimer's disease, diabetes and multiple sclerosis (Di Liegro et al., 2019). Physical activity aids cognitive processes and memory and has analgesic and antidepressant effects, and even induces a sense of wellbeing. A systematic review (Muntaner-Mas et al., 2023) reported that acute physical activity increased academic outcomes in school-aged youth – in fact, they found that improvements in academic performance can occur with as little as a four-minute 'dose' of physical activity.

Emotional health benefits

Emotional health refers to the degree to which you feel emotionally secure, relaxed and able to cope with the demands of everyday life. Being emotionally healthy helps you remain calm under pressure, have positive self-esteem and be patient with yourself and others. Emotionally healthy people feel safe and secure with their own emotions and feelings and can assertively express them, rather than trying to avoid certain feelings or wanting to control them. Of course, emotional health is on a continuum; it fluctuates weekly and daily, and can change from moment to moment. Emotional wellness is at the peak of this continuum – this is when you are very joyful or 'high on life'. Regular physical activity has been consistently shown to be associated with enhanced emotional wellness, by boosting mood, allowing vital energy to flow, and reducing feelings of anxiety and depressive symptoms.

Relationship between physical activity and mental health

Engaging in physical activity naturally triggers a range of physiological, psychological and emotional mechanisms. These result in numerous bodily processes associated with positive benefits and changes to your mental health, as they can improve your self-concept and body image, quality of life, sleep, mood and the functioning of brain.

Video
In focus: The relationships between physical activity and mental health

Potential biochemical and physiological mechanisms

The potential biochemical and physiological mechanisms include:

- increase in endorphins
- changes associated with an increase in core body temperature
- changes in central serotonergic systems (e.g. increased serotonin)
- increased availability of neurotransmitters
- enhanced blood flow to brain regions involved in emotional regulation
- disruption of the hypothalamic-pituitary-adrenocortical axis, which regulates endocrine response to stress
- improved sleep.

Potential psychological and emotional mechanisms

The potential psychological and emotional mechanisms include:

- distraction or time out from stressful contexts and negative thoughts
- enhanced feelings of control and mastery
- improved self-esteem and physical worth
- behavioural activation.

Participation in regular physical activity provides the following benefits:

- protects against the onset of anxiety disorders and symptoms
- protects against depression symptoms and the onset of major depressive disorder
- reduces feelings of distress (enhances wellbeing)
- enhances self-esteem
- improves psychological wellbeing.

It is thought that physical activity may also have the potential to reduce the risk of **dementia**, although more research is needed. Evidence of the other benefits of physical activity, however, is compelling. As mentioned, people who are regularly active have a reduced risk of heart disease and stroke, both of which are associated with an increased risk of developing dementia. Higher levels of physical activity have been associated with less cognitive decline in older people, and slower loss of brain tissue as they age.

dementia
A disorder that affects the brain; symptoms include memory loss and the loss of the ability to solve problems, do simple daily activities such as get dressed and control emotions

COLLABORATIVE TASK

Prac activity

Lifestyle physical activity

As a class, participate in a lifestyle physical activity (e.g. Pilates, a bike ride, a power walk, a yoga class, trampolining, stand-up paddle boarding, surfing or spin class).

1. **Identify** potential target groups who would benefit from the activity that you participated in. Explain why you have selected each target group.
2. Classify which subcategory of physical activity this activity represents.
3. **Describe** four characteristics of your chosen physical activity that meet the criteria for a lifestyle physical activity.
4. **Outline** all safety issues that need to be considered for the designated physical activity.
5. **Explain** how you felt after participating in this activity? What didn't you enjoy?

Command term

identify
Recognise and name and/or select an event, feature, ingredient, element, speaker and/or part from a list or extended narrative or argument, or within a diagram, structure, artwork or experiment.

Health benefits of physical activity and fitness

IMPROVED CARDIOVASCULAR FUNCTION

- Stronger heart muscle
- Increased fitness and health
- Lower heart rate
- Better electrical stability of heart
- Decreased sympathetic control of heart
- Increased O_2 to brain
- Reduced blood fat, including low-density lipids (LDLs)
- Increased protective high-density lipids (HDLs)
- Delayed development of atherosclerosis
- Increased work capacity
- Improved peripheral circulation
- Improved coronary circulation
- Resistance to 'emotional storm'
- Reduced risk of heart attack
- Reduced risk of stroke
- Reduced risk of hypertension
- Greater chance of surviving a heart attack
- Increased oxygen carrying capacity of the blood

IMPROVED STRENGTH AND MUSCULAR ENDURANCE

- Increased lean muscle mass and strength
- Greater work efficiency
- Less chance of muscle injury
- Reduced risk of lower back problems
- Improved performance in sports
- Quicker recovery after hard work
- Improved ability to meet emergencies

RESISTANCE TO FATIGUE

- Ability to enjoy leisure
- Improved quality of life
- Improved ability to cope with stress

OTHER HEALTH BENEFITS

- Decreased diabetes risk
- Improved quality of life for diabetics
- Improved metabolic fitness
- Extended lifespan
- Reduced chronic illness
- Decrease in dysfunctional years
- Aids people suffering from arthritis, PMS, asthma, chronic pain, fibromyalgia and impotence
- Improved immune system
- Reduced risk of menstrual symptoms, constipation and back pain
- Reduced risk of postnatal depression

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ENHANCED MENTAL HEALTH AND FUNCTION

- Relief from depression
- Improved sleep habits
- Fewer stress symptoms
- Greater ability to enjoy leisure and work
- Improved brain (cognitive) function
- Improved neuroplasticity of the brain
- Improved concentration

IMPROVED WELLNESS

- Improved quality of life (especially among older adults)
- Leisure time enjoyment
- Improved work capacity
- Ability to meet emergencies
- Improved creative capacity
- Improved independence

OPPORTUNITY FOR SUCCESSFUL EXPERIENCE AND SOCIAL INTERACTIONS

- Improved self-concept
- Opportunity to recognise and accept personal limitations
- Improved sense of wellbeing
- Improved enjoyment of life and ability to have fun
- Improved quality of life

IMPROVED APPEARANCE

- Improved figure/physique
- Improved posture
- Fat control

GREATER LEAN BODY MASS AND LESS BODY FAT

- Greater work efficiency
- Less susceptibility to disease
- Improved appearance
- Less incidence of self-concept problems related to obesity

IMPROVED FLEXIBILITY & COORDINATION

- Greater work efficiency
- Less chance of muscle injury
- Less chance of joint injury
- Decreased chance of lower back problems
- Improved motor co-ordination
- Improved sports performance
- Improved balance and stability

BONE DEVELOPMENT

- Greater peak bone density
- Less chance of osteoporosis

REDUCED CANCER RISK

- Reduced risk of colon and breast cancer
- Possible reduced risk of rectal, testicular, prostate and pancreatic cancers

REDUCED EFFECT OF ACQUIRED AGEING

- Improved ability to function in daily life
- Better short-term memory
- Fewer illnesses
- Greater mobility
- Greater independence
- Greater ability to operate an automobile
- Lower risk of dementia

Source: Corbin et al., 2004

acquired ageing
Characteristics commonly associated with ageing that appear at an earlier than normal age


PeopleImages.com – Yuri A/Shutterstock.com


anatoliy_gleb/Adobe Stock

FIGURE 7.22 Being active in nature has numerous spiritual benefits.

Spiritual benefits

The notion of spiritual fitness is used to convey someone's ability to find meaning and purpose, and to cope and enjoy their life. Physical activity can help people find stillness and quieten their mind through activities such as yoga, meditation and walking in nature, which can fuel the soul. Being mindful while spending time in nature, whether that is walking, swimming, canoeing or surfing, increases the production and release of endorphins, which lowers anxiety and depressive symptoms and boosts immunity and overall wellbeing, creativity and problem-solving.

DID YOU KNOW?

Engaging in exercise increases the chemicals in your brain that make you feel happy, such as endorphins, dopamine, adrenaline, endocannabinoids and myokine. These chemicals also help you feel confident, capable, less anxious, less stressed and less physical pain, making you more resilient to stress. They can also help people recover from depression and anxiety disorders.

Assessment
7.4 Check-in questions

Command word

justify
Show, prove or defend, with reasoning and evidence, an argument, decision and/or point of view using given data and/or other information

REFLECTIVE FOLIO

Class discussion
As a class, discuss how you feel when you have been active and how you feel when you have been mainly sedentary for a few days.

7.4 CHECK-IN QUESTIONS

1 **Identify** five body systems that can be improved from participation in regular physical activity.
2 **List** five benefits to the cardiovascular system from participation in regular physical activity.
3 **Outline** what vigorous intermittent lifestyle physical activity (VILPA) refers to.
4 **Describe** three physical benefits of participation in regular physical activity.
5 **Discuss** a social benefit of participation in regular physical activity.
6 **Describe** the importance of regular physical activity to build resistance to fatigue.
7 **Explain** the benefit of strengthening muscle and bone to avoid a loss of function.
8 **Justify** why being active with others is so important.
9 **Explain** the association between physical activity level and risk of depression.
10 Research and **discuss** one potential biochemical or physiological mechanisms associated with physical activity and emotional benefits.

ABOVE AND BEYOND THE STUDY DESIGN

MODULE 7.2, p. 238

Health benefits can be domain specific

This bonus section relates to both domains of physical activity and health benefits. A meta-analysis (White et al., 2017) of domain-specific physical activity and mental health across more than 98 studies found that mental health benefits are not consistently reported across all domains of physical activity. Findings revealed that leisure-time and transport physical activity domains both had a positive association with mental health. Although participation in all four domains is good for one's physical health, physical activity undertaken during leisure time may be the most beneficial in terms of mental health promotion and prevention of mental ill health.

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FIGURE 7.23 Studies have found that forms of physical activity during leisure time or as a form of transport have the most significant impact on mental health.

CHAPTER SUMMARY

Resource
Self-assessment checklist

Video
Masterclass: Chapter 7

7.1 Understanding the nature of physical activity

- Physical activity is defined by the WHO (2024) as 'any bodily movement produced by skeletal muscles that requires energy expenditure.'

7.2 Domains of physical activity

- Subcategories of physical activity include exercise, lifestyle activities and games. Physical activity may also be classified as structured or incidental. Structured physical activities tend to be planned, such as participation in organised sport, or going to the gym or for a bike ride.

7.3 Dimensions of physical activity

- Inactivity is defined as not engaging in any regular physical activity beyond daily activities, or a lack of moderate-intensity physical activity.
- Sedentary behaviour is defined as the amount of time spent sitting or lying down (with the exception of sleeping). Examples include watching television/screen viewing, using a computer or reading.
- 1 MET represents the amount of energy expended at resting levels; 2 METs represents twice the amount of energy expended at rest.
- Sedentary behaviours include activities that require around 1–2 METs.
- Lifestyle physical activities should be the most common form of daily physical activity. These activities form the base of the physical activity pyramid, and should be performed daily or on most days of the week.

7.4 Benefits of physical activity

- There are physical, social, emotional, mental and spiritual benefits associated with participation in regular physical activity.
- Research has also shown that active people have greater self-esteem and lower levels of anxiety.
- Increased physical activity is associated with improved brain function.

CHAPTER REVIEW

Assessment
Chapter 7 Review

1 Active transport is defined as:
  - A bike riding for exercise.
  - B any form of human-powered transportation used to get to and from specific destinations.
  - C walking the dog.
  - D skateboarding with friends.

2 Leisure-time physical activity is:
  - A activity that is over and above that which occurs within the workplace/schooling.
  - B activity you engage in during recess and lunch breaks only.
  - C physical activity you engage in during holiday breaks only.
  - D none of the above.

3 Research has shown that active people have:
  - A greater self-esteem.
  - B lower levels of anxiety.
  - C improved brain function.
  - D all of the above.

4 List the four domains of physical activity.

5 Select three of your favourite physical activities and determine the associated METS, you may have to do some research online using the Compendium of Physical Activity.

6 **Define** sedentary behaviour and provide three examples.

7 **Discuss** three social benefits to participating in regular physical activity.

8 **Describe** four characteristics of lifestyle physical activities.

9 **Explain** the benefit of having stronger bones.

10 **Explain** the benefit participation in regular physical activity has on brain (cognitive) function.

CHAPTER

8

SOCIOCULTURAL FACTORS INFLUENCING PHYSICAL ACTIVITY

UNIT 2 – AREA OF STUDY 1

Monkey Business/Adobe Stock

FIGURE 8.01 A multitude of sociocultural factors influence physical activity.

Quizzes

Chapter 8 Pulse check

8.1 Check-in questions

8.2 Check-in questions

Chapter 8 Review

Videos

Masterclass: Chapter 8

Resources

8.2 Template: Barriers to being active quiz

Chapter 8 Self-assessment checklist

Nelson MindTap

To access resources above, visit **cengage.com.au/nelsonmindtap**

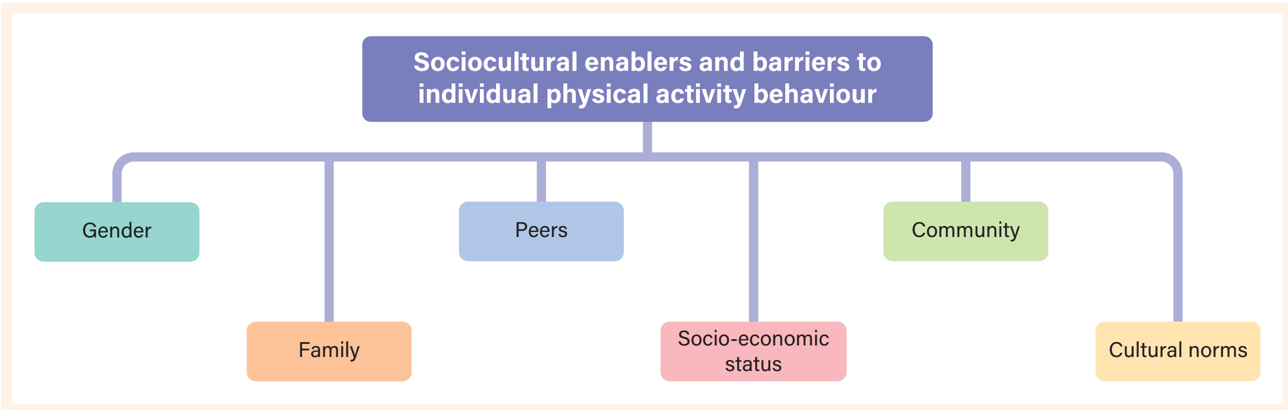
KEY KNOWLEDGE

- sociocultural enablers and barriers to individual physical activity behaviour such as gender, family, peers, socioeconomic status, community and cultural norms

KEY SKILLS

- investigate through participation, the sociocultural influences on physical activity behaviour across the lifespan

Source: VCAA VCE Physical Education Study Design (2025–29)



Video
Masterclass: Chapter 8

enablers
Factors that support and facilitate implementation, increase access to resources and encourage or support a person to participate in a sport or physical activity

barrier
Impedes implementation, use or access to physical activity

Assessment
Chapter 8 Pulse check

Participation in physical activity is important for improving and maintaining both our physical and mental health. With so many proven benefits, why don't all people participate in regular physical activity? What influences the decision to be physically active? This chapter will look at a range of modifiable (able to be changed, e.g. skill level or knowledge) and non-modifiable (not able to be changed, e.g. climate or age) factors that influence participation in physical activity.

Enablers are factors that support and facilitate implementation (e.g. extra time and money available), increase access to resources and encourage or support a person to participate in a sport or physical activity. In contrast to enablers, a **barrier** impedes implementation, use or access to physical activity (e.g. lacking skills, confidence or social support).

PULSE CHECK

Take the pulse check quiz to check your prior knowledge and understanding of the concepts covered in this chapter.

1 **Outline** what is meant by the term 'enabler.'
2 **Identify** three sociocultural factors that would enable someone to be active.
3 **Identify** three barriers to a 15-year-old being physically active.
4 **Describe** two examples of a constructed (human-made) feature within the built environment that would enable a child to be physically active.
5 **Explain** what the term 'self-efficacy' means in relation to being regularly active.

LOOKING BACK
BENEFITS OF PHYSICAL ACTIVITY

Unit 1

In Unit 1 we looked at how physical activity can prevent diseases such as type 2 diabetes, cardiovascular disease, osteoporosis, obesity and other musculoskeletal and cardiorespiratory injuries and illnesses. Participation in physical activity can also reduce depression, stress and anxiety, improve self-confidence and self-esteem, and increase your energy levels and sleep quality, improving concentration.

8.1 SOCIOCULTURAL FACTORS ENABLING PHYSICAL ACTIVITY

In this module you will learn about:

- sociocultural enablers to individual physical activity behaviour such as gender, family, peers, socio-economic status, community and cultural norms

and learn to:

- investigate, through participation, the sociocultural influences on physical activity behaviour across the lifespan.

Sociocultural factors influencing physical activity include enablers and barriers to individual physical activity such as gender, family, peers, socio-economic status (SES), community and cultural norms. There are literally hundreds of factors that have the potential to influence physical activity, but in this chapter we will focus on those mentioned above. Some of these factors are modifiable, meaning they can be changed or improved (e.g. knowledge, skills or motivation); other factors are non-modifiable and cannot be changed (e.g. terrain, climate, biological factors).

Engaging in regular physical activity leads to better overall health, increased life expectancy and decreased mortality and burden of disease. Despite this, many people do not meet the minimum recommendations for physical activity for their age group (see Chapters 9 and 10). Physical activity behaviour is complex and influenced by a combination of interacting factors. Different factors at the individual, sociocultural, physical environment and policy and organisational levels all play a role to influence our individual decision-making and behaviours. To develop effective evidence-based/informed physical activity interventions and programs, it is essential we understand which factors influence behaviour, which factors are enablers, and which are barriers to people being active at different stages across the lifespan. In this chapter we will explore a range of individual, sociocultural and environmental enablers and barriers to individual physical activity.

LOOKING FORWARD
Promotion of physical activity
Chapter 11

In Chapter 11 we will explore a range of strategies to promote physical activity behaviour that can be implemented within home, school, work or community settings.

Table 8.1 summarises a wide range of factors enabling physical activity, based on **systematic reviews** and **meta-analyses** of hundreds of studies exploring the factors associated with physical activity levels (Arts et al., 2023; Bingham et al., 2016; Choi et al., 2017; Elshahat et al., 2020; Koeneman et al., 2011; Mello et al., 2023; Sawyer et al., 2017; Zhou & Wang, 2019).

systematic review
An overview of primary studies which contains an explicit statement of objectives, materials and methods, and has been conducted according to explicit and reproducible methodology (Gopalakrishnan & Ganeshkumar, 2013)

meta-analysis
A quantitative, formal, epidemiological study design used to systematically assess the results of previous research to derive conclusions about that body of research. Typically, but not necessarily, the study is based on randomised, controlled clinical trials (Haidich, 2010)

TABLE 8.1 Physical activity enablers across different age groups

Level	Factor	0–6 years	5–18 years	18–65 years	Older adults 65+ years
Individual level	Physical health				+
	Intention to exercise			+	
	Perceived fitness			+	
	Gross motor skills	+		+	
	Positive attitude towards physical activity			+	
	High motivation and goal setting		+	+	
	Experiencing fun and pleasure with physical activity		+	+	
	More or better knowledge of physical activity			+	
	Perceived behavioural control			+	
	Self-efficacy			+	+
	Positive beliefs and experiences about PE		+		
	Enjoyment in PE		+		
Sociocultural level	Parental physical activity level/role modelling	+	+		
	Opportunities for play	+	+		
	Peer support for physical activity	+	+	+	
	Parental support for physical activity	+	+		
	Social support for physical activity	+	+	+	+
	Support from family member for physical activity	+	+	+	+

>

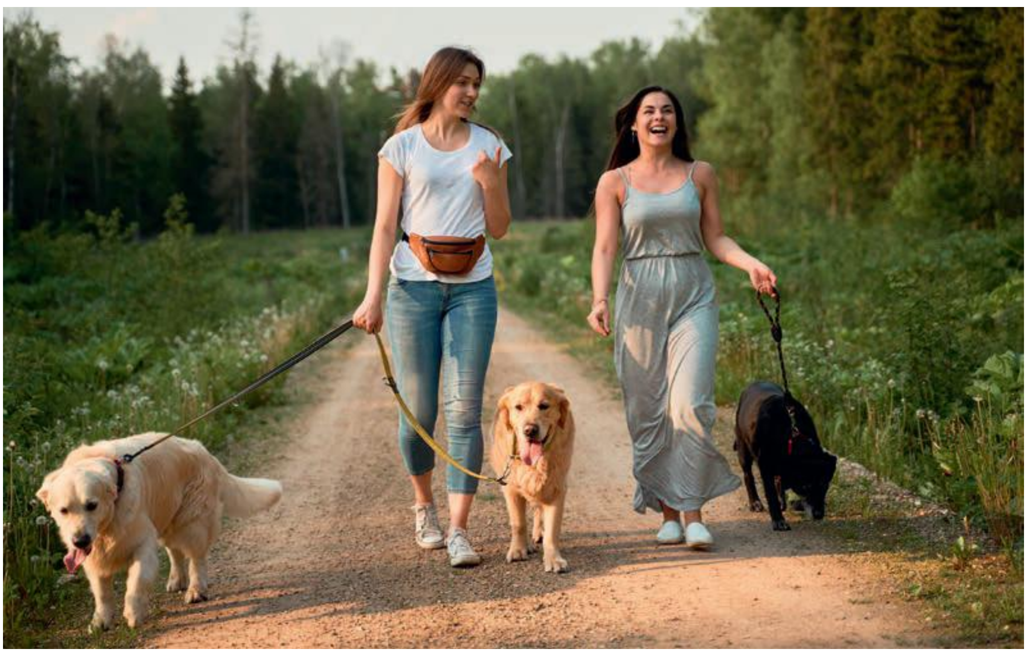
Level	Factor	0–6 years	5–18 years	18–65 years	Older adults 65+ years
Physical environment	Aesthetics of physical activity spaces			+	
	Access to facilities			+	+
	Land use mixed and diverse			+	
	Presence of footpaths			+	+
	Public transport provision			+	
	Safety at night/low crime rate			+	+
Policy/ organisational level	Time spent outdoors	+			
	In PE classes boys only		+		
	In PE outdoor classes		+		
	In PE classes team games		+		
	Access to programs and infrastructure		+		

+ denotes consistently reported positive association with physical activity

Social factors influencing physical activity

Social or interpersonal factors that influence involvement in physical activity include supportive behaviours, social climate and culture. Social environment refers to the people around you: your family, siblings, peers, classmates, work colleagues, coaches, instructors, health professionals and even your pets.

Supportive behaviours can include being active with someone, encouraging others to be active, and providing support to be active, such as by offering transport or financial support.



Sergey Mironov/Shutterstock.com

FIGURE 8.02 Having someone to be active with (even a furry friend) significantly increases the likelihood of people being active.

DID YOU KNOW?

Research has shown that people who own a dog walk more and are more likely to achieve sufficient physical activity than those who do not own a dog. Dogs are said to be a person's best friend – they're a vital form of social support!

Family support

The influence of the family is a very important enabler to young people being active. This influence changes over time from quite direct support to more of a facilitation role. Your parents and other important adults in your life play an essential role in supporting your involvement in physical activity (see Figure 8.03). This support may include:

- providing opportunities to be active
- playing with the young person
- being an active role model to the young person
- supervising the young person while they play
- encouraging the young person to be active
- transporting the young person to activities, parks or training sessions and competitions
- paying for fees, uniforms, equipment and memberships.

iStock.com/andresr

FIGURE 8.03 Social support for physical activity includes transportation to training sessions and competitions.

Peer support

Peer support is a very important factor influencing our physical activity behaviour across the lifespan, from toddlers engaging in **parallel play** within an early learning play environment to retirees going for a walk together. Having someone to be active with can increase one's motivation, enjoyment, commitment, access and engagement in physical activity.

parallel play
A form of play where children play adjacent and independently in the same area, with the same materials, but with minimal engagement with one another. They do not try to influence each other

Cultural factors influencing physical activity

culture
The beliefs, behaviours, objects and other characteristics common to the members of a particular group or society. Through culture, people and groups define themselves, conform to society's shared values and contribute to society

Culture is a shared set of characteristics, beliefs, behaviours, place of birth, language, social behaviours, art, literature and music common to members of a particular group or society. Through culture, groups often immerse themselves and define themselves, conform to society's shared values, and contribute to society. Some cultures are widespread and have many people who align themselves with those particular values and beliefs. In Australia, for example, we have very strong sporting cultures, where supporters, players and ancillary staff immerse themselves in an identity associated with a particular club within a particular sport. For example, hundreds of thousands of people participate in AFL in some way. The Collingwood Football Club hit a new record of over 100 000 members in 2023.

Cultural norms are shared standards of what is considered acceptable behaviour by groups. These are contextually driven, so something that might be acceptable within the culture of your family might not be considered acceptable within your workplace environment.

When it comes to leading change within an organisation, there is a saying: 'Culture is everything'. The culture of an organisation is shaped by the nature of the social relationships within it. Some schools have a strong focus on student wellbeing and on sport, and physical activity is an essential component of both. Changing the culture of an organisation is often very difficult, but a supportive culture is vital to encouraging participation in physical activity. Social relationships provide emotional support, develop expectations, and provide opportunities to take on various roles (coach, umpire, manager). The capacity of people to connect with others in the community enhances their social environment, which may have a positive impact on their participation in physical activity within that community. Fostering a workplace culture where people are encouraged to take active breaks has so many potential benefits for both employees and employers compared to a culture where people are discouraged from exercising during their breaks.

Research has shown that culturally and linguistically diverse population groups are less likely to participate in sufficient physical activity to provide health benefits. People from non-English speaking backgrounds are at a higher risk of being inactive. Certain cultural expectations, obligations and religious beliefs can also restrict opportunities to be physically active.

Australia being such a multicultural nation means we benefit from many different cultures being integrated into our society. Australia's migrant population has introduced a wide range of activities; for example, the high levels of participation in soccer in Australia have been partially attributed to the European migrant population. There are so many examples of how physical activity is shaped by culture and culture is shaped by our participation in physical activities and sport.

COLLABORATIVE TASK
Prac activity

Cultural activity

Participate in a cultural activity from Table 8.2. Do some research to investigate where it is played and how it is played. Discuss whether the activity could be classified as sport, play, game and/or lifestyle physical activity.

TABLE 8.2 Cultural physical activities originating in other countries

Physical activity/ sport/game	Origin	Image
Sepak takraw	Philippines	 Icon Sportswire/Icon Sportswire/Getty Images
Tchoukball	Switzerland	 ROSLAN RAHMAN/AFP/Getty Images
Bocce	Italy	 iStock.com/Christopher Futcher
Croquet	England	 Monkey Business/Adobe Stock

Physical activity/ sport/game	Origin	Image
Finska	Finland	 Johner Images/Alamy Stock Photo
Pickleball	USA	 Bob/Adobe Stock
Tai chi	China	 Robert Kneschke/Shutterstock.com
Lacrosse	North America	 Marcelo Murillo/Shutterstock.com

Physical activity/sport/game	Origin	Image
Shuffleboard	England	 Huntstock/Stockbyte/Getty Images
Padel tennis	Mexico	 iStock.com/pics721
Hurling	Ireland	 D. Ribeiro/Shutterstock.com
Gaelic football	Ireland	 D. Ribeiro/Shutterstock.com
Kilikiti	Samoa	 iStock.com/DoraDalton

REAL WORLD APPLICATIONS

Bossaball

Bossaball has been described as the world's newest extreme team sport and one of the most enjoyable sports to watch. Originally developed by Flip Eyckmans (born in Belgium) between 2003 and 2005 when he was living in Spain, it combines volleyball, soccer, music, gymnastics and extreme trampolining. Bossaball is played on an inflatable playing surface to enable a range of techniques, tactics and strategies. The sport is growing in popularity and clubs are popping up all over the world, including in Spain, Brazil, Germany, the Netherlands, Portugal, Singapore, Ecuador and Saudi Arabia. The meaning of the word 'bossa' itself means style, flair or attitude in Brazilian Portuguese. Do some research to find out how the game is played, and watch some videos of this incredible extreme sport.

Konstantin K4/Shutterstock.com

FIGURE 8.04 Bossaball is one of the world's newest extreme sports.

Weblink
Bossaball

CASE STUDY SPORTING CULTURE CROSSES BORDERS

MEET THE WOMEN WHO ESCAPED THE TALIBAN AND FOUND A HOME WITH MELBOURNE VICTORY

As the captain of the Afghanistan women's National Football team, Fatima Yousufi helped her teammates flee Afghanistan when the Taliban came to power in August 2021. A team of sportspeople and humanitarian activists agitated for the Australian Government to grant the girls emergency visas to enter Australia, knowing the Taliban would try to target high-profile advocates for women's rights. The team arrived in Australia with no family. They did not speak the same language, but being together, they knew they would be able to play football again. The Afghanistan national women's team, with the support of the A-League, were allowed to play under the name of Melbourne Victory FC AWT. Melbourne has an incredible sporting culture and, thanks to the generosity of the Melbourne Victory members, funds were raised to support the new team with player registrations, equipment uniforms, travel and coaching staff. Within two years of arriving

>

in Australia the team had been promoted to Victoria's state league 3. Coming from a culture ruled by the Taliban where the girls were not permitted to even go outside, Melbourne has been a dream come true for the girls, who get a standing ovation each time they play. This fairytale enabled the girls to escape a culture that was not supportive of women being active, and the culture of togetherness within their team enabled them to transition into their sporting community in Melbourne. The girls have left their families and friends behind, and hope to one day be able to play for Afghanistan again.


Kelly Defina/Getty Images Sport/Getty Images

FIGURE 8.05 Adiba Ganji of the Melbourne Victory Afghan Women's Team celebrates a goal in the play-off final match against Endeavour United in 2023.

QUESTIONS

1 Outline the challenges faced by the Afghanistan women's National Football team when the Taliban came to power in August 2021.
2 Describe three ways the girls may have provided social support to each other to play football upon arrival in Australia.
3 Discuss what we mean by Melbourne having a strong sporting culture.
4 Explain two enabling factors to participate in football experienced by Fatima and her teammates based on the case study.

DID YOU KNOW?

Tai chi is part of traditional Chinese culture and promotes health and overall wellbeing.

Environmental and policy level factors influencing physical activity

There are many environmental factors that influence our physical activity behaviour. Even within your local community there are dozens of natural and human-made (built environment) features that enable us to be active. Table 8.1 outlined a wide range of factors at the physical environment and policy/organisation levels that consistently showed a positive association with physical activity. Examples include having accessible transportation, footpaths, facilities, programs and aesthetic and safe activity spaces (Choi et al., 2017; Garcia et al., 2022).


Matko Medic/Dreamstime LLC

FIGURE 8.06 Tai chi at the Exhibition Buildings in Melbourne

Natural environments

The natural environment includes features such as water (beaches, rivers, lakes), trees, grasslands and bushlands (see Figure 8.07). These places provide aesthetically pleasing environments in which to be active. Other factors relating to the natural environment can also influence participation in physical activity, including where you live, the location, the terrain, the infrastructure and the weather. In Australia, we are incredibly fortunate to have a vast range of aesthetically pleasing natural environments suited to physical activity, including mountains, bushland and aquatic environments.

Amanda Telford

FIGURE 8.07 Australia has some of the most beautiful beaches in the world.

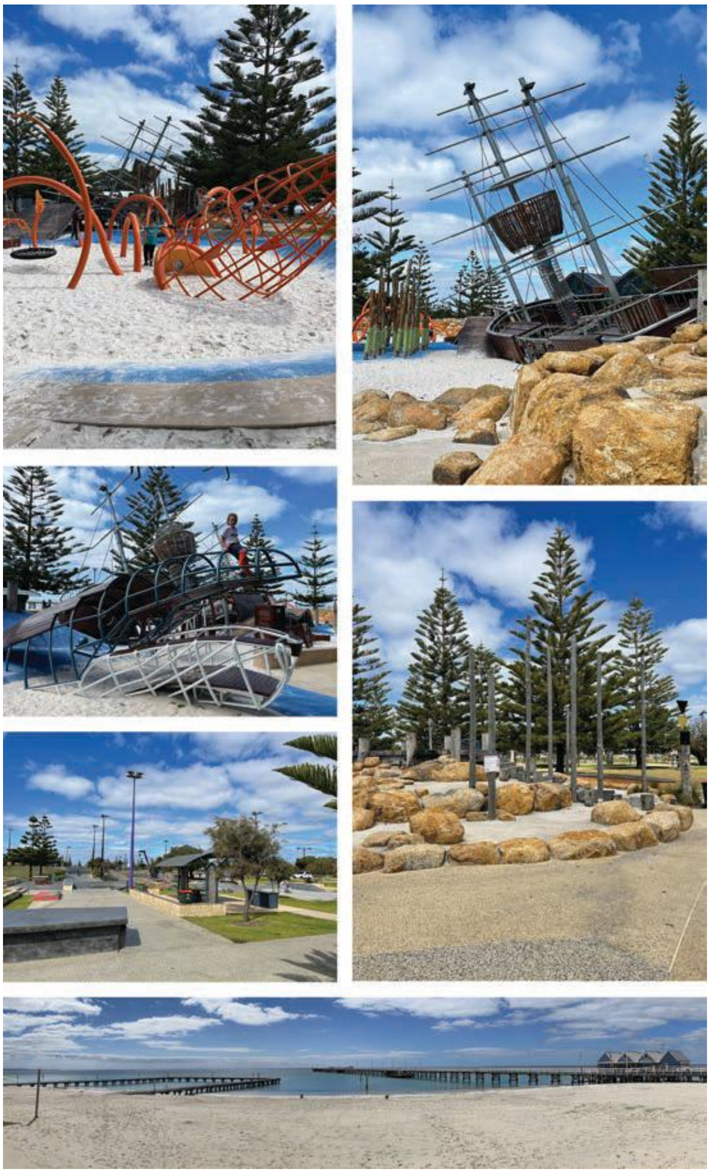
Built environments

As evidenced by Table 8. 1, built (human-made) or constructed environments include buildings, the grounds around buildings, the layout of communities, transportation, infrastructure, parks, playgrounds and trails. The availability of facilities can influence physical activity levels. For example, having an aquatic centre with well-maintained grounds and grass areas, ample parking, and easy access by public transport and on walking/cycling paths may encourage people within the community to be more active.

Community design and land use can also influence physical activity levels within the community. The proportion of land distributed across residential, commercial or institutional uses, or in parks and open spaces, as well as the connectedness and aesthetics of the environment have been shown to influence physical activity. For example, the presence of cycling trails that connect communities can encourage active transport for members of the community.

CASE STUDY BUSSELTON

The following images are from Busselton, which is a city on the south-west tip of Western Australia. Busselton is known for its seasonal humpback whale populations and a wood pier that stretches nearly 2 kilometres to an underwater observatory, where a coral reef is on view. The precinct also has a range of physical activity infrastructures that has to be seen to be believed, using both the natural and built environments, including adventure playgrounds, walking and biking trails, sporting grounds, skate parks, basketball rings and an outdoor swimming pool.



Amanda Telford

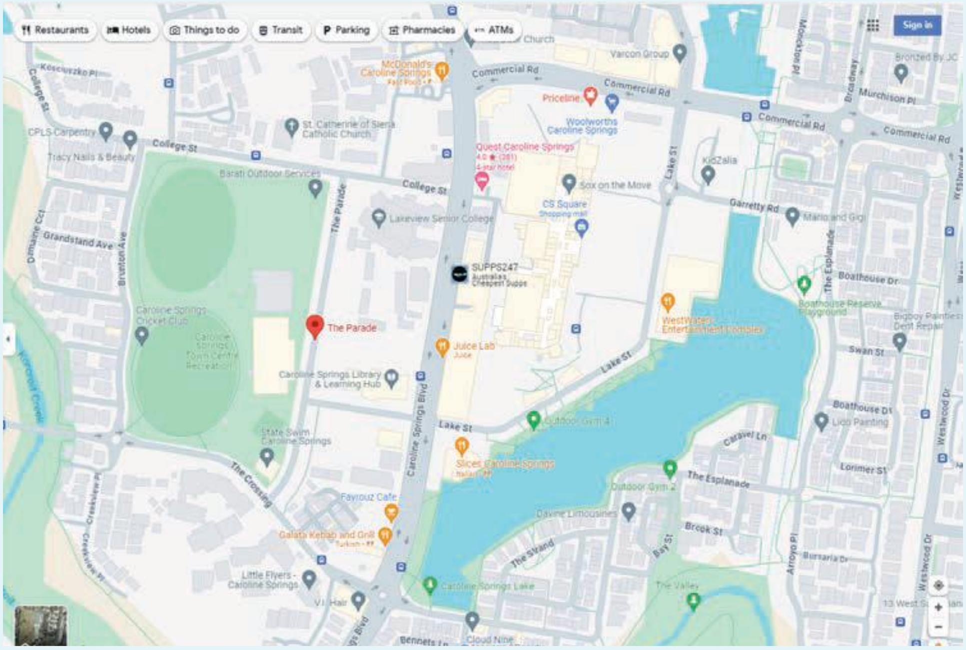
FIGURE 8.08 Parks and playgrounds are an important part of the built environment for young people to foster physical activity within their communities.

QUESTIONS

1 Identify who could be active within the areas described in the case study.
2 Discuss what features within the built environment at Busselton would enable physical activity.
3 Explain how parental support could enable children to be active in the precinct.

COLLABORATIVE TASK
Activity

Community audit



Google LLC

FIGURE 8.09 Auditing physical activity facilities in your community

DISCUSSION

Identify and locate one recreational facility in your community and answer the following questions about that facility:

1. Is it a natural or built environment?
2. How accessible is the facility by foot (e.g. footpaths) or bike (e.g. cycling paths)?
3. Is there a cost associated with using the facility? If yes, what is the cost?
4. What opportunities for physical activity are available in the facility?
5. How would you rate the safety of the facility? Consider lighting, crime rates in the neighbourhood, traffic etc.
6. Is the facility aesthetically pleasing? Why/why not?
7. Is use of the facility weather dependent?
8. Which of these factors (accessibility, aesthetics, safety, weather) are modifiable and which are not? How could you modify one of these factors to increase the likelihood of people using the facility?

LOOKING FORWARD
Strategies to enhance physical activity

Chapter 11

Chapter 11 will look at strategies and interventions to enhance or enable physical activity in more detail.

LOOKING BACK
Dedicated bike lanes

Chapter 7

As mentioned in Chapter 7, another great example of modifying the built environment to enable physical activity, in particular active commuting, is building dedicated bike lanes, bike-friendly parking, traffic calming and reduced speed zones. Amsterdam leads the world in this approach to encouraging physical activity by cycling.

Supportive policy

As mentioned, the availability of facilities influences physical activity, but we also need to consider the provision of suitable physical activity programs within those facilities. To help people feel confident using the new facility, they need access to programs or supportive policy, and must feel confident and safe in the new environment. Policies can also target specific groups – for example, local swimming pools can run female-only sessions. Gym or club policies might encourage people to bring a friend to access a discount, or government policies might fund particular groups to participate in sport or physical activity. We will talk more about supportive policies in Chapter 11.

Individual factors influencing physical activity

As mentioned previously, some of the factors influencing physical activity are modifiable, while others are not. There are several individual factors that can be enablers or barriers to physical activity. The non-modifiable factors include age, sex, ethnicity or cultural background and genetic or inherited factors. Modifiable factors at the individual level include SES, level of education, self-efficacy and other cognitive variables.

Gender

Research shows that males tend to be more active than females, particularly in relation to vigorous physical activity. Interestingly, behaviours can occur in clusters; for example, in relation to gender, females tend to be characterised by low physical activity and higher amounts of time spent socialising, in contrast to males, who tend to be characterised as exhibiting clusters of high physical activity and greater amounts of time spent watching TV (e.g. YouTube) and gaming (Mello et al., 2023).

Even in physical education classes, research has shown males tend to be more active than females, and all-boys classes tend to be more active than co-educational or all-girls classes (Zhou & Wang, 2019). Older women, mothers, and women from non-English-speaking backgrounds are less likely to engage in sufficient levels of physical activity for health benefits. Involvement in physical activity is often influenced by cultural beliefs about the gender appropriateness of various forms of physical activity.

LOOKING FORWARD

Tailored programs and strategies

Chapter 11

Both age and gender are important influences on physical activity behaviour, and are critical to informing the development of tailored intervention strategies and programs targeting specific groups, rather than a one-size-fits-all approach. We will look at physical activity promotion and tailoring of programs in Chapter 11.

socio-economic status (SES)
The position of an individual or group on the socio-economic scale, which is determined by a combination of social and economic factors such as income, amount and kind of education, type and prestige of occupation, place of residence, and – in some societies or parts of society – ethnic origin or religious background

LEARNING HACK

SES = Socio-economic status

Socio-economic status

Socio-economic status (SES) is affected by several factors, including but not limited to level of education, household income, workforce participation and area of residence (American Psychological Association, 2023). These factors all influence participation rates, as they limit people's opportunities to be physically active. Research consistently shows men and women from low SES groups have lower rates of participation in physical activity. Often people from a low SES background work long hours for lower wages, limiting both their time and resources to be active or explore active opportunities. With the cost of living ever increasing, the cost of many physical activities is becoming prohibitive. Figure 8.10 outlines some examples of physical activities people can engage in with at little or no cost.

FIGURE 8.10 Low-cost physical activities

FIGURE 8.11 Fitness equipment is readily accessible in many community parks.

Self-efficacy and other cognitive variables

Some cognitive variables (positive attitude, **self-efficacy**, enjoyment, expected benefits, intention to exercise) have a positive influence on physical activity (Choi et al., 2017). Importantly, these factors are modifiable – they can be changed, enhanced, developed or improved. Self-efficacy is consistently shown to be one of the strongest predictors of someone being physically active. Having a high level of self-efficacy to be physically active reflects your confidence in your ability to be active and exert control over your motivation; for example, feeling like you can be active even when you are tired or have no one to be active with. A person's self-efficacy can be enhanced by experiencing success, through verbal persuasion and vicarious experiences (observing others perform), and via the feelings associated with emotional arousal triggering endorphins in your brain.

self-efficacy
Confidence in your ability to be active within specific circumstances – for example, even when you have no one to be active with

LOOKING FORWARD
Ecological models are holistic

Chapter 11

Ecological models propose that physical activity is influenced by factors at the individual, social and physical environmental level that are independent and interactive. Research prior to the last decade had mostly focused on independent influences rather than considering the more holistic interaction of these factors (Sawyer et al., 2017). Throughout this chapter we have considered factors at an individual, social and physical environment level. You will learn more about ecological models in Chapter 11.

Assessment
8.1 Check-in questions

8.1 CHECK-IN QUESTIONS

1 **Identify** three social environmental factors that influence physical activities.
2 **List** four non-modifiable individual influences on physical activity behaviour.
3 **Outline** two physical environmental factors that are positively associated with adult physical activity.
4 **Describe** how SES can influence physical activity behaviour.
5 **Discuss** how motor skill competence may enable children to participate in physical activity.
6 What is the association between people from non-English-speaking backgrounds and physical activity?
7 **Explain** how self-efficacy to be active can be enhanced, and provide two examples.
8 Review Table 8.1, which lists enablers of physical activity, and **explain** which factors influences your own physical activity behaviour.

Command terms

identify
Recognise and name and/or select an event, feature, ingredient, element, speaker and/or part from a list or extended narrative or argument, or within a diagram, structure, artwork or experiment

describe
Provide characteristics, features and qualities of a given concept, opinion, situation, event, process, effect, argument, narrative, text, experiment, artwork, performance piece or other artefact in an accurate way

8.2 SOCIOCULTURAL BARRIERS TO PHYSICAL ACTIVITY

In this module you will learn about:

- sociocultural barriers to individual physical activity behaviour such as gender, family, peers, socio-economic status, community and cultural norms

and learn to:

- investigate, through participation, the sociocultural influences on physical activity behaviour across the lifespan.

Barriers can be the same as enablers

barriers
Obstacles that block or impede access to physical activity – for example, feeling tired or feeling too self-conscious

Where enablers of physical activity make it possible to participate in physical activity, **barriers** are obstacles that block or impede access to physical activity – for example, feeling tired or feeling too self-conscious. Like enablers, barriers can be physical or psychological, perceived or real. They may fall into several categories, such as demographic (age, gender, level of education, income, marital status), social, cultural or environmental. Table 8.3 outlines a range of barriers to physical activity at the individual, sociocultural, physical environment and policy levels that have been consistently reported across numerous studies to display a negative association with physical activity (Arts et al., 2023; Bingham et al., 2016; Choi et al., 2017; Elshahat et al., 2020; Mello et al., 2023; Sawyer et al., 2017; Zhou & Wang, 2019).

TABLE 8.3 Physical activity barriers across different age groups

Level	Factor	0–6 years	5–18 years	18–65 years	Older adults 65+ years
Individual level	Blue-collar worker			-	
	Lack of time			-	
	Negative emotions about physical activity			-	
	Maternal depressive symptoms	-			
	Financial struggles		-		
	Worse health condition			-	-
	Stress			-	
Sociocultural level	Being bullied by peers		-		
	Cultural practices		-		
	Difficulties getting to physical activity		-		
	Inactive friends		-		
	No friends		-		
	Transition to university			-	
Physical environment	Poor street connectivity		-		
	Terrain slope			-	
	Hot climate		-		
	Limited access to indoor physical activity facilities		-		-
	Limited community facilities		-		
	Inadequate footpaths and cycle lanes		-		-
	Feeling unsafe and safety concerns		-	-	-

Level	Factor	0–6 years	5–18 years	18–65 years	Older adults 65+ years
Policy/organisational level	Play rules	-			
	Lack of physical activity support from medical practitioner			-	
	Heavy school bags		-		
	Restricted active transport		-		
	Limited organised sport or structured activities for all ages		-		
	Village curfews		-		
	In Physical Education girls-only classes		-		

- denotes consistently reported negative association with physical activity

Barriers can change over time

The barriers that can make it difficult to do something can change over time. Barriers to participation in physical activity vary depending on the person and the situation. Our circumstances, roles, health, resources, interests and support networks change over time, and we have different priorities which competing for our limited time. For example, during major transitions in our lives such as commencing TAFE/university or work, or becoming a parent, some people are time poor. These transitions can be stressful, and may trigger behaviours that are not good for your health, such as unhealthy eating, lack of sleep or lower levels of physical activity.

Barriers according to type of physical activity

The barriers to participation in physical activity may be different depending on the activity, the person's skills (some activities may be too challenging, such as rock climbing or wind surfing) or even opportunity (for example, some children would not have learned to ride a bike). The barriers to walking may be different from the barriers to more vigorous activities such as jogging. Walking is considered accessible to all because it is a lifestyle physical activity that does not require expensive equipment or a high level of fitness. Walking can be planned or spontaneous, and does not cost anything.

Commonly cited barriers to vigorous physical activity include:

- feeling self-conscious
- lack of energy
- the discomfort associated with strenuous exercise
- lack of financial resources.

drobotdean/Freepik

FIGURE 8.12 Barriers to participation in physical activity vary depending on the person and the situation.

DID YOU KNOW?

Just because someone is highly active, we cannot assume they are rarely sedentary. Physical activity and sedentary behaviour are coexisting behaviours within the spectrum of human movement, and each behaviour exists independent of each other. Research has generally found that low-active young people are generally spending excessive time engaged in screens (Mello et al., 2023).

COLLABORATIVE TASK
Activity

Understanding your physical activity barriers

The quiz below lists reasons people give for not being as physically active as they think they should be. Read each statement in the quiz and indicate how likely you are to agree, using the digital version of Table 8.4 on Nelson MindTap.

Template
Barriers to being active quiz

TABLE 8.4 Barriers to being active quiz

How likely are you to say . . .		Very likely	Somewhat likely	Somewhat unlikely	Very unlikely
1	My day is so busy now. I just don't think I can make the time to include physical activity in my regular schedule.	3	2	1	0
2	None of my family members or friends likes to do anything active, so I don't have a chance to exercise.	3	2	1	0
3	I'm just too tired after work to get any exercise.	3	2	1	0
4	I've been thinking about getting more exercise, but I just can't seem to get started.	3	2	1	0
5	I'm getting older so exercise can be risky.	3	2	1	0
6	I don't get enough exercise because I have never learnt the skills for any sport.	3	2	1	0
7	I don't have access to jogging trails, swimming pools, bike paths etc.	3	2	1	0

	How likely are you to say . . .	Very likely	Somewhat likely	Somewhat unlikely	Very unlikely
8	Physical activity takes too much time away from other commitments – work, family etc.	3	2	1	0
9	I'm embarrassed about how I will look when I exercise with others.	3	2	1	0
10	I don't get enough sleep as it is. I just couldn't get up early or stay up late to get some exercise.	3	2	1	0
11	It's easier for me to find excuses not to exercise than to go out and do something.	3	2	1	0
12	I know of too many people who have hurt themselves by overdoing it with exercise.	3	2	1	0
13	I really can't see myself learning a new sport at my age.	3	2	1	0
14	It's just too expensive. You have to take a class or join a club or buy the right equipment.	3	2	1	0
15	My free times during the day are too short to include exercise.	3	2	1	0
16	My usual social activities with family or friends do not include physical activity.	3	2	1	0
17	I'm too tired during the week and I need the weekend to catch up on my rest.	3	2	1	0
18	I want to get more exercise, but I just can't seem to make myself stick to anything.	3	2	1	0
19	I'm afraid I might injure myself or have a heart attack.	3	2	1	0
20	I'm not good enough at any physical activity to make it fun.	3	2	1	0
21	If we had exercise facilities and showers at work, then I would be more likely to exercise.	3	2	1	0

______ 1	+	______ 8	+	______ 15	=	______ Lack of time
______ 2	+	______ 9	+	______ 16	=	______ Social influence
______ 3	+	______ 10	+	______ 17	=	______ Lack of energy
______ 4	+	______ 11	+	______ 18	=	______ Lack of willpower
______ 5	+	______ 12	+	______ 19	=	______ Fear of injury
______ 6	+	______ 13	+	______ 20	=	______ Lack of skill
______ 7	+	______ 14	+	______ 21	=	______ Lack of resource

Source: www.cdc.gov/diabetes/ndep/pdfs/8-road-to-health-barriers-quiz-508.pdf

SCORING

Follow these instructions to score yourself:

1 Enter the circled number in the spaces provided below, putting the number for statement 1 on line 1, statement 2 on line 2, and so on.

2 Add the three scores on each line. Your barriers to physical activity fall into one or more of seven categories: lack of time, social influences, lack of energy, lack of willpower, fear of injury, lack of skill, and lack of resources. A score of five or above in any category shows that this is an important barrier for you to overcome.

DISCUSSION

1 **List** your top three barriers to being active.

2 **Propose** a strategy you could implement to overcome one of these barriers.

Command term

propose
Suggest or put forward a point of view, idea, argument, diagram, plan and/or suggestion based on given data or stimulus material for consideration or action

Individual barriers

Many men and women feel self-conscious about exercising or being physically active in front of others. Entering an unfamiliar setting, such as a gym, can cause some anxiety. Some women feel more comfortable exercising in front of other women – this has led to the popularity of women-only gyms such as Fernwood and Curves.

Many people have busy lifestyles and are juggling a range of roles and demands on their time, and research has shown that this can create a significant barrier to engaging in regular physical activity. These demands include being in paid employment, caring for children and completing household chores, all in the same week, every week.

Social barriers – lack of social support

Social support has a positive influence on physical activity in general. Having someone to go for a walk, play sport or go for a ride with has an important influence on participation. People who feel isolated due to age, geographic location, or cultural or linguistic differences may not feel safe or confident participating in physical activity by themselves. Lack of social support can be a barrier to participation at all ages, from young children to the elderly.

Cultural barriers – First Nations Australians

Despite having a long and proud heritage of traditional sports and games, and many First Nations Australians being sports stars, Indigenous Australians are at a higher risk of being inactive than non-Indigenous Australians. This may be because for some Aboriginal and Torres Strait Islander people, physical activity is not thought of in the same way as it is by many non-Indigenous Australians. Traditional activities, such as hunting, gathering and participation in customs, are important to Aboriginal and Torres Strait Islander peoples and have been linked to health aspects of life, social structure, education, building and maintaining relationships, building and maintaining wealth, and managing and preserving the environment.

Weblink
Yulunga Traditional Indigenous Games

SIGNPOST

Check out the Yulunga Traditional Indigenous Games page on the Australian Sports Commission's website for a load of resources about traditional Indigenous Australian games and activities.


Bill Bachman/Alamy Stock Photo

FIGURE 8.13 Australian Rules football is a popular sport among many First Nations communities.

A cultural barrier to physical activity for First Nations Australians is the importance of family and friends. Many Aboriginal and Torres Strait Islander peoples prefer to spend time with loved ones, rather than exercising alone for personal benefit or for health reasons.

Other common barriers to physical activity for Aboriginal and Torres Strait Islander peoples include:

- mistrust and uncertainty created by colonisation
- lack of programs led by community leaders and elders
- the relative scarcity of sports facilities and healthcare providers in remote areas if injuries occur
- the experience of racism – First Nations Australians are twice as likely to be victims of racism as non-Indigenous Australians
- cost – Aboriginal and Torres Strait Islander peoples with low incomes have less money to spend on physical activity opportunities
- limited access to public transport, making it hard for those living in remote areas to get to physical activity venues and programs.

Sporting and recreational environments need to ensure that they are **culturally inclusive** to all people including First Nations Australians, that the environment is safe and supportive for everyone, and that they encourage physical activity that is supported in the family and community context (Gidgup et al., 2022).

culturally inclusive
Addresses and supports the needs of people from diverse cultures, and values their unique contribution. It involves ongoing awareness raising, where negotiations and compromise may be necessary

COLLABORATIVE TASK

Prac activity

Battendi

BACKGROUND

A spear game was played by Aboriginal peoples in the Lake Murray, Lake Alexandrina and Lake Albert areas of southern Australia. A prize such as a newly made shield was offered to the winner. The contest was in two parts: distance throwing and target throwing.

LANGUAGE

The game is named battendi, which means to 'throw a spear' in the Kaurna language spoken in the south-east area of South Australia. In the Western Desert language of central Australia, 'nyuntuku nyintji' means 'It is your toy spear.'

SHORT DESCRIPTION

This is a distance-and-accuracy throwing contest using a woomera to propel a tennis ball.

Weblink
Battendi – Yulunga Traditional Indigenous Games

PLAYERS

Organise players in teams of two to four, or player against player in an individual contest.

EQUIPMENT

- Use a pet toy commonly called a 'dog thrower'. This consists of a one-metre long plastic stick with a 'cup' at the end to hold a tennis ball. You could even use dog ball launchers or soft/lacrosse sticks instead. When used correctly it acts like a *woomera* and projects a tennis ball for some distance and accuracy.
- A large supply of tennis balls is used. If several players use the same target in the target contest then different-coloured balls are recommended, otherwise get the players to throw in turns.

GAME PLAY AND BASIC RULES

- Players take turns in the contest, which consists of a distance throw and a target throw.
- The first contest is a distance-throwing contest. Each player gets three attempts. Allow a 10-metre area to run up and throw. Wind conditions should be the same for all players. The measurement is made from the throwing line and in a direct line to where the ball landed – different coloured markers can be placed at different distances as a guide.
- The target contest consists of throwing at a target (such as a large wheelie bin) to represent a kangaroo 20–30 metres away. The distance to the target depends on the age of the players. A round of 20 attempts is allowed, and the ball must hit the target on the full to count. If time and availability of targets allows then two rounds can be conducted. If players have the same score at the end of the contest, a tie-break for first place, with additional throws (rounds of five throws), is conducted to determine the winner.

SCORING

The player who wins the distance-throwing contest receives 50 points, the next player 49 points and so on. The winner of the target contest receives 75 points, the next player 74 points and so on. The target contest was the most important one, so the points are allocated to reflect this, but it is possible to use the same point scoring for both contests. The overall winner of the event is the player or team who places best (most points) when both contests are considered. The winners of the individual contests may be acknowledged along with the overall winner.

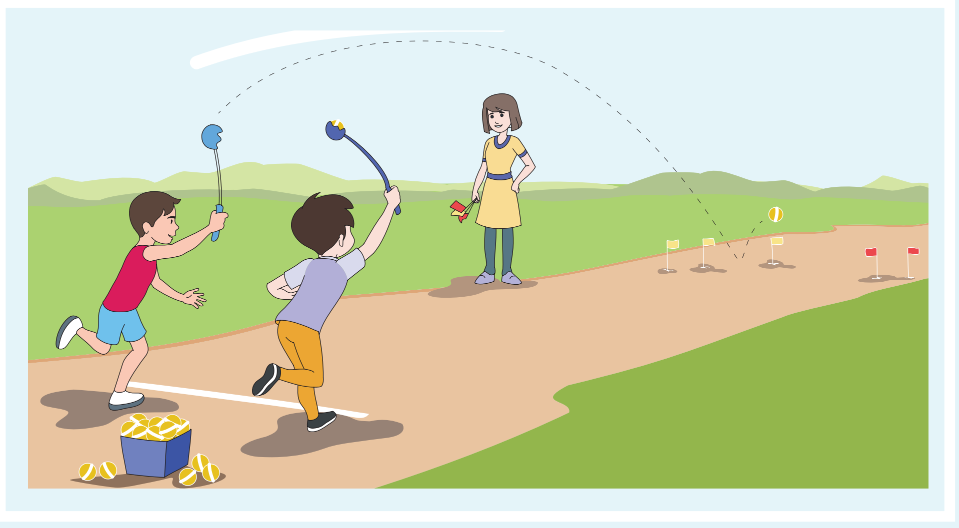


FIGURE 8.14 Battendi means 'to throw a spear'.

Environmental barriers

A major barrier to being physically active is the physical environment, in particular the built (human-made) environment. New housing areas are commonly laid out in a cul de sac formation, in contrast to the traditional grid network. A cul-de-sac design (see Figure 8.15) generally has poor connectivity, which makes walking directly to specific destinations very difficult. So, while the cul de sac design might provide a beneficial play space for a small number of residents, the remaining residents are disadvantaged. Studies have shown that adults are more likely to walk if they can access a variety of places within 400 metres.

redbrickstock.com / Alamy Stock Photo

trekandshoot/Shutterstock.com

FIGURE 8.15 Traditional grid networks **(a)** have greater connectivity for walking than cul-de-sac designs **(b)**.

Physical activity is also affected by the provision of footpaths, safety measures such as pedestrian crossings, traffic volume, calming devices and speed limits and mixed land use, including green spaces. All these things affect the walkability of an environment. Lighting on streets and in sporting venues (e.g. skate park or basketball courts) allows for after-hours use.

Influences on physical activity across the lifespan, and the enablers of and barriers to physical activity, will change based on specific circumstances and contexts. Parental support may not be as important at 25 years of age as it was at 15. Social support from peers may be of greater influence for teenage boys than for middle-aged men, but just as important for older adults. It is important to remember that these factors are often interrelated; for example, access to some physical activity opportunities will be influenced by cost. An understanding of the influences, enablers and barriers to physical activity allows strategies and intervention programs to be tailored to specific groups and settings, such as individuals, workplaces, schools and communities.

Assessment
8.2 Check-in questions

8.2 CHECK-IN QUESTIONS

1 **Identify** two physical environmental factors that are associated with adult physical activity.
2 **Discuss** how a lack of fundamental movement/motor skill competence may be a barrier to children participating in physical activity.
3 'An enabler to one person can be a barrier to another.' Provide an example and **discuss**.
4 **Describe** how a lack of social support can be a barrier to physical activity for an older person.
5 Does living in close proximity to physical activity facilities guarantee a person's access to these facilities? **Discuss**.
6 **Propose** two changes to the physical environment in your school and two in your community that may encourage physical activity.

Command term

discuss
Present a clear, considered and balanced argument or prose that identifies issues and shows the strengths and weaknesses of, or points for and against, one or more arguments, concepts, factors, hypotheses, narratives and/or opinions

CHAPTER SUMMARY

Resource
Self-assessment checklist

Video
Masterclass: Chapter 8

8.1 Sociocultural factors enabling physical activity

- The factors influencing physical activity behaviours are very complex and vary across the lifespan.
- Many factors that influence physical activity participation are considered 'modifiable' and can be targeted for change within intervention programs.
- Social support (family, peers, health professionals) is an enabling factor and can range from being driven to sporting venues to receiving praise and encouragement for being active.
- Physical environmental factors can facilitate or hinder physical activity. Physical environmental factors in both the natural and constructed environments include access to facilities, opportunities to be active, aesthetics of the environment, safety and weather.

8.2 Sociocultural barriers to physical activity

- Barriers can differ depending on the type of physical activity. The barriers to walking are different from the barriers to more vigorous activity, such as jogging.
- Demographic, social, cultural and environmental enablers of physical activity may be different for different people. What might be an enabler for one person may be a barrier for another.
- Aboriginal and Torres Strait Islander peoples and people living in rural and remote communities are at higher risk of being inactive.

CHAPTER REVIEW

Assessment
Chapter 8 Review

1 Generally, factors influencing physical activity behaviour are:
   A generic across all age groups.
   B varied according to age group and context.
   C consistent across all contexts.
   D not related to age, gender or socio-economic status.

2 Which of the following influences would be considered an environmental factor?
   A Self-efficacy
   B Age
   C Dog ownership
   D Constructed environment

3 **Identify** three individual influences on participation in physical activity.

4 **Outline** three examples of environmental influences that could be a barrier to physical activity.

5 **Describe** what self-efficacy is and how it relates to physical activity.

6 Social support can be provided to a child in many forms. Give three examples.

7 Can a factor be an enabler for one person and a barrier for another? **Explain** in your own words and provide an example.

8 **Identify** why First Nations Australians are more likely to be inactive than non-Indigenous Australians.

9 Lack of role models has been identified as a barrier to physical activity for adults and older adults. **Suggest** reasons why this may not be a barrier for children and young people.

10 Bailey is 12 years old. He has a trampoline, a basketball ring, swings and a pool in his backyard. He also has a bike and a scooter, and plays baseball and tennis. Both of Bailey's parents are physically active themselves, and support his activity by paying his fees, buying uniforms and equipment and driving him to training sessions and competition.

   Identify the physical activity enablers for Bailey and explain how they have influenced his participation. Use correct terminology in your answer.

Command term

suggest
Put forward for consideration a solution, hypothesis, idea or other possible answer

CHAPTER

9

PREVALENCE AND TRENDS OF PHYSICAL ACTIVITY, PHYSICAL INACTIVITY AND SEDENTARY BEHAVIOUR

UNIT 2 – AREA OF STUDY 1

IndiaPix/Adobe Stock

FIGURE 9.01 Cricket has thousands of participants in Australia.

Quizzes

Chapter 9 Pulse check

9.1 Check-in questions

9.2 Check-in questions

9.3 Check-in questions

9.4 Check-in questions

Chapter 9 Review

Videos

Masterclass: Chapter 9

Resources

Chapter 9 Self-assessment checklist

Nelson MindTap

To access resources above, visit **cengage.com.au/nelsonmindtap**

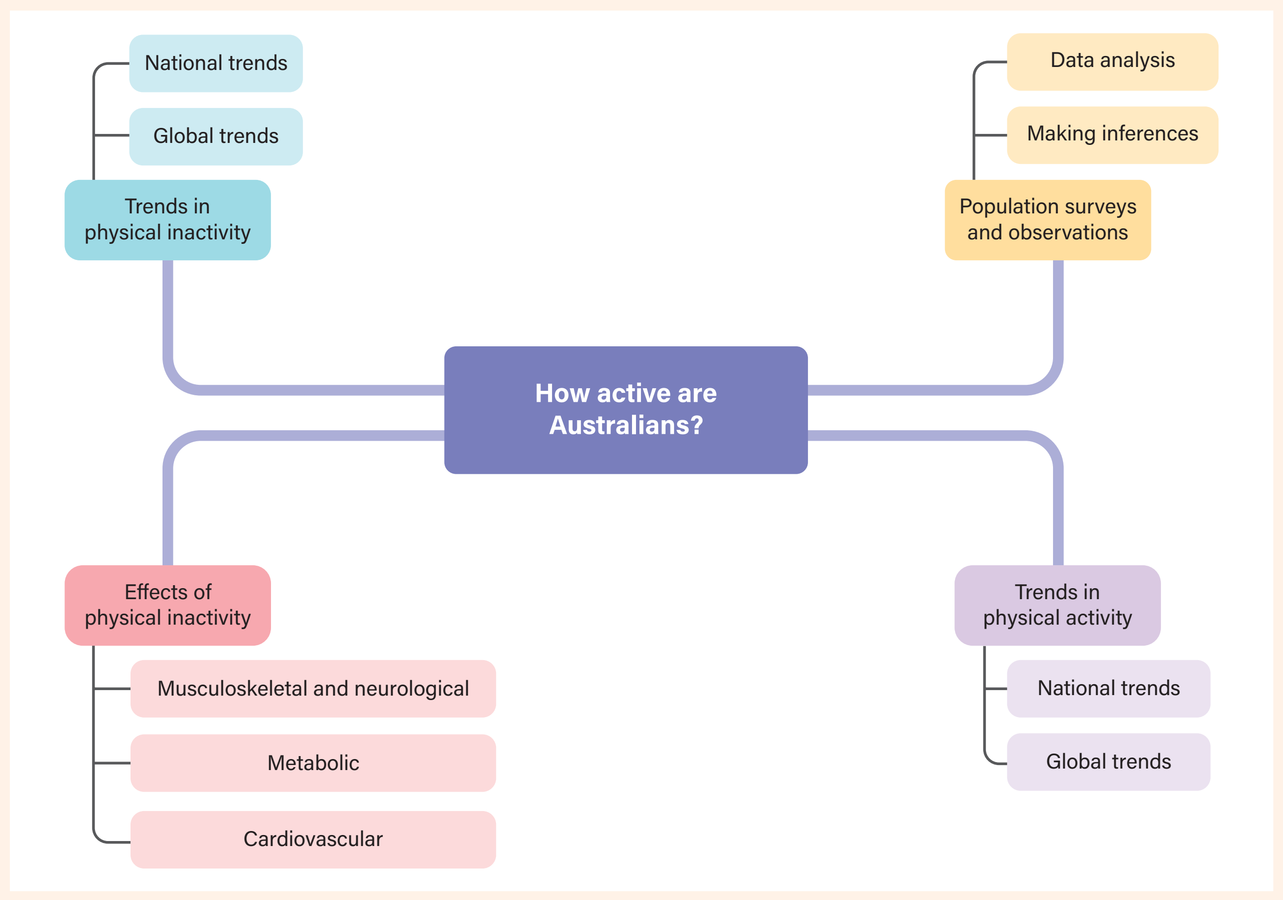
KEY KNOWLEDGE

- prevalence and trends of physical activity, physical inactivity and sedentary behaviour

KEY SKILLS

- analyse and interpret secondary data related to physical activity behaviour to explain outcomes of physical activity and sedentary behaviour

Source: VCAA VCE Physical Education Study Design (2025–29)



Video
Masterclass: Chapter 9

In the previous chapters, we learned about the types of physical activity and the associated benefits of participation. We also considered some of the sociocultural barriers and enablers to physical activity.

With this information in mind, we can now turn our attention to physical activity data to examine trends and patterns in physical activity. Through an awareness of these trends and patterns, we can start to make links between physical activity and health outcomes such as illness, disease and wellbeing. Population physical activity data is measured through surveys and observational techniques; however, these are very expensive assessments, requiring a lot of people to collect, analyse and interpret the data.

Assessment
Chapter 9 Pulse check

PULSE CHECK

Take the pulse check quiz to check your prior knowledge and understanding of the concepts covered in this chapter.

1 How many hours per day do you think the average Australian spends in physical activity?
2 How much time do you spend in physical activity per day? Per week?
3 List some activities that are sedentary. How many of these do you do in a day? In a week?
4 What percentage of Australian office workers do you think might spend six hours or more sitting at their desk per day?
5 Do you think it is likely that hours spent sitting per day will increase or decrease over time? **Explain** your answer.
6 **Identify** some of the health outcomes that are likely to result from long hours without physical activity.

9.1 ANALYSING PHYSICAL ACTIVITY DATA

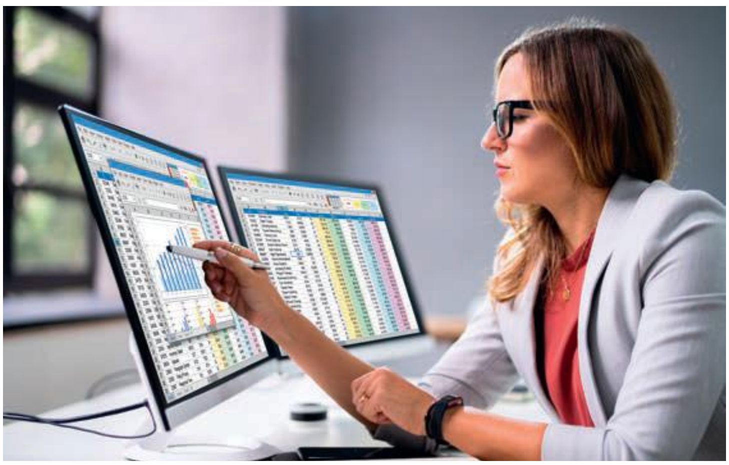
In this module you will learn about:

- numerical data that can describe physical activity

and learn to:

- interpret data that relates to physical activity.

inference
An interpretation or observation made using our senses



Andrey Popov/Adobe Stock

FIGURE 9.02 Data can help us to analyse people's levels of physical activity.

Data that is provided in the form of physical activity records, or even more complex data from population-level studies, needs to be analysed so that we can make meaning from the raw data. In many cases, data analysis requires complex mathematical and/or computational tools. Via visual inspection, we can observe representations of data to look for patterns, trends and other features. Noticing these features allows us to comment or draw **inferences** from the data itself.

Patterns

When we observe representations of data to draw our inferences, we firstly look for patterns and trends. **Patterns** are observable, regular, repeated sequences or relationships in the groups represented by the data.

patterns
Observable, repeated sequences represented by data

Patterns might include:

- two groups increasing in a factor at the same rate. This is an example of a positive relationship – for example, males and females of all age groups tending to decrease in physical activity with age
- one group increasing in a factor while another group decreases. This is an inverse or negative relationship – for example, males aged 40–45 being more physically active between 9–11 a.m. than males aged 18–20
- a specific decrease in a factor over time, then an increase (or an increase followed by a decrease). This pattern is known as a periodic or cyclic pattern – for example, children aged 2–5 being highly active, then seeing a decrease between ages 5–7, followed by an increase at ages 10–13.

Trends

In contrast to patterns, which look at the relationships in groups, trends are overall or 'bigger picture' patterns. Trends can have the following appearances:

- **increasing:** the values of the data get higher as the data moves across the graph from left to right. An example of an increasing trend might be total number of steps taken in a year, measuring steps against months of the year in an accumulative way.
- **decreasing:** the values of the data get lower as the data moves from left to right across the graph. An example might be the amount of outdoor physical activity an individual does per month for the first eight months of the year. The data might decrease between January and August, as the weather gets colder, and people spend less time outdoors.
- **constant:** trends may also be constant, although this is rare. Constant trends neither increase nor decrease, but stay 'about the same', even if there are small changes, across the graph. An example might be a graph representing the days of the week spent at work for a full-time office worker. The trend would more or less be a straight line, a constant, unless the individual took time off – that is, for annual leave.

Outliers

While not a pattern or trend, outliers – values that are significantly different from others in the whole data body for a given individual, **variable** or group – can be useful to comment on, as they might give us a better understanding of behaviours or other factors that may affect the data.

variables
Factors or elements in studies that are subject to change. Independent variables are changed in the study (think about these as the trigger). Dependent variables are observed in the study (think about these as the effects of changes to the independent variable)

We should identify outliers as significant differences in recorded data for a particular group, rather than a random point in the data that is different to others. For instance, comparing two groups and identifying a significant difference at one point is not an outlier. But finding that one group is significantly higher or lower at one point compared to other points for that group may be an outlier.

If there are outliers, we could examine the particular group or point on the graph to determine whether there are any other factors that might be in play. For instance, if a graph showed that 17–18-year-old students are more active across the year than 19–20-year-old students, at all time points, but we saw a significant drop in activity during October/November for individuals aged 17–18, we could identify this as an outlier. Thinking more closely about that particular outlier, the difference can probably be explained by the fact that many students in that age group spend more time at a desk preparing for, and doing, their end of year exams.

LEARNING HACK

Tips for data analysis

- Look at the title and figure legend to identify the independent variable or groups (usually on the horizontal or 'X' axis) and the dependent variable/s (usually on the vertical or 'Y' axis).
- Examine the data overall – determine the direction on the graph from left to right. Does it increase or decrease?
- Examine the data in groups – determine whether there are differences or similarities based on the visual appearance of the data that appears at each point on the horizontal axis. Can you see whether one group increases for the independent variable while another decreases? Or do all groups increase or decrease in the same way? Is there a cyclic pattern (rise then fall, or fall then rise)?
- Are there any outliers (groups or points on the graph that are significantly different for one particular group or variable)? Can we hypothesise any reasons for that outlier?

CASE STUDY PRACTICAL DATA ANALYSIS

A study conducted by Jack Evans and colleagues (2023) examined whether a motivational text message program would improve rates of physical activity through public transport use. The researchers organised a group of people into control (no messages) and intervention (received motivational messages) groups. The groups were assessed for their physical activity before the study (baseline) and over a period of time after the study (follow-up). The study measured transport-related physical activity, leisure time physical activity, and total physical activity through various methods.

A graph of some of the main findings of the study is presented below. **Note:** Median is the middle value found in the data set for each group. Stratified means 'broken up by'.

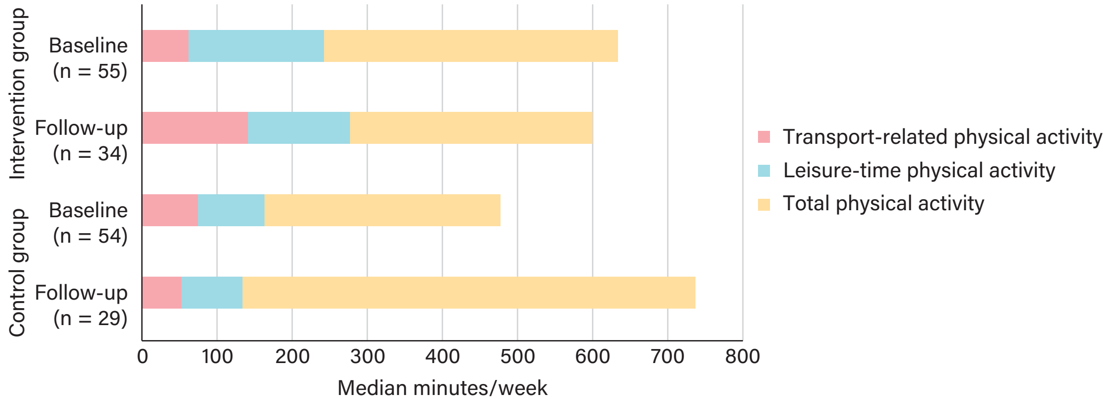


FIGURE 9.03 Median activity levels stratified by group and time point. Key results from the trips4health study of Australian adults.

Source: Evans, J.T., Stanesby, O., Blizzard, L., et al. (2023). trips4health: a single-blinded randomised controlled trial incentivising adult public transport use for physical activity gain. *International Journal of Behavioral Nutrition and Physical Activity*, 20, 98.

QUESTIONS

1 **Examine** the data displayed in the graph above. Identify two patterns or trends that you see in the data.

2 The follow-up data for the control group is an outlier. **Suggest** a possible reason that might explain this outlier.

Command term

examine
Consider an argument, concept, debate, data point, trend or artefact in a way that identifies assumptions, possibilities and interrelationships

REAL WORLD APPLICATIONS

Data analysis in the real world

Data scientists are individuals who use statistics and mathematics to make very precise judgements about collections of data. Often, data scientists are tasked with digesting the vast volumes of raw data collected from studies and presenting this so that the study authors can make meaning from it. Data science is no longer limited to finance and economics and is increasingly applied to the life sciences, including health and physical education. Recent studies conducted overseas, such as that of Deng and colleagues (2022), applied data science principles to physical health management of university students. Through their study, the team generated complex digital data management and teaching programs that support physical activity and physical health. Their work is an example of the ways that we can apply a deep understanding of data to health and physical education.

Another project, run by Chen, Chen and Lin (2021), examined how we can use artificial intelligence systems to design physical activity and training programs for individuals. Artificial intelligence relies on processes just like the data analysis we have done above, but it uses significantly larger data sets. The accessibility and availability of artificial intelligence could mean that training and exercise prescription is revolutionised by data in the not-too-distant future.

iStock.com/gorodenkoff

FIGURE 9.04 Sophisticated computer programming is increasing our understanding of physical activity patterns.

You don't have to be a computer programmer to study data science in health and physical education! Practising the principles we have explored in this section, identifying patterns and trends, can help to develop interventions into health and wellbeing that target specific factors, variables or groups that you have identified through an examination of physical activity data.

Don't be afraid of data! It's one of the most powerful tools we can use in designing physical activity interventions to support the physical health of young people and adults worldwide.

DID YOU KNOW?

Data science and data analytics is a relatively new field of expertise. This field is interdisciplinary, and is expected to grow significantly in the next 10 years. While it is mainly a job that involves computers and computer programming, the applications to a range of fields including health, medicine, biology and physical activity are exciting. Perhaps you might combine your interests in health and physical activity with studies in data science in the future! Individuals with these skills will be increasingly in demand in the job market.

Assessment
9.1 Check-in questions

Command term

state
Give a specific name or value or other brief answer without explanation or calculation

9.1 CHECK-IN QUESTIONS

1 **State** the axis that usually includes independent variables and groups.
2 **State** the axis that usually includes dependent variables.
3 **Outline** the meaning of a pattern.
4 **Compare** the meaning of 'patterns' and 'trends' in data analysis.
5 **Suggest** two ways that we can use data science and data analysis to promote health and physical activity.

9.2 PHYSICAL ACTIVITY: PREVALENCE AND TRENDS

In this module you will learn about:
- prevalence and trends of physical activity

and learn to:
- analyse and interpret secondary data related to physical activity behaviour.

Kumar Sriskandan/Alamy Stock Photo

FIGURE 9.05 Strolling in a park is a pleasant way to exercise.

At the beginning of this chapter we considered how much of the day people spend in physical activity and inactivity. In this section and the next, we will explore some of the statistics and data related to physical activity. This data is collected through population surveys that are conducted periodically, usually around every 4–5 years. These studies are not conducted annually because they are very expensive to run, produce a lot of data that takes a significant amount of time to analyse, and generally, patterns do not change all that much over a one-year time span.

COLLABORATIVE TASK
Activity

Trends in weekly activity

1 As a class group, collect data for the following statements. Record your answers as a tally or in a table. (You could break your responses up by gender, birth month or a similar category.)
   - **a** In the last week, I was physically active for at least 30 minutes per day.
   - **b** In the last week, I did weight-bearing or strength-based exercise at least twice.
   - **c** In the last week, I achieved an average of eight hours of sleep per night.
   - **d** In the last week, I chose to walk, bike, or other active option, to school, work, or another activity instead of taking a car or public transport.

2 **Summarise** the data as percentages or proportions. These are your frequency values.

3 Make a graph for each question. The frequency goes on the vertical ('Y') axis. The horizontal ('X') axis will display the categories that the responses were classified into.

4 **Discuss** any surprising or unusual patterns or trends that you notice in the class data.

5 **Compare** the class data to your own responses.

CASE STUDY TRENDS IN PHYSICAL ACTIVITY

You will find two graphs below. Figure 9.06 represents physical activity in days per week. Figure 9.07 shows physical activity in minutes per week.

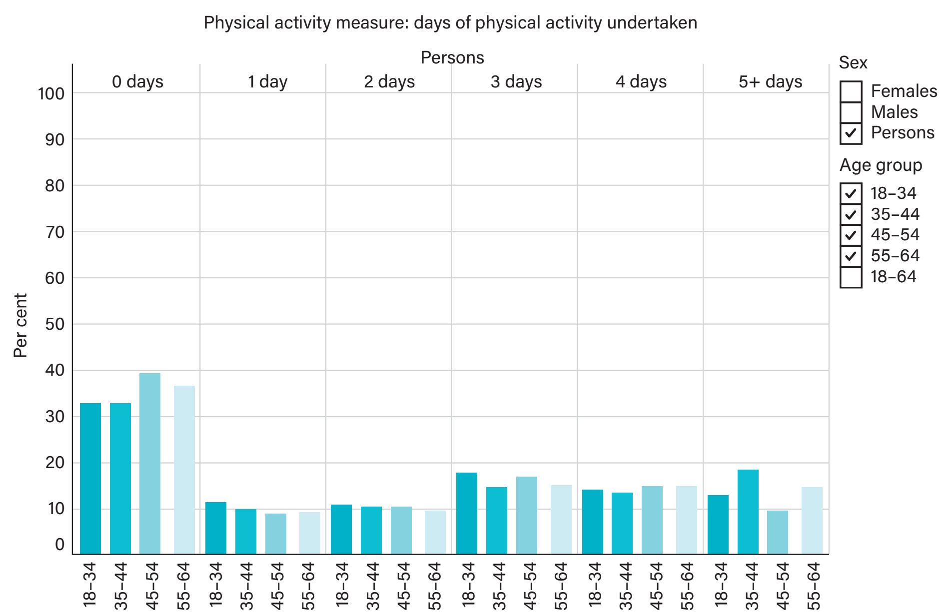


FIGURE 9.06 Days of physical activity undertaken

Source: Australian Institute of Health and Welfare. (2023). Physical activity. Retrieved from https://www.aihw.gov.au/reports/physical-activity/physical-activity

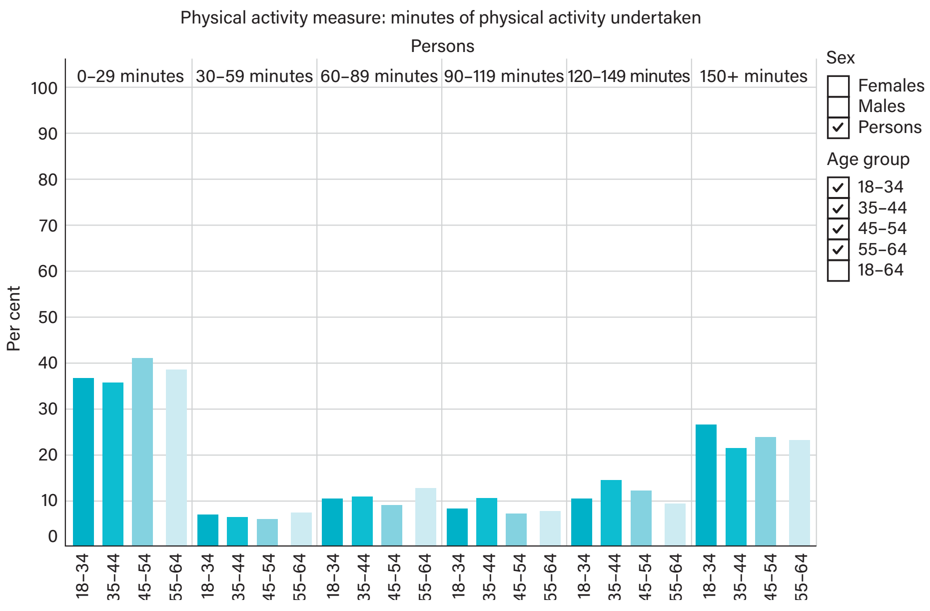


FIGURE 9.07 Minutes of physical activity undertaken

Source: Australian Institute of Health and Welfare. (2023). Physical activity. Retrieved from https://www.aihw.gov.au/reports/physical-activity/physical-activity

QUESTIONS

Using your data analysis skills, answer the following questions about the graphs, and discuss them as a group.

Figure 9.06

1 **Name** the **independent variable/s**.
2 Examine the one day and two days of exercise per week categories. What do you notice about the data?
3 **Identify** similarities across the age groups in the four days of exercise per week category.

independent variable
Can be changed to measure the impact of a dependent variable – that is, the impact intensity has on heart rate

Figure 9.07

1 Name the **dependent variable**.
2 What percentage of each age group engaged in 0–29 minutes of physical activity per week?
3 What percentage of each age group engaged in 150+ minutes of physical activity per week?
4 Focusing on the 30–59 minutes category, **describe** the trend that is apparent across the age groups. Suggest reasons for this trend.
5 There is a very slight increasing trend across the categories from 30–59 minutes and 150+ minutes of physical activities per week. **Suggest** one or two reasons for this trend.

dependent variable
Derives its value from changes to an independent variable – that is, heart rate will change in response to changes in intensity

Interpreting trends in physical activity data

We have described trends as overall, 'bigger picture' patterns in data. Trends are much more apparent in population-level studies, such as physical activity data from the Australian Bureau of Statistics (ABS) and the Australian Institute of Health and Welfare (AIHW). In this data, we can not only see the overall trends, but also draw conclusions about the **prevalence** of certain behaviours over time. In the context of physical activity and inactivity, prevalence refers to how common or how uncommon a particular behaviour may be in a population or given subset of the population.

prevalence
How often a behaviour occurs

The most striking finding from the 2023 AIHW Physical Activity report is that most Australians are not meeting the physical activity recommendations. In Figure 9.08, the percentage of adults not meeting the physical activity recommendations are expressed by age group and gender. For both males and females, there is an overall increasing trend towards not meeting physical activity recommendations as age increases.

There is a somewhat constant trend for males in the age ranges 35–44 and 45–54, with around 30 per cent of males in these age groups not meeting the recommendations.

Females in the age groups 25–34, 35–44, 45–54 and 55–64 show a cyclical pattern; there is an increase in physical activity from the 25–34 age group, peaking in the 45–54 age range, then decreasing at 55–64 before increasing again in the 65+ age group.

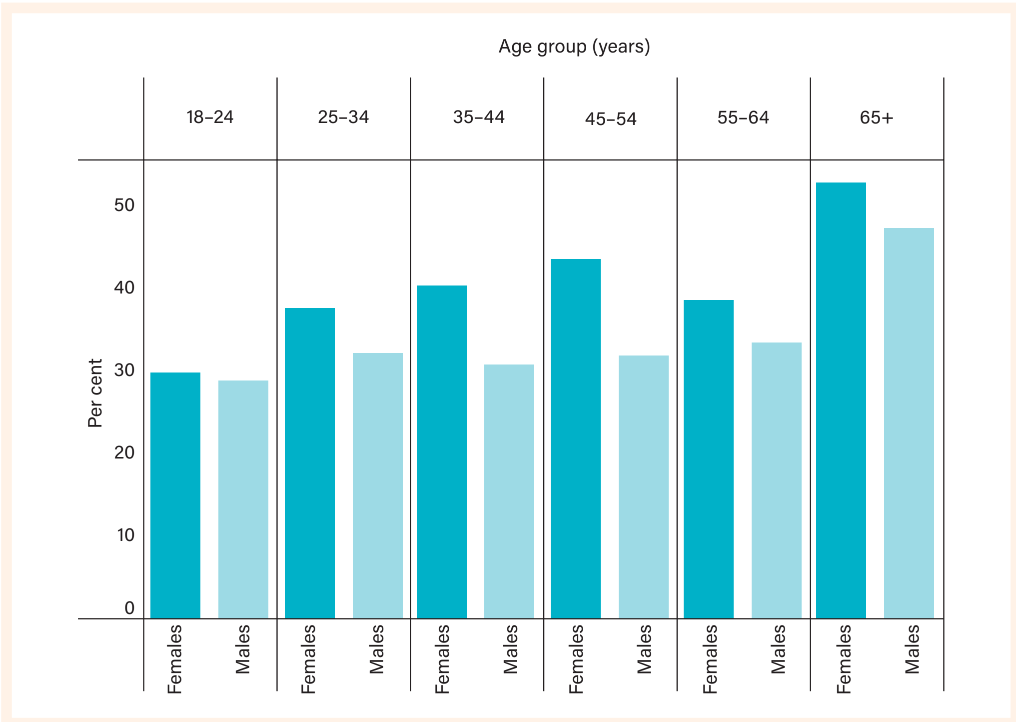


FIGURE 9.08 Proportion of insufficiently active adults aged 18–64, by age and sex, 2020–2021

Source: Australian Institute of Health and Welfare. (2023). Physical activity. Retrieved from https://www.aihw.gov.au/reports/physical-activity/physical-activity

A major reason for the cyclical pattern observable in the female subset of the population is motherhood and work. As a result of spending more time looking after their children, as primary carers, one observable trend is that women prioritise the wellbeing of their children over their own. While people of any gender can be primary carers, higher proportions of women generally take on these duties, such as transporting children, grocery shopping and being part of school and community committees. These activities often involve extended stationary periods. Care for young children tends to end around 45–54 years of age, when many people begin retirement and take up additional care duties, such as minding grandchildren. Even

iStock.com/SbytovaMN

FIGURE 9.09 Time spent caring for young children can reduce opportunities for physical activity.

physical infirmity
Physical weakness resulting from changes to body chemistry, low levels of weight-bearing exercise, loss of lean muscle, or reduced physical activity that is caused by either old age or disease

though their activity levels may not increase dramatically during this time, the recommendations are lower, which is likely a reason for the cyclic trend in the data.

In the 65+ age group, there is a marked increase in the number of males and females not meeting the recommendations for physical activity. A reason for this observed increase is likely to be **physical infirmity**, the result of illness, and even long-term physical fatigue, which can follow retirement. As a result of these factors, the proportion of older people not meeting the physical activity recommendations increases significantly.

CASE STUDY RUNNING MUMS AUSTRALIA

Established in 2013, Running Mums Australia (RMA) is a nation-wide network that supports mothers who love to run. It is a not-for-profit social network for women only. The aim of RMA is to create a supportive environment that encourages and promotes physical activity, in the form of running, to mums. One of the core beliefs of RMA is 'nothing is out of your reach', including excellent physical, emotional and mental health through regular exercise.

RMA organises training and coaching programs for mums who are new to running, as well as those who might be established in their running career. While promoting health in this way is excellent, there is also a social function to physical activity. When we are members of a group, we often follow the behaviours of other members, at least in part. As the number of running mums increases, there might be a flow-on effect, where we may see an increase in physical activity in women.


MoMo Productions/DigitalVision/Getty Images

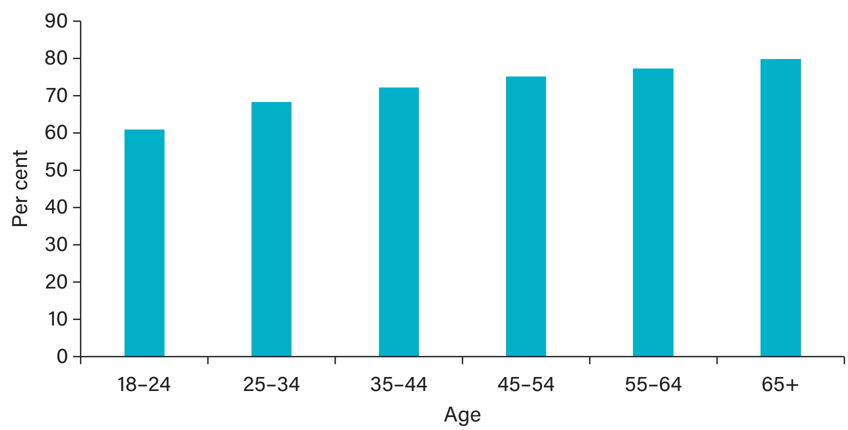
FIGURE 9.10 Running with friends is healthy, social and fun!

QUESTIONS

1 **Identify** the year that RMA started.
2 **List** one of the core beliefs of RMA.
3 **Explain** why women would be more likely to be physically active through joining RMA.
4 **List** the dimensions of health and wellbeing that are positively impacted by running, as stated in the case study.
5 Based on your understanding, and the case study, **suggest** one reason why RMA seeks to encourage mothers to be physically active.
6 How does a positive social influence impact the ways that people engage in physical activity? Can you think of some ways that this may appear in your life?
7 Why is it important to focus on improving the physical activity levels of women? Think about the Australian data in your response.
8 Thinking about the statistic that the average maternal age at the birth of the first child is around 30, **interpret** the cyclic pattern seen for women of all age groups in the graph in Figure 9.08. In your answer, link the ideas from the case study to the data in the graph.
9 Design a similar physical activity promotion strategy that could be used to support a different population group.

CASE STUDY WEIGHT-BEARING EXERCISE

Weight-bearing exercise, or the lack of it, is a probable cause of physical infirmity, especially as we age. The ABS has investigated the number of individuals meeting the recommendation for weight-bearing exercise or strength and toning exercise. The recommendation is that individuals engage in these activities on two days per week. The graph in Figure 9.11 represents this data.



Australian Institute of Health and Welfare

FIGURE 9.11 Percentage of individuals not meeting strength and weight-bearing exercise recommendations

QUESTIONS

Let's analyse this data by answering the following questions.

1. What is the approximate trend that is visible across the graph?
2. There is a slight decrease in the number of individuals not meeting the strength recommendation at age 55–64 years. **Suggest** one or two reasons for this.
3. Complete the following table:

	18–24	24–34	35–44	45–54	55–64	65+
Percentage not meeting recommendation	68		75			78
Percentage meeting recommendation (100 – % not meeting recommendation)	100 – 68 = 32					

4. **Create** a graph of the number of individuals meeting the strength and conditioning recommendation.
5. **Identify** any trends in the graph you have generated. Are these similar to or different from the graph above?

LOOKING FORWARD
Collecting data

Chapter 10

In Chapter 10 we will explore a range of surveys that be used to collect data at an individual and population level.

Delving deeper into data

Before we look at another graph that represents similar data, let's think about two summary points that the ABS writes about people who participated in the 2022 Physical Activity Survey:

- Two in three (67.4%) undertook at least some physical activity on five or more days.
- Three quarters (74.2%) did at least 150 minutes of physical activity in the week.

These points are very broad, and require our data analysis skills to unpack their meaning. On the surface, these figures look good – more than two-thirds of the surveyed population were regularly physically active and almost three-quarters of the surveyed population were physically active for 150 minutes or more, approaching the physical activity recommendations.

If we read closely, however, the words 'at least some' in the first point should stand out. In a survey, qualifiers (words like 'at least', 'about', 'up to', 'some') can be helpful to participants, but may also change the meaning of the data that we record. Unless we define these words clearly within the survey, participant responses may not represent the key points that we intend. Our surveys must be unambiguous and clear. In the data summaries above, 'at least some' could be interpreted in many ways. Perhaps participants think 'at least some' means walking to the letterbox to collect the post or similar incidental activities, which may change the way their largely sedentary lives are represented.

Weblink
Physical activity guidelines for all Australians

Australian Bureau of Statistics Report 'Physical Activity, 2022'

In 2022, the ABS released information and data about exercise and physical activity in the Australian population, as summarised in Figure 9.12.

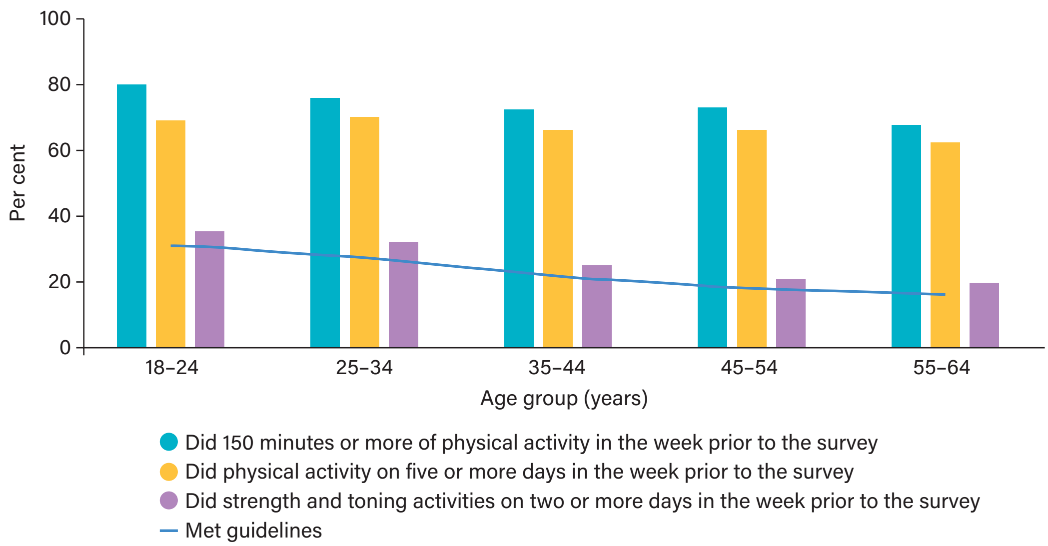


FIGURE 9.12 Proportion of Australian adults aged 18–64 years who met physical activity guidelines

Source: Australian Bureau of Statistics (2022). Physical activity, ABS website, accessed 15 August 2024. CC BY 4.0

Identifying patterns

There are some patterns that are immediately noticeable in the data shown in Figure 9.12. In all cases, strength and toning activities seem to be underperformed or overlooked by participants. People are performing physical activity on several days of the week, with most age groups seeming to be active on more than five days. The majority of all age groups did 150 minutes of physical activity in the week prior to the survey.

This last point may indicate that there might be some bias in the data. **Bias** is a source of untruthful data. In this case, if participants knew the survey was approaching, perhaps they, even only semi-consciously, did more activity than normal. This is called **response bias**, which is a psychological phenomenon that makes study participants answer in a way that makes them look/feel better. Response bias often skews the results towards the goals of the people running the study. This kind of bias can make data 'look good', but when there is further analysis or additional data collected, the real story can become clear.

bias
A source of untruthful data

response bias
A psychological phenomenon that makes study participants answer in a way that makes them look/feel better

Have a close look at the trend line – the blue line that runs from left to right on the graph. Look at the way the clusters of data for each age group change from left to right. If we start with the bars in each age group, we can see a 'step down' trend across the graph. This means that as their age increases, people are less likely to have completed 150 minutes of physical activity or engaged in physical activity on five or more days of the week.

Identifying trends

Turning our attention to the trend line, we see a similar story. There is a decreasing trend in the number of people who met the physical activity guidelines. In other words, as age increases, people are more likely not to meet the physical activity guidelines. The bars in each age cluster, without our critical data analysis, might have led us to believe that most people were physically active.

Some further trends in the patterns of physical activity are summarised in Table 9.1, based on the ABS *Physical Activity Report* (2023).

TABLE 9.1 Patterns of physical activity

Population characteristics
Individuals experiencing higher levels of disadvantage (low income, lower qualifications, low-skilled occupations) may be less likely to: • meet the physical activity recommendations (21.5 per cent) • engage in at least some physical activity during the week (83.1 per cent).
Young people aged 15–17 years
• In this group, 5.6 per cent of people met the physical activity guidelines. • In the 2017–2018 survey period, only 1.9 per cent of individuals met the guidelines. • Males are more likely to meet the guidelines (9.9 per cent) compared to females (3.7 per cent).
Adults aged 18–64 years
• One-fifth of adults (22.5 per cent) met the physical activity guidelines. • In 2017–2018, one in six adults (17 per cent) met the guidelines for physical activity. • More than half of the individuals in this group did physical activity on more than five days (56.4 per cent). • About one-quarter undertook strength training (26.6 per cent). • Males were more likely to meet the physical activity guidelines (24.9 per cent) compared to females (19.9 per cent).
Older adults aged 65+ years
• One in three people (33.3 per cent) met the physical activity guidelines. • About four in 10 (43.4 per cent) of adults did at least 30 minutes of physical activity on five or more days. • About three in ten (30.8 per cent) of adults were physically active every day.

CASE STUDY OVERALL TRENDS IN PHYSICAL ACTIVITY

The overall trend in physical activity participation in the Australian population is shown in the graph below. The trend is decreasing, meaning that people are less likely to participate in physical activity.

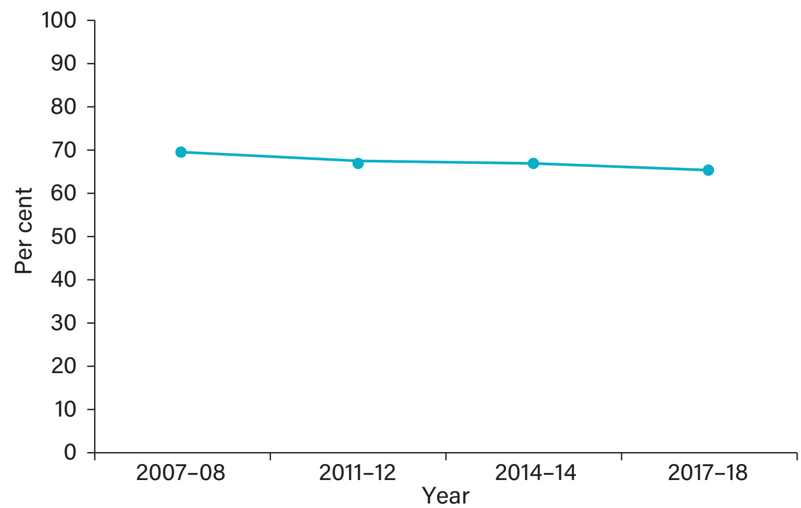


FIGURE 9.13 Overall trends in physical activity in Australia

Source: Australian Institute of Health and Welfare (2024). Physical activity, AIHW, Australian Government, accessed 15 August 2024. CC BY 4.0

A type of data analysis involves working out rate of change. Rate of change can be used to extrapolate (forecast, make predictions) about how data will change in the future, when those values are not yet available. The rate of change method is relatively unrefined, and is not always a good predictor of how data will change, but it can be useful in making simple predictions.

To calculate rate of change, we identify two points on the graph and find the value at each point.

For example, in 2007–08 about 70 per cent of the population met physical activity recommendations. In 2011–12 about 66 per cent of the population met the recommendations.

To determine the rate of change, we take the value at the first point away from the value at the second point. You might know this as Final – initial. The rate of change between 2007–08 and 2011–12 is –4% (66–70).

We can use this rate of change to predict that in 2013–14, about 62 per cent of the population engaged in physical activity. Of course, this is not extremely accurate, as we have data available for that time period. Sometimes it can be useful to generate an overall rate of change (first point and final point).

QUESTIONS

1 What is the overall rate of change from 2007–08 to 2017–18?
2 What is the yearly rate of change (calculate it for each year)?
3 Use the overall rate of change to make a prediction about the percentage of people meeting physical activity requirements in 2020–21. Use the rate of change to make these predictions.

CASE STUDY LIFE. WE CAN STILL BE IN IT!

It's been 50 years since the launch of the 'Life. Be in it' campaign, but the majority of adult Australians still do not meet the recommended levels of physical activity, according to data from the ABS. The campaign mascot was Norm, a stereotypical Australian couch potato. Norm told Australians to be physically active, to make healthy food choices, and to be part of life, rather than being a couch potato.

National activity guidelines recommend adult Australians undertake at least 150 minutes of physical activity per week in five or more separate sessions. The 2022 National Health Survey found that only 23.9 per cent of adult Australians met these guidelines, down from 43 per cent in the 2011–12 National Nutrition and Physical Activity Survey.

The state averages are displayed in the table below.

FIGURE 9.14 Norm from the 'Life. Be in it' campaign that was launched in Australia in 1975

Illustration courtesy of Alex Stitt. 1975, 'Norm' from the 'Life. Be in it' Campaign. Victorian Department of Youth, Sport and Recreation © Alex Stitt

State	Percentage of state population meeting physical activity recommendations
Victoria	23.9
New South Wales	24.3
Queensland	23.6
Western Australia	23.0
South Australia	23.9
Tasmania	22.3
Australian Capital Territory	20.7
Northern Territory	24.6

The effects of the 'Life. Be in it' campaign, which was launched in 1975, have not been as long-lasting as would have been intended. However, reflections by Colin Benjamin and Jane Shelton (2007) suggest that there is still interest in the campaign. The office receives regular calls for advice, and the website routinely exceeds 2000 hits per month.

With this seemingly positive data, perhaps it is about time Norm got up off the couch again to rally a new generation of Australians to take control of their health and wellbeing.

QUESTIONS

1 What is the difference in percentage of Australians meeting the physical activity guidelines in the two surveys mentioned in the case study?
2 What two pieces of data do Colin Benjamin and Jane Shelton use as evidence of continued interest in 'Life. Be in it'?
3 Which Australian states or territories have the highest physical activity levels?
4 **Suggest** two reasons why these states have the highest activity levels.
5 Which state has the lowest physical activity level?
6 **Suggest** one reason why this may be.
7 Western Australia, South Australia, Queensland and Victoria have similar percentages of adults meeting the physical activity recommendations. Rank these states from highest to lowest percentage of people not meeting physical activity recommendations.

8 Melbourne is particularly spread out. **Suggest** two reasons why geographical factors may contribute to higher percentages of adults not meeting physical activity recommendations.

9 Norm was targeted to adults – he was a middle-aged, beer-drinking couch potato. Create a list of characteristics that might make Norm more appealing to a younger audience, so that a reboot of 'Life. Be in it' might catch the attention of a broader population.

Assessment
9.2 Check-in questions

Command terms

suggest
Put forward for consideration a solution, hypothesis, idea or other possible answer

summarise
Retell concisely the relevant and major details of one or more arguments, text, narratives, methodologies, processes, outcomes and/or sequences of events

infer
To conclude from evidence and reasoning

9.2 CHECK-IN QUESTIONS

1 **List** two reasons for not conducting population studies annually.
2 **State** the type of bias that might be present in a survey about health behaviours.
3 **Describe** two of the physical activity features of young people aged 15–17.
4 The graph in Figure 9.12 showed that most older adults (56–64) are meeting the physical activity requirements. But the summary of data says that only 30 per cent of this population is meeting the requirements. **Suggest** a reason for the difference in the data.
5 **Summarise** the key findings and statistics for each of the groups shown in Figure 9.12 (18–24, 25–34, 35–44, 45–54, 55–64).
6 The data in Figure 9.12 is organised into five age brackets (18–24, 25–34, 35–44, 45–54, 55–64). **Identify** two issues related to grouping data in this way.

9.3 PHYSICAL INACTIVITY AND SEDENTARY BEHAVIOURS: PREVALENCE AND TRENDS

In this module you will learn about:
- trends in physical inactivity and sedentary behaviour and data that describes these

and learn to:
- analyse and interpret secondary data related to physical inactivity and sedentary behaviours to describe these trends.


iStock.com/baona

FIGURE 9.15 Sedentary behaviours like watching television can reduce time spent in physical activity.

Less than one-quarter of Australian adults are meeting the physical activity recommendations, meaning that around three-quarters of the population are regularly physically inactive or sedentary. Physical inactivity refers to irregular or insufficient engagement with active behaviours over the course of the week, while sedentary behaviours refer to those activities that are inactive, such as watching television, playing video games or even reading a book.

The data explored earlier in the chapter demonstrates that there is a high proportion of Australians who do not meet the physical activity recommendations. We can **infer**, therefore, that these Australians are likely to be more physically inactive, and routinely engage in sedentary behaviours. Occupational activity and incidental activity at work (or during the worktime commute) is also decreasing. The graph in Figure 9.16 shows the type of physical activity in the workplace reported by Australian adults.

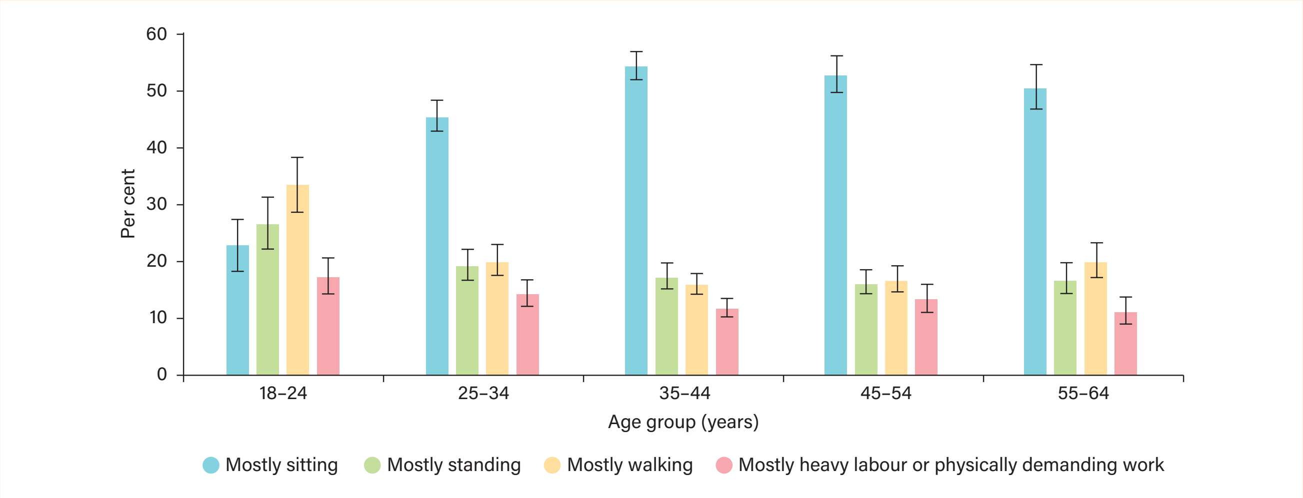


FIGURE 9.16 Proportion of adults aged 18–64 years by age and type of activity at work on a typical work day in the previous week, 2022

Source: Australian Bureau of Statistics (2022). Physical activity, ABS website, accessed 15 August 2024. CC BY 4.0

There are interesting patterns in this data. There seems to be a somewhat periodic pattern in jobs that are 'mostly sitting' – the rate seems to increase then decrease, though the decrease is only fractional. Reasons for this pattern are complex, but may be related to retirement or partial retirement reducing the response rate from older adults.

We also see higher levels of standing and walking at work in younger adults (18–24 years). This is likely due to individuals employed in casual work in retail or other industries that involve occupational exercise as a matter of course. As individuals become more qualified, they leave these professions, and report higher levels of sedentary work.

Compare the data between the 18–24 and 25–34 age groups for the 'mostly walking' descriptor. It drops by more than 10 per cent between the two groups. Think about one of the major milestones that occurs during these 10-year periods – individuals graduate from university and leave part-time work, which may be more physically active as it is less skilled, and they move into professional careers that are often more sedentary.

In the previous section (and in Chapter 8), we also explored ways that disadvantage can influence physical activity levels. In the graph in Figure 9.18, we can see a trend towards lower levels of physical inactivity as disadvantage is reduced.

Jeffrey Isaac Greenberg 4+/Alamy Stock Photo

FIGURE 9.17 Data shows higher levels of walking among younger adults compared with older adults.

LOOKING BACK
BENEFITS OF PHYSICAL ACTIVITY

Chapter 7

In Chapter 7 we examined the benefits of participating in regular physical activity. In this chapter we are exploring the prevalence of inactivity and the associated health risks and outcomes.

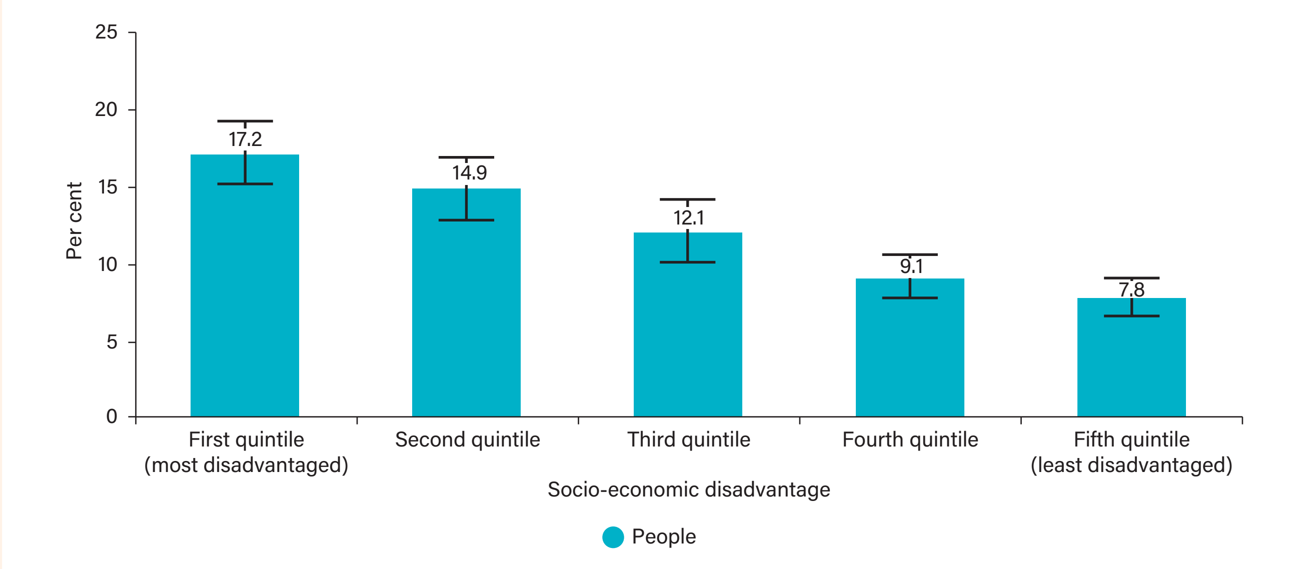


FIGURE 9.18 Proportion of adults by whether they did zero minutes of physical activity in the previous week, grouped by disadvantage

Source: Australian Bureau of Statistics (2022). Physical activity, ABS website, accessed 15 August 2024. CC BY 4.0

Disadvantage may mean that individuals need to spend more hours in activities that are related to preserving the fundamental aspects of their wellbeing. Individuals with higher levels of disadvantage may not have the financial resources to participate in physical activities that require specialised equipment. These individuals may also not have sufficient education to understand the importance of physical activity or ways to be more physically active. In contrast, people with lower levels of disadvantage may not be participating in physical activity due to longer hours spent at work in a sedentary environment, and/or preference for higher-cost, lower-activity leisure time.

CASE STUDY THE REPORT CARD IS IN

The 2022 Australian Physical Activity Report Card includes a number of indicators of physical activity. The data was recorded between 2016 and 2021. The indicators are Overall physical activity, Organised sport and physical activity, Active play, Active transport, Screen time, Physical fitness, Family and peers, School, Community and built environment, and Strategies and investment.

Young Australians, nationwide, have not performed well. Their report card is shown in Figure 9.19.

The grades are awarded based on the following percentages of individuals represented in the particular indicator:

A+ is 94–100 per cent participation
A is 87–93 per cent participation
A– is 80–86 per cent participation
B+ is 74–79 per cent participation
B is 67–73 per cent participation
B– is 60–66 per cent participation
C+ is 54–59 per cent participation
C is 47–53 per cent participation
C– is 40–46 per cent participation

REPORT CARD	
Overall physical activity	D–
Organised sport and physical activity	B–
Active play	UG
Active transport	D+
Screen time	D–
Physical fitness	D+
Family and peers	C+
School	C+
Community and the built environment	A–
Strategies and investments	C–

Active Healthy Kids Global Alliance

FIGURE 9.19 Physical activity report card

D+ is 34–39 per cent participation
D is 27–33 per cent participation
D– is 20–26 per cent participation
F is less than 20 per cent participation
UG means that not enough data was present to make a judgement.

When it comes to screen time, the D– grade is the result of only 20–26 per cent of Australian young people meeting the limits around the use of technology during leisure time. The limit is currently set at around two hours of screen time during recreation per day. This result is alarming, as it means that between 74 and 80 per cent of Australian young people are using technology for more than two hours per day in recreation!


Prostock-studio/Shutterstock.com

FIGURE 9.20 Two hours per day is the recommended limit for leisure-time screen usage.

Australia's young people are not faring well. While there are some positives in organised sport and physical activity, participation is still low (only 60–66 per cent of Australian young people were involved). As a nation, we seem to invest positively in community initiatives and providing physical resources for activity, but we do not invest enough in strategies and marketing and other programs to encourage participation in physical activity. There seems to be a disconnection between our intentions and aims, the resources we establish, and the effort we put behind promoting those resources and implementing our aims.

Australia has a long way to go in terms of improving physical activity levels in young people.

QUESTIONS

1 **State** the grade achieved by Australian young people for the indicator Active play.
2 **Identify** the reason why this grade was awarded.
3 There was a drop from B to B– for Organised sport and physical activity between 2016 and 2021. **Describe** how the pandemic might have impacted this grade.
4 **Explain** one reason why participation in physical activity remains low, even though Community and the built environment (spaces to do activity) is given a grade of A–.
5 Based on your knowledge of the benefits of physical activity, write a brief paragraph to persuade politicians to consider the disappointing results received by Australian young people on the 2022 Australian Physical Activity Report Card.

Trends in physical inactivity

Physical inactivity is prevalent in our society, and sedentary behaviours are on the rise. While national level surveys are not done every year, recent data reveals the following patterns in physical inactivity and sedentary behaviours in Australia.

There is generally an overestimation of physical activity levels in young people, especially those that are primary and early secondary aged. This overestimation can be up to about 33 per cent of the actual value. That means that if a child reports one hour of physical activity, they are likely engaging in about 40 minutes.

The pandemic-related lockdowns caused a 75 per cent increase in physical inactivity and higher rates of non-work-related screen use and sitting. These changes have continued, at least in part, since the end of the pandemic (Robinson et al., 2023), across all levels of society.

Victorian young people are using screens for recreation about 71 per cent of the time, while in other states this figure ranges between 34 and 53 per cent.

Unsurprisingly, Victorian children also reported doing much less outdoor physical activity. About 63 per cent of participants said they do not regularly engage in outdoor physical activity. Against the statistics related to recreational screen use, these results make sense.

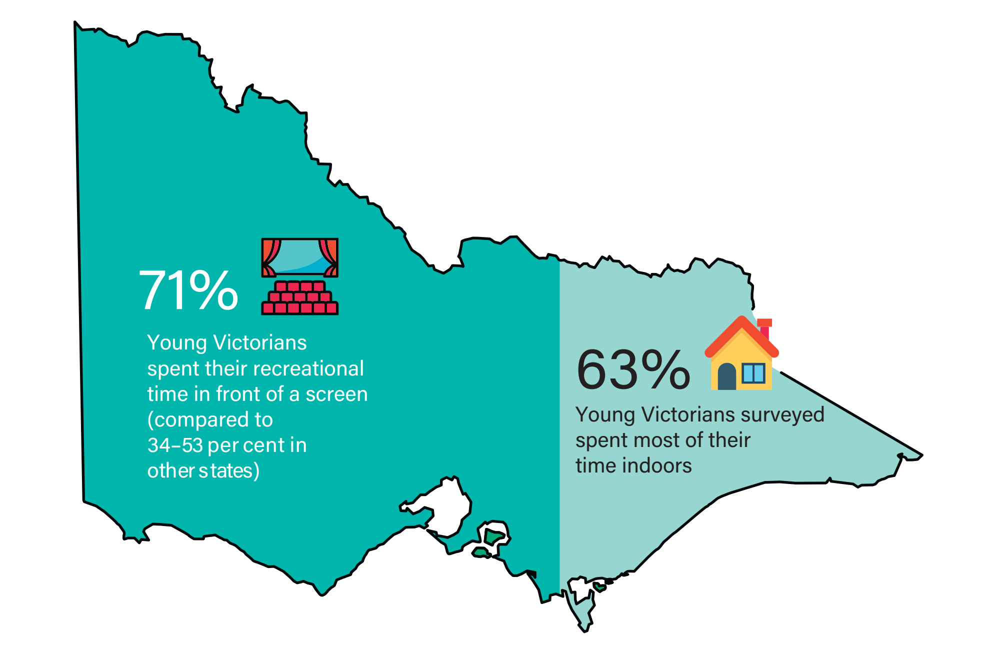


FIGURE 9.21 Young Victorians' screen-time use and time spent outdoors

COLLABORATIVE TASK
Activity

Then and now

In small groups, design and carry out a method for recording your physical activity levels over the last five years. Gather and present the class data graphically.

- Compare your physical activity levels of five years ago, two years ago and now.
- Can you see any changes in your physical activity levels individually, as a small group or as a class?
- If there is a trend towards reduced physical activity, determine how prevalent or common this is in the class group. Discuss potential reasons for these trends.

International perspectives

The World Health Organization (WHO) has made the following comments on global data related to the prevalence of physical inactivity and sedentary behaviours.

> In the 20-year period since the last global study, the WHO reports no improvement in the physical activity levels of adults. The constant trend they report is alarming. Of all adolescents, only 20 per cent engaged in at least 60 minutes of physical activity per day.
>
> The impact of sedentary behaviours such as watching television, reading, playing video games and using mobile phones can be reduced by including physical activity such as upper body tasks or coordinated leg movements. The WHO reports no significant uptake of this recommendation.

In developed countries, about one-quarter of the adult population is not physically active enough, while only about 12 per cent of adults in developing countries are not sufficiently active. This finding is likely related to the types of work conducted and lifestyle factors. Passive transport (such as driving a car or catching a bus), increased sedentary work, and increased sedentary leisure time are the causal factors that drive lower levels of physical activity.

9.3 CHECK-IN QUESTIONS

1 How prevalent is insufficient physical activity among adults in Australia?
2 What inferences can we make about physical inactivity and sedentary behaviours based on the prevalence data for physical activity?
3 **Suggest** a reason why higher levels of educational attainment might be linked to lower levels of physical activity.
4 **Describe** the relationship between level of disadvantage and prevalence of insufficient physical activity.
5 **Compare** the global patterns and trends in physical inactivity data with the Australian data.

Assessment
9.3 Check-in questions

Command term

compare
Recognise similarities and differences and the significance of these similarities and differences

9.4 PHYSICAL INACTIVITY AND SEDENTARY BEHAVIOURS: HEALTH RISKS AND OUTCOMES

In this module you will learn about:
- health risks and outcomes of chronically insufficient physical activity and sedentary behaviours

and learn to:
- explain certain health outcomes as the product of physical inactivity and sedentary behaviours.

Being sufficiently physically active is essential to general health and wellbeing, as well as treating a range of illnesses. Physical activity promotes good social interactions, better academic performance, better management of personal resources including time, as well as better mental and emotional health and wellbeing. When individuals are not sufficiently physically active, or engage too regularly in sedentary behaviours, there are significant risks to health and wellbeing. In this section, we discuss the link between insufficient physical activity and:
- heart disease and vascular disease
- type 2 diabetes
- overweight and obesity
- neurological and musculoskeletal disorders.

Heart disease and vascular disease

Heart disease is a complex condition related to a number of biological and lifestyle factors. In short, the body deposits fatty substances along the walls of blood vessels, the body tries to remove the fatty substances, but cannot, and as a result **plaques** form (combinations of fat, damaged cells, immune cells, and other 'scar-like' components). Plaques reduce the area of the blood vessel, impeding blood flow and adding to increased blood pressure. When vessels become blocked, especially around the heart, the tissue or organ cannot get the oxygen it needs, resulting in a heart attack.

plaques
Combinations of fat, damaged cells, immune cells, and other 'scar-like' components that can form along the walls of blood vessels

iStock.com/vm

FIGURE 9.22 Regular exercise reduces risk of heart disease and type 2 diabetes.

Exercise is one of the most powerful preventative measures for the development of heart disease. Regular exercise improves the way the body manages and metabolises stores of fatty substances, as well as how these are used as they enter the diet. Aerobic exercise also contributes to improved vascular elasticity, reducing the hardening effect of heart and vascular diseases.

When exercise is insufficient, there is a greater risk of these fatty substances being deposited along blood vessels, resulting in the development or worsening of heart and vascular disease.

Type 2 diabetes

Type 2 diabetes is a lifestyle disease that arises when stress put on the pancreas through sustained high levels of glucose in the blood. This overwhelms the pancreas, resulting in insufficient insulin production and insufficient response of cells to insulin. High concentrations of glucose in the blood cause tissue damage, contributing to heart and vascular disease, damaging nerves, suppressing the immune system and harming the function of the kidney due to changes in blood volume and pressure.

Exercise is an efficient means of managing blood glucose levels. When we engage in physical activity, chemical changes occur that make cells more receptive to the presence of insulin. Even when the pancreas is overwhelmed, it will still produce some insulin. Improving the way the body responds to insulin, through exercise, can also help to reduce the severity or development of type 2 diabetes.

Sedentary behaviours are often coupled with overeating or unnecessary caloric intake. Without the messages to the body to increase sensitivity to insulin, and with a chronically high blood glucose concentration, the potential for the onset of type 2 diabetes increases drastically.

REAL WORLD APPLICATIONS

Treating type 2 diabetes: one step at a time

When a patient is diagnosed with type 2 diabetes, many doctors will turn to the first line treatment of modifications to diet and prescribed exercise, before prescribing medications. The reason for this is that exercise changes an individual's metabolic hormone profile, prompting their body to use fuels differently. Physical activity also builds muscle cells that are not resistant to signals from insulin. As muscle cells increase in number through exercise, individuals use fuels differently. Blood sugar is not consistently high and blood fats and cholesterol are reduced, which further reduces the burden on the pancreas.

Orange Line Media/Shutterstock.com

FIGURE 9.23 Exercise benefits our health at all ages.

Following sustained and appropriate exercise, individuals can reverse their diabetic status. Often, a reduction in body mass of about 10–15 per cent, achieved through exercise prescription and dietary modification, is sufficient to reverse type 2 diabetes, without medication.

Overweight and obesity

We are all familiar with the phrase that energy in must equal energy expended in order to maintain weight – this is the basic principle of energy balance. When the body is supplied with fuel, which is energy dense, it only uses a proportion of that fuel and energy to maintain body functions. The rest is often converted to fat and put into long-term storage in the body. While the biochemistry and physiology of obesity and being overweight are complex and not yet perfectly understood, this mismatch between energy intake and energy output is a core principle that drives development of these conditions.

Both overweight and obesity lead to a number of health conditions, such as high blood pressure, heart disease, type 2 diabetes, certain cancers and, according to some research, neurological and psychiatric disorder.

Exercise tells the body to burn stored fuel, especially when exercise is sustained and consistent, such as is achieved through meeting the recommendations for physical activity. Without regular exercise, the body is not triggered into using stored fuels, and the individual is predisposed to becoming overweight or obese.

Neurological and musculoskeletal disorders

The line 'sitting is the new smoking' may have some truth to it. Just as smoking does not produce illnesses that are immediately obvious, the same is true of sedentary behaviour, sitting in particular.

Sitting, such as at an office chair, puts pressure on nerves and muscles. A lack of ergonomics and increased body mass (perhaps through overweight and obesity caused by insufficient physical activity) can irritate these nerves and muscles. An increasingly common disorder in younger members of the population is sciatica, or pain in the upper part of the buttocks, lower back, side and back of the legs, and even in the knee and foot. The pain is reported as tingling, a feeling of cold or, in the worst cases, incapacitating and excruciating. The pain arises from compression-related inflammation of the sciatic nerve – one of the long nerves that innervates the lower limb, exiting through the pelvis in the cauda equina nerve bundle. Sitting in an office chair puts immense pressure on the sciatic nerve. Glucose may also play a role in the development of sciatic pain. High blood glucose levels have been associated with higher levels of inflamed nerves. Again, exercise and movement reduces blood glucose and pressure on anatomic structures, reducing the potential for nerve damage.

iStock.com/JohnnyGreig

FIGURE 9.24 Prolonged sitting is detrimental to physical health.

Many Australians sit for eight hours or more each day. Taking regular breaks from sedentary activities, working at a standing desk, and engaging in walking meetings or similar activities that promote physical activity at work and school are all good ways to reduce the **incidence** of sedentary nerve damage.

incidence
The number of new cases of a disease diagnosed per year

While the link is not clear, insufficient physical activity may contribute to the worsening or chances of developing certain neurological conditions, such as dementia or Alzheimer's disease. The theory is that exercise causes immune activation in the brain, which promotes clearing of toxic substances that may be linked to these disorders. Regular activity also increases muscle mass, which may have some as yet undefined role in protecting against neurological disease.

Insufficient physical activity, therefore, increases the risks of developing these conditions.

CASE STUDY LET'S GET PHYSICAL!

A long-term study conducted in Japan has found a negative relationship between experience and worsening of dementia symptoms and regular physical activity. The researchers determined that higher levels of physical activity, coupled with simple mental tasks, affectionately termed 'cognicise' (a combination of cognition and exercise), effectively reduced the experience of dementia symptoms and even seemed to slow progression of the disease (Bando, 2021; Suzuki et al., 2015).

iStock.com/Julio Rivalta

FIGURE 9.25 Crosswords are a great way to stay mentally healthy.

Cognicise includes basic aerobics routines, tailored to the ability level of the participants but designed to cause an increase in heart rate to about 65 per cent of maximum. It also includes brain training-type exercises, such as mental arithmetic (less-common times tables, division and subtraction) and word games (giving a word that is related to a stimulus by theme, letter or some other requirement).

The idea behind the success of cognicise is that it promotes blood flow to the brain, perhaps helping to clear the toxic compounds that accumulate there in dementia. It also builds lean muscle, which, as stated above, has some undefined protective effect on the progression of neurological conditions.

Results of several studies have indicated that cognicise is helpful in dementia, but also significantly reduces the effects of age-related mild cognitive impairment (Shimada et al., 2019). The studies are generally structured around comparing the intervention (cognicise) with no specific physical intervention. Participants are usually in their late seventies or older. It was found that individuals in the study were significantly different from those not in the study for tests of mobility and mental functioning. The z-score difference between the groups was 31.3 – meaning that the treatment group moved about 31 whole values away from the average score of the treatment group.

QUESTIONS

1 **Name** the intervention that has been developed to improve dementia symptoms.
2 What is the percentage of maximal heart rate achieved during the exercise program?
3 **Describe** the types of activities that someone in this program would do.
4 **Describe** the supposed mechanism of action (the way the treatment works).
5 Why do you think this program is not more widely used? **Explain** your answer.
6 Develop a fact sheet or infographic that encourages adoption of this program. Use evidence as well as behavioural principles to encourage people to adopt this program as a useful method for slowing and perhaps pausing the development of dementia.

COLLABORATIVE TASK
Activity

Promoting activity for better health outcomes

Marketing companies and other agencies tend to use scare tactics to urge people to take up or stop a certain behaviour. Design a poster with a slogan that relates physical inactivity or sedentary behaviour to one of the health outcomes discussed in this section. Use colour, images and simple words to attract attention. Present your posters as a gallery to the class and discuss them.

9.4 CHECK-IN QUESTIONS

1 **Identify** the four conditions that insufficient physical activity may lead to.
2 Which of the following statements best describes how exercise reduces the risk of most of these conditions?
   A Physical activity changes the way blood flows in the body, cleaning out toxic products and improving health.
   B Physical activity changes the way fuels are used and stored, causing less damage related to high sugar, fat, and other compounds in the blood.
3 **Name** two components of the plaques that appear in blood vessels in heart disease.
4 **Explain** why an individual who is overweight or obese is more likely to experience sciatic pain.
5 **Compare** the treatment of overweight and obesity with the initial treatment of diabetes. Why do you think there are so many similarities?

Assessment
9.4 Check-in questions

Command terms

name
Provide a word or term (something that is known and distinguished from other people or things) used to identify an object, person, thing, place etc.

explain
Give a detailed account of why and/or how with reference to causes, effects, continuity, change, reasons or mechanisms; make the relationships between things evident

CHAPTER SUMMARY

Resource
Self-assessment checklist

Video
Masterclass: Chapter 9

9.1 Analysing physical activity data

- Surveys and other tools are used to measure population physical activity data. These are expensive to conduct and produce a lot of data that needs to be analysed, so they are not run every year.

9.2 Physical activity: prevalence and trends

- Trends are 'big picture' patterns that are visible in graphs and other representations of data. Usually, we can see a trend as we look across the data from left to right.
- Patterns are characteristics or features of data that we can see for specific groups or other independent variables.
- Dependent variables go on the vertical axis and independent variables go on the horizontal axis.

9.3 Physical inactivity and sedentary behaviours: prevalence and trends

- Australian adults are active, but do not meet the recommended levels of daily physical activity. Less than 25 per cent of Australian adults are meeting recommended daily physical activity targets.
- Australians are spending more time sitting at work, spending less time moving during commutes, and are using screens and engaging with sedentary behaviours more regularly during leisure time.
- Globally, patterns among adults and young people are similar to the Australian data, with one quarter of adults meeting recommended targets. There have been no significant improvements or changes to this level.

9.4 Physical inactivity and sedentary behaviours: health risks and outcomes

- A lack of physical activity predisposes individuals towards a range of conditions, including diabetes, obesity, heart disease and some neuromuscular conditions. Regular physical activity is thought to change the way metabolism of fuels in the body works, reducing the presence of compounds that have the potential to initiate or worsen these lifestyle diseases.

CHAPTER REVIEW

Assessment
Chapter 9 Review

1 True or false: Patterns in data refer to the overall movement of the data across the graph.

2 **State** two reasons why Australian adults appear to be physically active, but the trend in sufficient activity shows a different result.

3 **Define** prevalence.

4 **Explain** why sedentary behaviours are likely to contribute to the development of a range of lifestyle diseases.

5 **Describe** how physical activity can be used to reduce the risk and progression of type 2 diabetes.

6 **Explain** what a grade of 'D+' for the indicator physical fitness means for Australian young people.

7 **Suggest** a reason why some locations in Australia may exhibit lower proportions of the population meeting physical activity recommendations. Justify your response.

8 Illustrate with examples how interventions like cognicise and social groups like Running Mums Australia can influence physical activity patterns and health outcomes. Use data to support your answers.

9 A patient has been recently diagnosed with type 2 diabetes and has come to you as an exercise physiologist with a referral from their doctor. Write a short script of an explanation you can use with the patient that explains why exercise is beneficial to their condition.

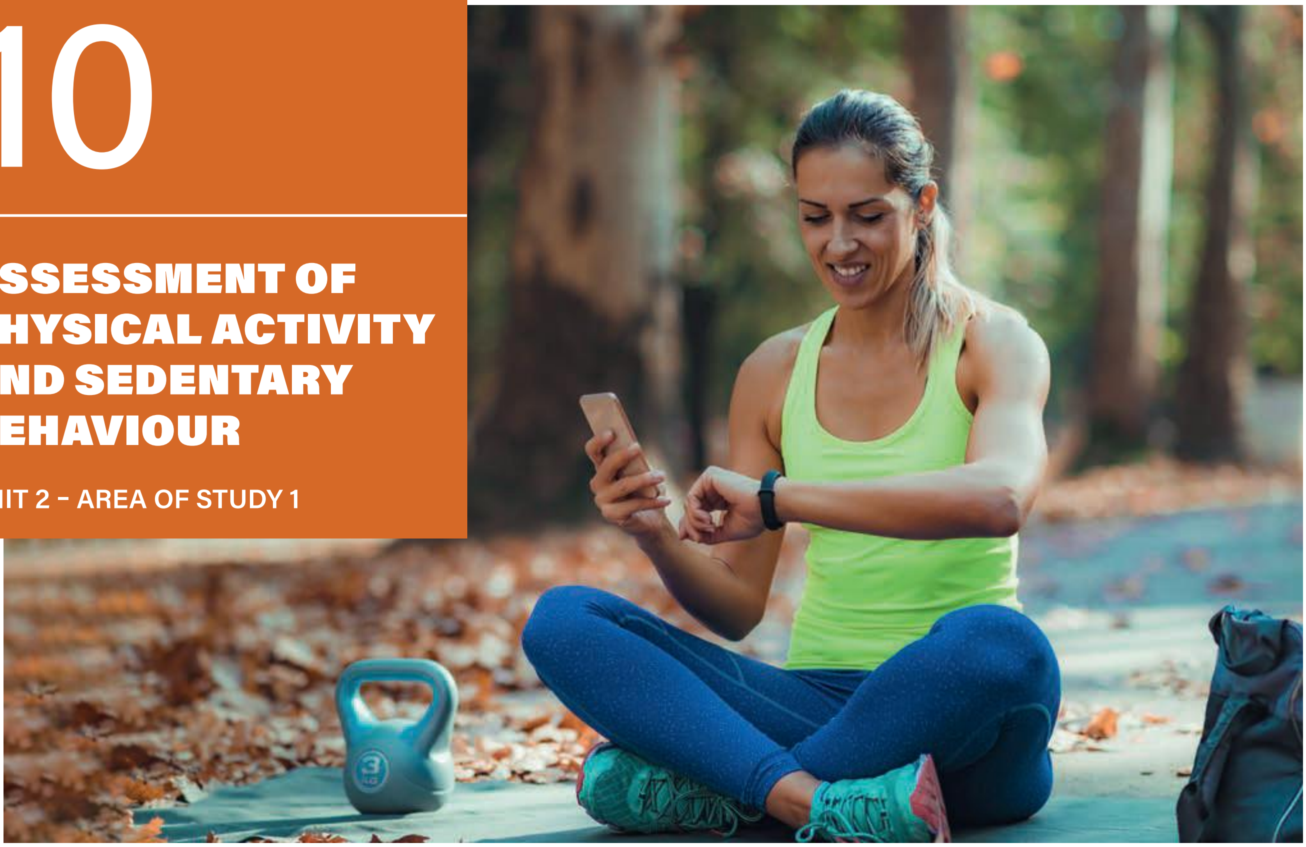
10 'Sitting is the new smoking.' Write a short argument supporting this statement.

CHAPTER

10

ASSESSMENT OF PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOUR

UNIT 2 – AREA OF STUDY 1



Microgen/Adobe Stock

FIGURE 10.01 Monitoring physical activity is an important behavioural change strategy.

Quizzes

Chapter 10 Pulse check

10.1 Check-in questions

10.2 Check-in questions

Chapter 10 Review

Videos

Masterclass: Chapter 10

10.2 In focus: Wearable technologies to assess physical activity and sedentary behaviour

Resources

10.2 Template: Determining your stride length

10.2 Template: Comparing intensity - walking versus running

10.2 Template: Estimating your step count

10.2 Template: Estimating total distance covered

10.2 Template: Observation form

10.2 Template: SOFIT recording sheet

10.2 Template: Student activities and contexts

Chapter 10 Self-assessment checklist

Nelson MindTap

To access resources above, visit **cengage.com.au/nelsonmindtap**

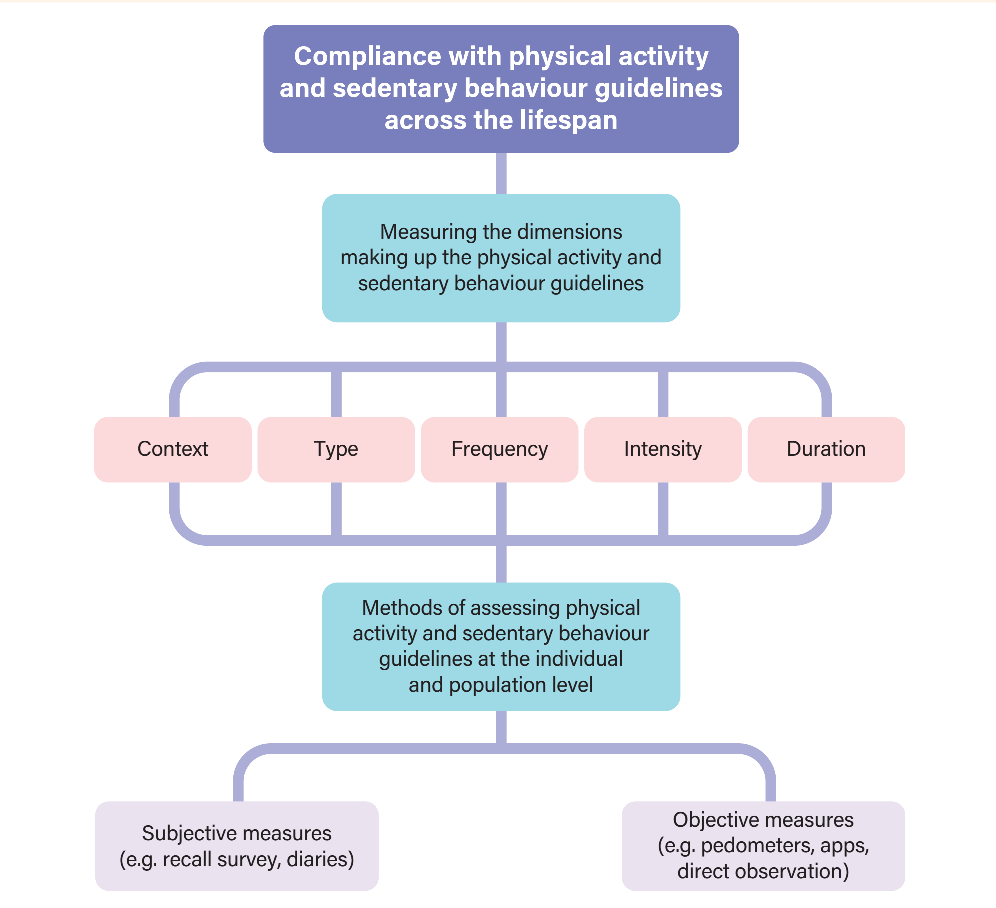
KEY KNOWLEDGE

- physical activity and sedentary behaviour guidelines for different age population groups
- subjective and objective methods of assessing physical activity and sedentary behaviour such as recall surveys or diaries, pedometry, observation tools, digital tools and wearable technology

KEY SKILLS

- describe the physical activity and sedentary behaviour guidelines for different age population groups
- analyse and interpret secondary data related to physical activity behaviour to explain outcomes of physical activity and sedentary behaviour
- justify and use appropriate methods to measure and analyse physical activity and sedentary behaviour at the individual and population level

Source: VCAA VCE Physical Education Study Design (2025–29)



Video
Masterclass: Chapter 10

Assessment
Chapter 10 Pulse check

In this chapter we will explore the physical activity and sedentary guidelines for different population groups. We also take a look at how to determine whether someone meets the guidelines for their designated population group via measurement. We will explore a range of subjective and objective methods of assessing physical activity and sedentary behaviour.

PULSE CHECK

Take the pulse check quiz to check your prior knowledge and understanding of the concepts covered in this chapter.

1 Who determines the physical activity guidelines for Australians?
2 **List** three measures that can be used to assess physical activity.
3 If you accumulated 10 000 steps in one day, would you meet the physical activity guidelines?
4 **Describe** the difference between a subjective and objective measure of physical activity.
5 **Explain** the benefits of using wearable technology to monitor physical activity.

10.1 PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOUR GUIDELINES

In this module you will learn about:
- physical activity and sedentary behaviour guidelines for different age population groups

and learn to:
- describe the physical activity and sedentary behaviour guidelines for different age population group.

Physical activity and sedentary behaviour guidelines for all Australians

Within developed countries, the degree to which the population is involved in physical activity is increasingly considered a significant public health issue. According to the World Health Organization (WHO, 2024), inactivity is the second leading cause of death due to non-communicable disease worldwide, and the cause of more than three million preventable deaths per year (approximately 6 per cent of deaths annually). Governments set national physical activity guidelines and monitor what proportion of the population meets these guidelines. As discussed in Chapter 7, high levels of sedentary behaviour are dangerous to overall health, and have also been linked to chronic disease and obesity.

Most developed nations have a set of national physical activity and sedentary behaviour guidelines. Australia's physical activity and sedentary behaviour guidelines outline how much physical activity people should do, the importance of reducing the time spent sitting or lying down and how much sleep children and young people should get. These guidelines vary according to a person's age (see Tables 10.1 and 10.2). The Australian guidelines were informed by what we know about the relationship between physical activity dimensions (type, frequency, duration and intensity) and health outcome indicators, including the risk of **chronic disease**.

chronic disease
Long-lasting conditions with persistent effects

REAL WORLD APPLICATIONS

How were the guidelines developed?

Australia's physical activity and sedentary behaviour guidelines were based on a rigorous evidence review process that considered:

- the relationship between physical activity (including the amount, frequency, intensity and type of physical activity) and health outcome indicators, including the risk of chronic disease and obesity
- the relationship between sedentary behaviour/sitting time and health outcome indicators, including the risk of chronic disease and obesity.

TABLE 10.1 Summary by age – children and young people

Recommendations	Under 12 months	1 to 2 years	3 to 5 years	5 to 17 years
Physical activity	Interactive floor-based play, and at least 30 minutes of tummy time for babies per day	At least 3 hours (180 min) of energetic play per day	At least 3 hours (180 min) per day, with 1 hour being energetic play	At least 1 hour (60 min) of moderate to vigorous activity involving mainly aerobic activities per day Vigorous activities should be incorporated at least 3 days per week Several hours of light activities per day
Strength				At least 3 days a week
Sedentary time	Do not restrain for more than 1 hour at a time	Do not restrain for more than 1 hour at a time	Do not restrain (e.g. in pram) for more than 1 hour at a time	Minimise and break up long periods of sitting
Sedentary recreational screen time	None	Under 2 years: none 2 years: no more than 1 hour per day	No more than 1 hour per day	No more than 2 hours per day
Sleep	0 to 3 months: 14 to 17 hours 4 to 11 months: 12 to 16 hours Includes naps	11 to 14 hours, including naps	10 to 13 hours; some still need naps	5 to 13 years: 9 to 11 hours 14 to 17 years: 8 to 10 hours

Source: Australian Government, Department of Health and Aged Care, 'Physical activity and exercise guidelines for all Australians', https://www.health.gov.au/topics/physical-activity-and-exercise/physical-activity-and-exercise-guidelines-for-all-australians#physical-activity-guidelines-by-age

TABLE 10.2 Summary by age – adults

Recommendations	18 to 64 years	Pregnancy	65 years and over
Physical activity	Be active on most (preferably all) days, to weekly total of: 2.5 to 5 hours (150–300 min) of moderate activity or 1.25 to 2.5 hours (75–150 min) of vigorous activity or an equivalent combination of both	Be active on most (preferably all) days, to weekly total of: 2.5 to 5 hours (150–300 min) of moderate activity or 1.25 to 2.5 hours of (75–150 min) vigorous activity or an equivalent combination of both Do pelvic floor exercises	At least 30 minutes of moderate activity on most (preferably all) days
Strength	At least 2 days a week	At least 2 days a week	Do a range of activities that incorporate fitness, strength, balance and flexibility
Sedentary time	Minimise and break up long periods of sitting	Minimise and break up long periods of sitting	

Source: Australian Government, Department of Health and Aged Care, 'Physical activity and exercise guidelines for all Australians', https://www.health.gov.au/topics/physical-activity-and-exercise/physical-activity-and-exercise-guidelines-for-all-australians#physical-activity-guidelines-by-age

LEARNING HACK

From time to time the language and terms used in relation to the physical activity guidelines will vary. Sometimes the term 'exercise' is included (e.g. physical activity and exercise guideline for all Australians) and in some materials they are simply referred to as the physical activity guidelines. You will notice the guidelines for younger people under 18 years are more prescriptive, especially in relation to sedentary behaviour and sleep.

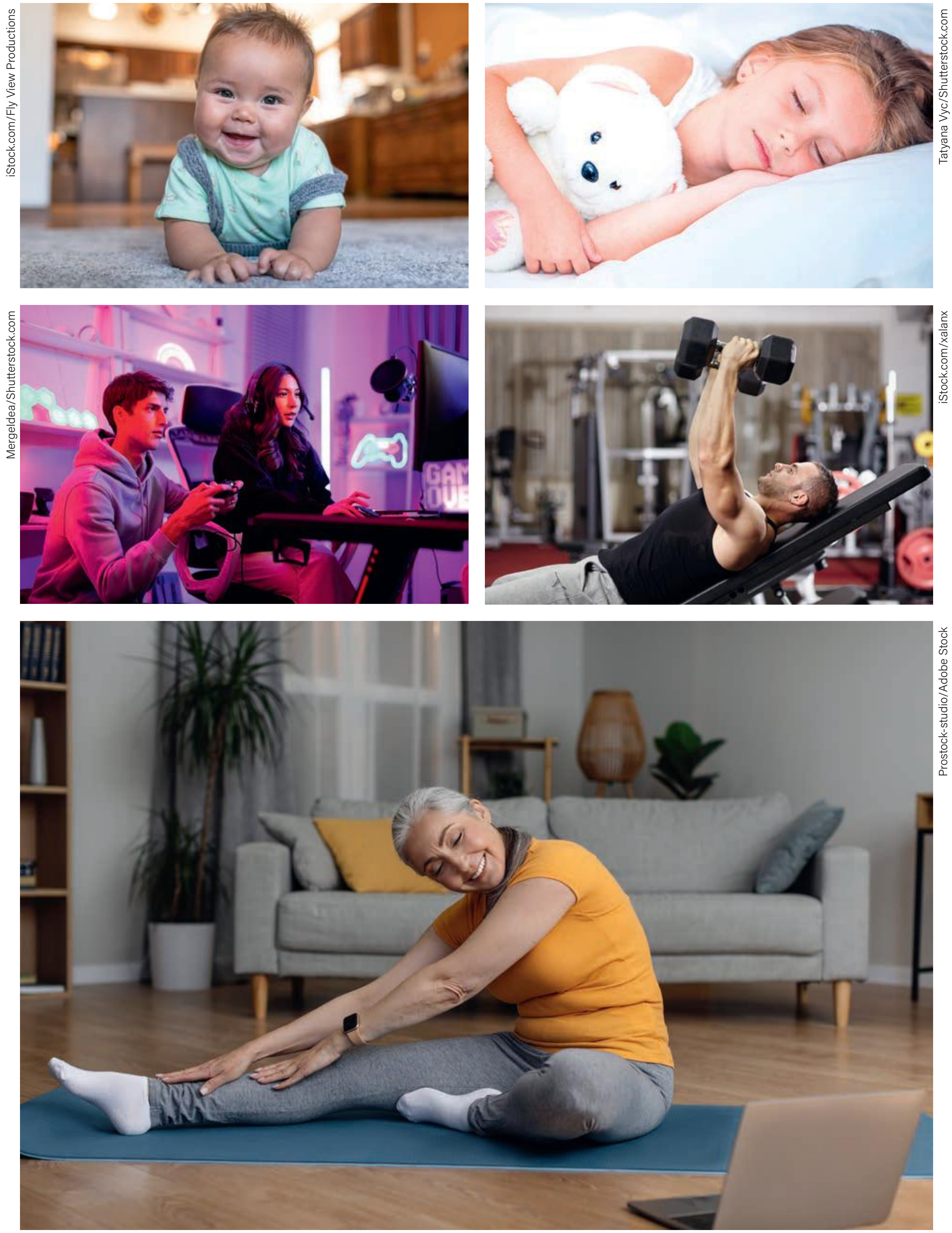


FIGURE 10.02 Guidelines for physical activity, sedentary behaviour and sleep vary by age group.

REAL WORLD APPLICATIONS

Australian teenagers not getting enough sleep

AUSTRALIAN TEENS NOT GETTING ENOUGH SLEEP

TUESDAY, 3 DECEMBER 2019

A study of the sleep patterns of Australian children and adolescents has found that around a quarter of 12–15 year-olds and half of 16–17 year-olds are not getting enough sleep on school nights to meet national sleep guidelines. The findings from the Growing Up In Australia Longitudinal Study of Australian Children show that large numbers of Australian adolescents slept less than the recommended minimum for healthy growth, learning and development.

Australian Institute of Family Studies Director, Anne Hollonds said the study found links between shorter sleep times and higher rates of anxiety and depression. 'The group most at risk of not getting enough sleep on school nights is older adolescents who may need to be taught how to improve their sleep, by reducing caffeine intake, limiting internet use before bedtime, keeping a consistent sleep routine and getting plenty of physical activity,' she said. 'Younger age children, especially boys, are also at risk of not getting enough sleep on non-school nights, highlighting the importance of parents setting regular bedtimes, even on weekends and holidays for younger children.'

Institute Research Fellow, Dr Tracy Evans-Whipp said sleep guidelines from the Australian Department of Health recommend that children aged 5–13 years have between 9 and 11 hours of sleep and adolescents aged 14–17 years between 8 and 10 hours of sleep. 'The good news is that most children aged between 6 and 11 years are generally getting enough sleep on school nights, highlighting the importance of enforced regular bedtimes,' she said. 'However, around a quarter of 12–15 year-olds and half of 16–17 year-olds don't get enough sleep on school nights and commonly try to catch up by sleeping longer on weekends. This "yoyo" pattern across the week increases with age. It also leads to disrupted sleep wake cycles and goes against the sleep guidelines which advise regular sleep and wake up times.'

Mental health

Dr Evans-Whipp said the study confirmed that insufficient sleep was linked to poorer mental health. 'Across all age groups from 12–17 years, adolescents not meeting minimum sleep guidelines were more likely to show symptoms of anxiety and depression and were less likely to report being happy,' she said. 'Of adolescents aged 16–17 years with symptoms of anxiety or depression, close to 60 per cent did not meet the minimum sleep guidelines. This is considerably more than for those without these symptoms. Much greater proportions of adolescents across all age groups who rated themselves as "not happy" compared to "happy" did not meet the minimum sleep guidelines.'

Physical health

Dr Evans-Whipp said that sleep, physical health and caffeine intake were also keenly related. 'The study found that obese 12–13 year-olds were more likely than those in the normal weight range to not meet minimum sleep guidelines. However, this difference was not apparent in the older age groups,' she said. 'Children aged between 12–13 years and 14–15 years, who participated in sport, were more likely to be getting enough sleep, suggesting that physical activity is associated with longer sleep times. More 14–15 year-olds who consumed caffeine failed to meet the minimum sleep guidelines on a school night, suggesting caffeine impacted on sleep duration. However, at 16–17 years this difference was no longer evident.'

>

Internet access

More than 28 per cent of 12–13 year-olds and 27 per cent of 14–15 year-olds with internet access in their bedrooms did not meet sleep guidelines. 'Almost 1 in 5 16–17 year olds spent 8 or more hours per day on the internet, while two-thirds spent between 2 and 8 hours per day and overall this age group was not getting enough sleep,' Dr Evans-Whipp said. 'It's not clear whether internet use contributes to reduced sleep or whether adolescents who have difficulty sleeping use the internet to deal with that or have more time to spend online because they are sleeping less.'

Homework time

At all ages, adolescents spending more than 5 hours on homework per week were more likely to not meet minimum sleep guidelines, than those doing 1 to 3 hours a week. 'Homework may displace sleep time, especially when adolescents have busy after school schedules. Nearly all homework activities are completed on a PC, laptop or mobile device and exposure to blue light from screens in the evening may impact sleep duration,' Dr Evans-Whipp said.

Adult recommended sleep guidelines

As people age, they tend to need less sleep to support their health. There are no formal guidelines on sleep for adults in Australia's Physical Activity and Sedentary Behaviour Guidelines. International guidelines recommend for adults:

- 7–9 hours for 18–64 year olds;
- 7–8 hours for people aged 65 and over.

FIGURE 10.03 Getting enough sleep is part of a healthy lifestyle.

Source: 'Austrailan teens not getting enough sleep', Media release, Australian Institute of Family Studies (AIFS) on behalf of the Commonwealth of Australia, CC BY 4.0, https://creativecommons.org/licenses/by/4.0/

Weblink
Sleep problems as a risk factor for chronic conditions

SIGNPOST

The Australian Institute of Health and Welfare has released a study on 'Sleep problems as a risk factor for chronic conditions,' which includes research, statistics and guidelines. Visit their website to read the article.

ABOVE AND BEYOND THE STUDY DESIGN

Sedentary behaviour, p. 358

Assessment
10.1 Check-in questions

10.1 CHECK-IN QUESTIONS

1 **Identify** how much physical activity, sedentary time and sleep is recommended for you.
2 **State** how much screen time is recommended for children under 12 months.
3 **Discuss** why pelvic floor exercises are important during pregnancy.
4 **Describe** the physical activity guidelines for children aged three years.
5 **Compare** and contrast the guidelines for 18–64-year-olds and those for adults aged over 65 years.
6 Based on your typical bedtime and morning wake-up time, **discuss** whether you meet the sleep guidelines for your age group.

Command term

identify
Recognise and name and/or select an event, feature, ingredient, element, speaker and/or part from a list or extended narrative or argument, or within a diagram, structure, artwork or experiment

10.2 MEASURING PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOUR AMONG INDIVIDUALS AND POPULATIONS

In this module you will learn about:

- subjective and objective methods of assessing physical activity and sedentary behaviour such as recall surveys or diaries, pedometry, observation tools, digital tools and wearable technology

and learn to:

- justify and use appropriate methods to measure and analyse physical activity and sedentary behaviour at the individual and population level.

Measuring physical activity is more complex than measuring someone's height, weight or a specific fitness component. While cardiovascular fitness is an indicator of someone's physical activity level, it is not a direct measure of physical activity behaviour. This section will explore the measurement of different dimensions of physical activity and sedentary behaviour (type, frequency, intensity and duration) and the use of several subjective and objective measures at the individual and population levels.

Table 10.3 outlines the main purposes of measuring physical activity at an individual and population level (Sallis & Owen, 1999). One of the most important aims of measuring physical activity is to determine whether an individual, group or population is meeting the physical activity and sedentary behaviour guidelines.

TABLE 10.3 Main purposes of measuring physical activity

At the population level  New Africa/Adobe Stock	• To document the frequency and distribution of physical activity in defined population groups • To monitor the achievement of physical activity guidelines and population trends over time • To study the relationship between physical activity and health conditions (for example, cardiovascular risk factors, type 2 diabetes, obesity, cancer and mental health) • To determine the amount or dose of physical activity required to influence specific health parameters • To identify the biological, psychological and environmental factors that influence physical activity • To evaluate the effectiveness of large-scale physical activity intervention programs
At the individual level  oatawa/Shutterstock.com	• To detect change in an individual's health and/or behaviour • To determine the effect of any change in physical activity behaviour

monitoring and surveillance
Monitoring means to measure physical activity, and surveillance of physical activity is a core public health function that is necessary for monitoring population engagement in physical activity, including participation in physical activity initiatives

Choosing measurement instruments

The choice of assessment method depends on the purpose of the measurement. The tools used during **monitoring and surveillance** may be very different from those selected to conduct an evaluation. Figure 10.04 shows how the measurement used varies according to purpose, number of participants and cost (Dollman et al., 2009). The flow chart shows that when the measurement involves a large number of people, low-cost subjective measures are generally used. When more precision is required (in clinical settings with individuals or small numbers of people), objective measures are more likely to be used.

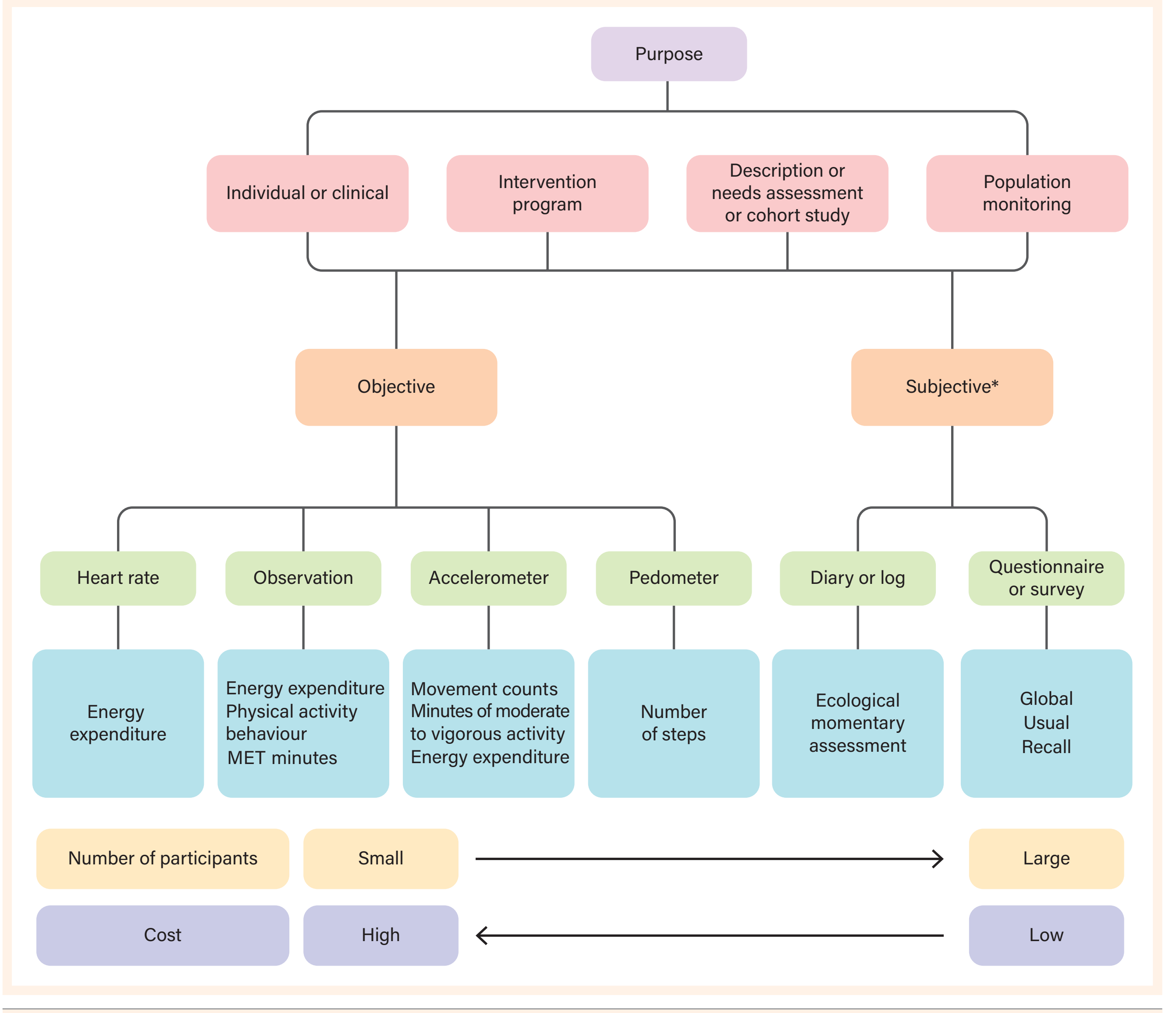


FIGURE 10.04 Type of assessment of physical activity is associated with the purpose of that assessment.

* Parent, teacher, self-reports (>10 years)

Source: Adapted from Dollman, J., Okely, A. D., Hardy, L., Timperio, A., Salmon, J., & Hills, A. P. (2009). A hitchhiker's guide to assessing young people's physical activity: Deciding what method to use. *Journal of Science and Medicine in Sport*, 12(5), pp. 518–525. https://doi.org/10.1016/j.jsams.2008.09.007

Collecting data about physical activity and sedentary behaviour at a population level (that is, community, state or national) requires surveillance.

> Surveillance of population levels of physical activity using a standardized protocol is an important and necessary part of a public health response to current concerns regarding lack of physical activity in many populations. Surveillance of physical activity in populations is most often undertaken using questionnaires, as these are relatively inexpensive and easy to administer compared to objective measurement techniques . . .
>
> (WHO, 2016).

Many developed nations have systems in place for monitoring physical activity and sedentary behaviour, along with many other health behaviours.

Evaluation of physical activity is generally more specific and directly linked to a particular intervention, such as a physical activity program. For example, if the goal of the intervention is to increase the physical activity level of Year 9 girls in your school, several levels of assessment may be planned within the project's evaluation framework.

Physical activity can be measured directly (for example, the number of times per week a person walks or cycles to work) or indirectly (for example, the number of people per week using a walking and/or cycling path).

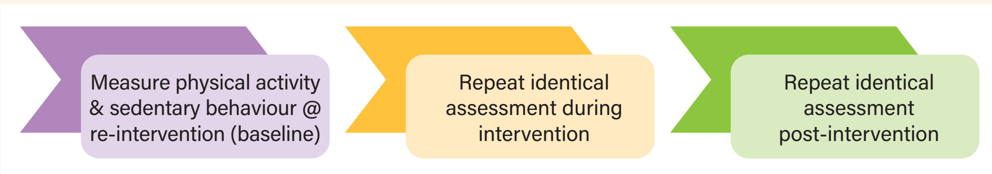


FIGURE 10.05 Just like we would measure fitness at regular intervals, we assess physical activity to track progress over time.

To determine whether the behavioural change is sustained over time, follow-up assessments at six and 12 months post **intervention** are needed. A physical activity intervention means making a change that might include a single strategy or a range of strategies as part of a more comprehensive physical activity program or initiative. Generally, a minimum period of 12 weeks is necessary to achieve detectable behavioural change.

intervention
Making a change that might include a single strategy or a range of strategies as part of a more comprehensive physical activity program or initiative

LOOKING FORWARD
Measures of fitness components
Unit 4

You will learn more about direct and indirect measures of fitness components in Unit 4.

The only way to determine whether a physical activity program increases a person's physical activity behaviour is to measure physical activity at key periods at regular intervals.

iStock.com/IPGGutenburgUKLtd

FIGURE 10.06 Active transport is a key source of physical activity. What are some other means of active transport?

Physical activity monitoring in context

Physical activity behaviour is rarely measured in isolation. Sometimes the purpose of measurement is to identify biological, psychosocial and environmental factors that influence physical activity behaviour. Therefore, in addition to measuring physical activity and sedentary behaviour, questions relating to **correlates** are examined.

Measuring the dimensions of physical activity and sedentary behaviour

Various instruments can measure either one dimension of physical activity and sedentary behaviour or a combination of dimensions. Before looking at specific physical activity measures, it is important to understand the dimensions of physical activity and how they are measured.

TABLE 10.4 Dimensions of physical activity

Frequency	Intensity	Type	Time (duration)
 iStock.com/AndreyPopov	 Sebastian de Lanz/ Shutterstock.com	 Philip Bird LRPS CPAGB/ Shutterstock.com	 leungchopan/Adobe Stock

correlate
A mutual or complementary relationship between two or more factors, such as a cause and an effect, or a test result and an estimated rating

context
The circumstances that form the setting for an event, statement or idea

metabolic equivalent (MET)
Stands for metabolic equivalent. 1 MET is the amount of energy you expend at rest, and 2 METs is twice the energy expenditure of resting levels

leisure-time physical activity
Activity over and above that which occurs within the workplace or at school

Assessing the type and context of physical activity and sedentary behaviour

There are hundreds of different types of physical activities that people can engage in.

The main source of physical activity for most people are lifestyle activities such as household/gardening tasks, walking, golf, swimming, household chores, bike riding, kayaking or tennis. As well as the type of physical activity or sedentary behaviour, the specific **context** must also be assessed. Physical activity might occur at school, at work, or at home during leisure/recreational time.

Many physical activity measures ask respondents about the various types of activity they participate in. This may be for one or more of the following reasons:

- to determine the energy expenditure associated with that particular physical activity by assigning a **metabolic equivalent (MET)** via the compendium of physical activities (Herrman et al., 2024)
- to assess what proportion of physical activity is accumulated within the various domains, such as household and gardening, active transport, occupation/work or (for youth) school and **leisure-time physical activity**

- to determine the most common activities performed by particular population subgroups, or within a specific context or setting. For example, children in Year 1 participate in very different types of physical activities and sedentary behaviours to those in Year 9. Direct observation measures could be used to determine the most common activities for each year level.

LOOKING BACK

Lifestyle physical activities

Chapter 7

The characteristics of lifestyle physical activities are described in detail in Chapter 7.

The Children's Leisure Activities Study Survey (CLASS)

The CLASS survey is a self-report for children aged over 10 years and a proxy-report questionnaire completed by parents for children aged 10 years and under (Telford et al., 2004) that has been widely used throughout the world. It assesses all dimensions of physical activity (including type, frequency, intensity and duration) performed during a typical week of a school term.

Children's Leisure Activities Study Survey (CLASS)
Children's questionnaire

Important
We are interested in what you do in your leisure time during a typical week.
There are no right and wrong answers – **this is not a test**.
Please answer all the questions as honestly and accurately as you can – **this is very important.**

Which of the following PHYSICAL activities do you USUALLY do during a typical WEEK (from the start of the current school term, do NOT include school holidays)?

During a typical WEEK, what activities do you usually do?	Do you usually do this activity?		MONDAY–FRIDAY		SATURDAY & SUNDAY	
			How many times Monday–Friday?	Total hours/minutes Monday–Friday	How many times Saturday & Sunday?	Total hours/minutes Saturday & Sunday
e.g. Bike riding	*No*	*Yes*	*2*	*40 minutes*	*1*	*15 minutes*
Aerobics	No	Yes				
Dance	No	Yes				
Calisthenics/gymnastics	No	Yes				
Tennis/bat tennis	No	Yes				
Aussie rules football	No	Yes				
Soccer	No	Yes				

Adapted from: Telford et al., 2004

FIGURE 10.07 The CLASS instrument comes in both a self-report and proxy-report format.

DID YOU KNOW?

CLASS was developed in Melbourne in 2000 by Professor Amanda Telford (the lead author of this textbook), Professor Jo Salmon and Professor David Crawford. It has since been used to assess young people's physical activity and sedentary behaviour throughout Australia and in more than 40 countries throughout the world. The UK surveillance survey for youth is based upon this survey.

Measuring intensity of physical activity

Table 7.3 (page 242) summarises four commonly used classifications of physical activity intensity: sedentary, low, moderate and vigorous. Not all measures, however, can assess physical activity intensity (see Table 10.5).

Ground Picture/Shutterstock.com

FIGURE 10.08 Bike riding is a great way to encourage children to meet the physical activity guidelines.

Measuring metabolic equivalent levels

The data collected by many physical activity instruments (for example, self-reported recalls, diaries or logs, proxy-reported recalls, physical activity measures, direct observation) requires the classification of MET scores.

The MET value assigned to a particular activity is based upon the amount of oxygen consumed. At rest, an average male consumes 250 millilitres of oxygen per minute (mL/min), and an average female consumes about 200 mL/min. One MET is the equivalent of 3.5 millilitres of oxygen per kilogram of body weight per minute (mL/kg/min). Because the amount of oxygen a person is consuming cannot be easily measured, a MET equivalent can be assigned as an estimate of the intensity of the activity. The Compendium of Physical Activities (Herrmann et al., 2024) gives typical MET values for a wide range of activities. However, it is important to understand that the number of METs expended at each intensity level depends on an individual's age and gender.

LOOKING BACK
Metabolic rate

Chapter 7

As introduced in Chapter 7, a MET score for a particular activity is a comparison between an average person's metabolic rate while at rest and their metabolic rate while engaging in the activity. At rest, one MET is expended. A MET value of 4 indicates an intensity four times that of resting levels.

Measuring frequency of physical activity and sedentary behaviour

Frequency refers to the number of physical activity **bouts** during a specific period of time (for example, per day or per week). The physical activity guidelines recommend adults accumulate between 150 and 300 minutes of moderate-intensity physical activity, or 75–150 minutes of vigorous-intensity physical activity, or a combination of both moderate and vigorous activities, each week. The guidelines encourage adults to be active on 'most, preferably all, days every week' (Australian Department of Health, 2021). Here, 'most days' is interpreted as meaning at least five days per week. An individual could accumulate this in different ways: for example, over three 10-minute bouts per day (3 × 10 min/day × 5 days).

bout
A period of time, usually the duration of an intense exercise session or activity; for example, a distance runner may sprint for a 5-minute bout at a high intensity

DID YOU KNOW?

'Weekend warriors' are people who do several hours of physical activity on weekends, but no other activity throughout the week. Although they exceed the recommended weekly minimum time (150 to 300 minutes), they do not meet the required frequency.

Measuring duration (time) of physical activity and sedentary behaviour

The duration of physical activity and sedentary behaviour simply refers to how long a person is engaged in a particular activity. The duration recommended for different population subgroups varies. If an adult was moderately active for 30 minutes per day they would burn approximately 600 kilojoules per day, or about 4000 kilojoules per week. (This is equivalent to about 150 kilocalories per day or 1000 per week.) For other levels of intensity, the time taken to burn this minimum of 600 kJ/day would vary. For example, it would take only 22 minutes at a vigorous intensity. Additionally, the number of kilojoules you would burn during 30 minutes, for example, varies by weight.

LOOKING FORWARD

Seeking the advice of a doctor

Chapter 13

People who are not regularly active should always check with their doctor before beginning an exercise routine. We will explore the importance of this in detail in Chapter 13.

ABOVE AND BEYOND THE STUDY DESIGN

Measurement of sedentary behaviour, p. 358

Video
In focus: Wearable technologies to assess physical activity and sedentary behaviour

Methods used to monitor physical activity at the individual and population level

This section describes some of the most commonly used subjective and objective measures of physical activity and sedentary behaviour. These measures can be used at both the individual and population levels. Table 10.5 shows a variety of physical activity instruments, and Figure 10.09 highlights the trade-off that exists between practicality (also known as feasibility) and accuracy (or **validity**). Measures offering a high level of precision (such as direct observation and logs or diaries) may not be practical for assessing large numbers of people. In these cases, it may be necessary to adopt measures with a lower level of precision. All these measures can utilise digital tools, and can also be incorporated into wearable technologies; however, objective measures

validity
The degree to which a test or instrument measures what it purports to measure; for example, self-reporting of time engaged in vigorous-intensity activity can be validated against the time recorded by a heart rate monitor or accelerometer

such as pedometry and accelerometer functions are more commonly embedded into wearable technologies than into things like diaries, for example.

TABLE 10.5 Instruments used to measure physical activity

Instrument	Measure	Is instrument suitable for assessing:						Expense	Reactivity
		Frequency?	Intensity?	Duration?	Type?	Context?	Energy expenditure?		
Recall survey[1]	Subjective	Yes	Yes	Yes	Yes	Yes	Yes[3]	Low	n/a
Diaries[1]	Subjective	Yes	Yes	Yes	Yes	Yes	Yes[3]	Low	High
Pedometer	Objective	No	No	No	No	No	Yes[2]	Low	Low
Accelerometer	Objective	Yes[2]	Yes[2]	Yes[2]	No	No	Yes[2]	High	Low
Direct observation	Objective	Yes	Yes	Yes	Yes	Yes	Yes[3]	Moderate	High

[1] Can be administered by self-report or proxy report;
[2] Only with certain versions of this type of instrument; [3] If MET values can be assigned to activities

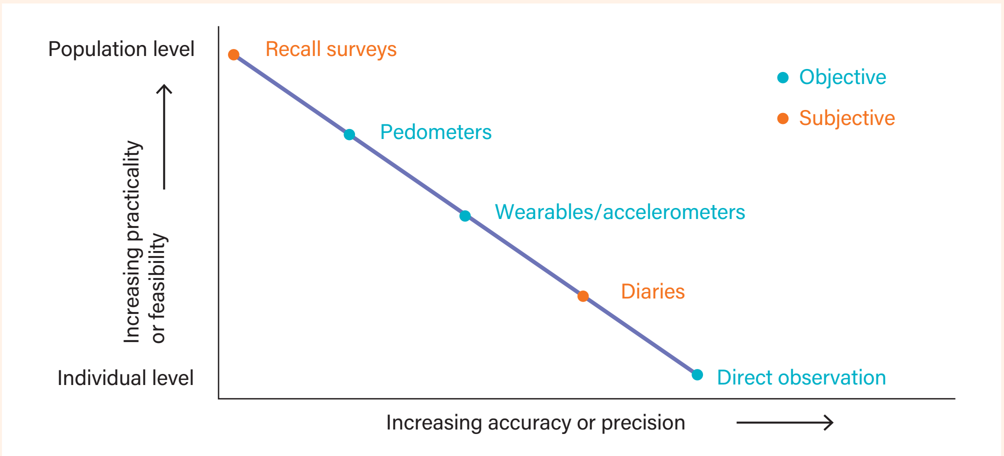


FIGURE 10.09 The trade-off between practicality and accuracy

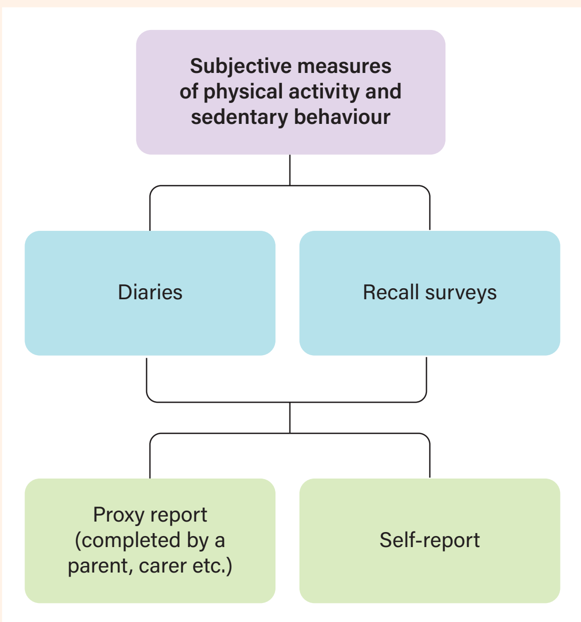


FIGURE 10.10 Subjective measures

Subjective measures of physical activity

Some assessments of physical activity rely on a person remembering which activities they participated in, or their perception of the intensity of an activity session. Recall can also be influenced by the opinion and perception of the participant, proxy reporter or researcher. Other measures require people to record what activities they participated in during the day or week, entering this data into a diary. Such assessments are known as subjective measures, and they can be completed either via self-report or proxy-report. It is important to note that recalls and diaries can be completed using digital tools via apps on smart phones or tablets or using wearables that are connected to the internet.

Self-report and proxy-report measures

Self-report measures are the most commonly used subjective measures of physical activity. They include self-administered and interviewer-administered recalls through the use of interviews, questionnaires, diaries or logs. Self-report surveys are completed by the subjects themselves. They always involve some bias, with people often reporting what they think is socially acceptable rather than their actual behaviour. This is known as **social desirability bias**.

social desirability bias
Occurs when people provide describe what they believe is the desired response rather than their actual behaviour

Proxy-report measures involve an individual reporting on behalf of someone else. Typically, proxy reports are completed for someone who is unable to self-report in a reliable or accurate (valid) manner. Proxy reports may be completed for a child by a parent, guardian or teacher. A carer might complete a proxy report on behalf of an elderly person or a person with a disability.

Young children are less able to recall their behaviour than an adolescent or adult because their activity pattern is more variable and harder to remember. Children under the age of 10 years display a huge variation in cognitive and linguistic ability, and they may not understand the questions being asked of them. Proxy-report methods can be limited by adults being unable to recall children's physical activity. For example, a teacher or childcare worker is unable to constantly monitor every one of the children in their care in terms of their physical activity behaviour, intensity of movement or who they are playing with.

Recall instruments

Recall instruments require respondents to remember which physical activity they engaged in during the previous day, week, month or year. Recalling behaviour is a complex task: children under the age of 10 years and some elderly people, in particular, are likely to have limited capacity to recall specific details due to cognitive and/or memory limitations.

Recall instruments:

- vary in the way they are administered (self, telephone, online or interviewer)
- can be used to assess physical activity across multiple domains (leisure, household, transport and occupation)
- have numerous limitations that reduce their accuracy, including social desirability bias, cognitive or memory limitations
- can be administered via an interviewer-administered format online, via the phone or in person, either in written form or via interview
- include the Active Australia Survey, International Physical Activity Questionnaire (IPAQ) and the Global Physical Activity Questionnaire (GPAQ).

TABLE 10.6 Key characteristics of subjective measures for measuring physical activity

Characteristic	Self-report recall/usual	Proxy-report (parent/guardian/teacher/carer)	Diaries
Population (age)	10–18 years 18+ years	3–9 years 10+ intellectual disability	10–18 years 18+ years
Sample size	Small to large		
Dimensions assessed	Type, frequency, intensity, duration (varies from measure to measure)		
Method/delivery mode	Questionnaire (pen and paper format and electronic formats, e.g. online survey) or interview (telephone, face to face)		Pen and paper and electronic formats/online/apps Periodic recording of activities in range of 1 minute to several hours

>

Characteristic	Self-report recall/usual	Proxy-report (parent/ guardian/teacher/carer)	Diaries
Assessment time frame	Typically, one-off assessment covering a ‘usual’ week, previous week or previous 1–3 days		Typical 7 days to capture habitual physical activity
Data output	Type (behaviour) – organised vs non-organised Frequency (times per week) Intensity (estimated METs based on adult compendium) Duration (minutes)		
Assessment of physical activity guidelines	Usually can, but will vary from instrument to instrument		
Associated with reactivity	No	No	Yes (high)
Technical error	Large	Large	Moderate
Cost	Low	Low	Low
Sources of error and limitations on dimension of physical activity captured	• Poor respondent memory and/or motivation • Susceptibility to socially desirable responses • Underestimation of incidental activities • Low sensitivity to change • Individual variation in intensity within the same activities	Caregiver is not necessarily within a couple of metres the whole day and may not know exactly what the child is engaged in; for example, a parent will not be able to accurately report on the child’s activity during school hours.	Potential for participant reactivity
Additional considerations	• Computer availability for electronic administration varies among schools. • Literacy levels among respondents can vary widely. • Lists of physical activity cues need to be culturally appropriate.		
Tips to improve compliance and/or data quality	In class – circulate to keep students on task.	Check responses with respondent.	Send reminders to complete diary entries, e.g. via text or email.

Source: Adapted from Dollman, J., Okely, A. D., Hardy, L., Timperio, A., Salmon, J., & Hills, A. P. (2009). A hitchhiker’s guide to assessing young people’s physical activity: Deciding what method to use. *Journal of Science and Medicine in Sport*, 12(5), pp. 518–525. https://doi.org/10.1016/j.jsams.2008.09.007

Weblink
Global Physical Activity Questionnaire

COLLABORATIVE TASK

Activity

Global Physical Activity Questionnaire (GPAQ)

The Global Physical Activity Questionnaire is a recall instrument designed to assess physical activity patterns. It was developed by the WHO for physical activity surveillance in all countries, especially developing countries. The GPAQ collects data about physical activity participation in three domains or settings: physical activity at work, recreational activity and travel to and from places. The 16-item GPAQ questionnaire also assesses sedentary behaviour. The GPAQ is usually administered by an interviewer, either face to face or over the telephone.

Visit the WHO's website and search for 'Global Physical Activity Questionnaire' to see a question-by-question guide for interviewers administering the GPAQ. Administer the questionnaire to an adult and determine whether they met the physical activity guidelines for a given week.

You can download a template of the questionnaire from the WHO's website.

Peerakit Jirachetthakun POPCITY/ Shutterstock.com

jiraphoto/Shutterstock.com

FIGURE 10.11 GPAQ can be used to assess physical activity in developing countries.

CASE STUDY INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

The International Physical Activity Questionnaire (IPAQ) has been used extensively in population-based and global surveillance of physical activity. It was developed so a uniform and systematic approach could be used to enable comparisons within and between countries and to guide policy development relating to health-enhancing physical activity across various life domains. Extensive testing has shown that the IPAQ is a reliable and valid physical activity instrument suitable for use in a variety of settings and in different languages, to measure physical activity prevalence at a population level nationally.

There are short and long versions of the IPAQ available online. The long version asks about each of the five activity domains separately, whereas the short version consists of four generic items. In non-English speaking countries, translated versions of the instrument are used. Both the short and long version of the IPAQ are designed for use with young and middle-aged adults (15–69 years). The short version of the IPAQ is commonly used because it is much quicker for respondents to complete. Data from the short version cannot be compared with data from the long version because they measure different things. The short IPAQ has been shown to be as valid and reliable as the long version, and is much quicker to use.

The most common limitation associated with the IPAQ is over-reporting. It has been suggested that IPAQ interviewers need to be made aware of the maximum acceptable hours so they can probe and clarify with the respondent when an extreme value is given (Rzewnicki et al., 2003). For example, if someone reports that they do 60 hours of vigorous-intensity physical activity per week, the interviewer might clarify whether they meant 60 minutes instead.

>

Weblink
IPAQ

Visit the IPAQ website for more information and to access this instrument, then interview someone (aged over 18 years) to determine whether they met the physical activity guidelines for a given week.

QUESTIONS

1 **Outline** the domains measured by the long version of the IPAQ.
2 **Describe** why you can't compare the data from the short version of the IPAQ with data from the long version.
3 **Define** and **state** differences between the terms 'reliability' and 'validity.'
4 **Explain** why the IPAQ was developed.

Diaries

Diaries provide rich and detailed information about several dimensions of physical activity (type, frequency, intensity and duration) and require participants to document their physical activity level at the same time each day. Diaries are used to capture all sources of physical activity within a specified time frame (for example, every 30 minutes).

Activity diaries are limited by the participants' ability to follow instructions and remember to document their activities. Perhaps the largest problem and/or opportunity associated with the use of diaries or logs is **reactivity**: many people change their behaviour because it is being monitored.

reactivity
When individuals alter their behaviour because they are aware they are being observed

LOOKING FORWARD

Behavioural change strategies

Chapter 11

Research shows that writing down health behaviours is a very powerful behavioural change strategy. Chapter 11 will discuss physical activity promotion strategies.

REAL WORLD APPLICATIONS

Multi-activity recall for children and adolescents (MARCA)

One of the largest national surveys of young Australians' physical activity, known as the National Children's Nutrition and Physical Activity survey, assessed the physical activity and sedentary behaviour of more than 4000 children and adolescents. The survey used a time diary recall instrument known as multi-activity recall for children and adolescents (MARCA). MARCA is used to assess physical activity and sedentary behaviour (Ridley, Olds & Hill, 2006).

Weblink
Multi-activity recall for children and adolescents

Advantages of using subjective measures

- Can capture both quantitative and qualitative information
- Can be administered quickly and easily
- Cost-effective for large-scale studies
- Usually low burden on participants
- Have the potential to predict energy expenditure from daily physical activities when compared to the Compendium of Physical Activities (see Table 7.5 on page 243)

Disadvantages of using subjective measures

- Not suitable for assessing children under the age of 10 or very old adults, or people with an intellectual disability due to **cognitive** limitations, as they may not understand what questions are asking
- Reliability and validity problems associated with over-reporting due to social desirability bias, memory limitations or misinterpretation of physical activities in different populations
- Interviewer may be needed to obtain accurate data

cognitive
Involving attitudes, thinking and awareness

Summary of subjective measures

Table 10.7 provides a summary of the dimensions and domains each subjective measure can assess, along with information about their capacity to assess physical activity in relation to physical activity, exercise and sedentary behaviour guidelines.

TABLE 10.7 Assessment of physical activity dimensions, guidelines and domains using subjective measures

Measure		GPAQ	IPAQ[1]	AAS	MARCA[1]	CLASS[1]
Dimensions	Type[2]	×	×	×	✓	✓
	Frequency	✓	✓	✓	✓	✓
	Duration	✓	✓	✓	✓	✓
	Intensity	✓	✓	✓	✓	✓
METs energy expenditure		✓	✓	✓	✓	✓
Physical activity guidelines for children/youth	Physical activity	n/a	n/a	n/a	✓	✓
	Sedentary behaviour	n/a	n/a	n/a	✓	✓
Physical activity guidelines for adults		✓	✓	✓	n/a	n/a
Sedentary behaviour		✓	✓	✓	n/a	n/a
Contextual data		n/a	n/a	n/a	✓	✓
Total physical activity		✓	✓	✓	✓	✓
Domains	Leisure time	✓	×	✓	✓	×
	Occupation/school	✓	×	×	✓	×
	Household/gardening	✓	×	✓	✓	×
	Active transport	✓	×	×	✓	×

[1] IPAQ, MARCA and CLASS can measure physical activity across various domains but IPAQ and CLASS cannot measure specific dimensions within each domain.
[2] Type means specific behaviours, such as tennis, weight-training or swimming.
n/a = not applicable; AAS = Active Australia Survey

Objective measures of physical activity

Objective measures generally include the use of digital tools and wearable technologies. Physical activity assessments using either direct observation or a device such as a pedometer or accelerometer are examples of objective measures. Objective measures remove the disadvantages associated with subjective measures.

Digital tools

Although subjective methods such as diaries or questionnaires are inexpensive, they rely on individual recall and subjective judgements and interpretation, making assessment results inconsistent.

Prior to the past decade there were very few devices available to the general public that were considered an accessible and accurate way of assessing physical activity. But technology has moved quickly, and today multifunction devices are becoming the norm. Digital tools can include smart devices, apps, pedometers and wearables. Mechanical pedometers or 'step counters' are the simplest wearable sensors to measure physical activity, and are standard in all personal activity trackers. We will talk more about these later in the chapter.

Multifunction personal activity trackers, which include accelerometry-based wearable motion detectors, can be used for physical activity monitoring and assessment, including posture, movement classification (for example, sitting versus standing, walking and cycling), estimation of energy expenditure, fall detection and balance control evaluation. Energy estimation and metabolic rates estimated from accelerometers are determined by skin temperature and conductivity. Accelerometers can be stand-alone for measuring physical activity, but are commonly integrated within wearables such as smart watches, smart devices and clothing. This is where we will start our study of objective measurement of physical activity and sedentary behaviour.


agencies/Shutterstock.com

FIGURE 10.12 Wearable technology has exploded and is advancing at a rapid pace.

Types of wearable technologies

'Wearable technologies are devices with sensors, screen, processor, memory and software with algorithms to filter, interpret, organize and store raw data that is collected which can connect with the internet and present data to the user in real time or retrospectively' (Sousa, Ferrinho & Travassos, 2023, p. 2). Wearable devices typically sync to smart devices and/or upload to computers for wireless connectivity. They can be used as a motivational tool, and integrate with apps that can be used to record and track things like physical activity, ECG and temperature. They can be used to monitor physical activity on a daily basis or to evaluate an activity program. Wearable technologies can be worn on the wrist, leg or chest, as patches, strips or even within clothing. They can be textile-based, and have been used for medical sciences, fashion and sports.

In 2024 there were five main types of wearables: pedometers, fitness trackers, GPS watches, smart watches and standalone heart rate monitors. It won't be long before a wearable device will incorporate dozens of functions enabling you to track all sorts of data, including a range of metrics to assess your physical activity intensity, type, duration and frequency, as well as sedentary activities. Table 10.8 provides a snapshot of some of the functionality possible in wearables.

The original wearables were pedometers. Now, in addition to counting steps, modern-day wearables, mostly worn as either a wrist band (for example, Fitbit, Mio) or smart watch (for example, Apple Watch, Samsung, Garmin) incorporate accelerometers and altimeters that can calculate distance, GPS, overall physical activity, frequency, time at different intensities, calculation of calorie expenditure, heart rate sensors, time standing, time sitting and, in some models, quality of sleep. Wearables enable automatic, continuous and long-term assessment of physical activity during everyday life (Gregori, 2021).

TABLE 10.8 Wearables are commonly worn on the wrist or chest

Fitness trackers	GPS watches	Smart watches	Standalone heart rate monitors
 Vantage_DS/ Shutterstock.com	 Chinnapong/ Adobe Stock	 mahod84/Adobe Stock	 Jeffrey Blackler/ Alamy Stock Photo
Record steps, heart rate, stress levels, sleep and workouts. These may not offer much in-depth data such as GPS, but they are sleek, lightweight and good for everyday monitoring of wellness.	Will include all the features of a tracker plus GPS functionality, enabling tracking of pace, distance and, in some models, maps, workout suggestions and training feedback. Generally more expensive and bulkier than trackers, but also more accurate and durable.	Similar to trackers but can sync with smart phone/device apps and enable calling, texting and in some models also GPS.	Usually come either as a wrist or arm band or as a chest strap. Although most GPS and fitness wearables incorporate heart rate monitoring, chest straps generally provide the most accurate reading. People using interval workouts or effort-based run training often select these or combine them with a smart watch or other option.

LOOKING FORWARD
Wearable technologies

Units 3&4 – Chapter 11

You will learn more about wearable technologies in Chapter 11 in *Nelson Physical Education VCE Units 3&4*.

TABLE 10.9 Examples of functionality of wearable devices

Physical activity and fitness	Health	Sedentary time, stress and sleep	Smart tech
Heart rate tracking, heart rate on gym equipment, active zone minutes	ECG app for heart rhythm assessment	Stress management score	Do not disturb and sleep mode
Daily readiness score	High and low heart rate notifications	EDA scan app for stress management	YouTube music controls
40+ exercise modes	SpO_2 (blood oxygen) tracking	Sleep score	Google maps
Walking, jog, run speed, steps	Skin temperature variation	Sleep profile	Google wallet
Activity duration and intensity	Resting heart rate	Sleep tracking and sleep stages	Call, text and app notifications
Built-in GPS	Breathing rate	Smart wake alarm	Colour touchscreen
Cardio fitness score	Irregular heart rhythm notifications	Sleep duration	Find my phone
Smart track exercise recognition	Blood glucose tracking		Always on display mode
Water resistant	Menstrual health tracking	Can nudge you to stand up and move	7-day+ battery life
Workouts on your phone	Health and wellness reminders	Sedentary time	Clock faces and accessories

>

Physical activity and fitness	Health	Sedentary time, stress and sleep	Smart tech
All-day activity tracking	Health status	Sit to stand activities	Compatible with iOS and Android devices
Workout intensity map		Upright time	Memberships (e.g. Fitbit)
Timer and stopwatch			Google fast pair
Pedometer step count, distance			Temperature
Energy expenditure			Sunset, sunrise
Stride length			Fully compatible with apps for tracking, recording, goal setting, social media

Amanda Telford

FIGURE 10.13 Fitness trackers are simple to use, inexpensive and durable, making them an excellent wearable and often waterproof option for children.

Advantages of wearable devices

- Non-invasive (meaning they can be worn comfortably on the body)
- Can estimate energy expenditure
- Can monitor physical activity remotely
- Allow monitoring of physical activity, physiological functions, daily activities and individual behaviours
- Can integrate miniature sensors that can measure heart rate, skin temperature, ECGs and EEGs
- Allow monitoring and processing in real time, 24 hours per day
- Data transmission via wireless networks allows monitoring from external groups such as healthcare professionals, exercise scientists, trainers and researchers
- Can be worn by an individual as an accessory
- Can be integrated with GPS, music and apps to provide motivation and educational information

- Can be worn in any setting or field environment, indoor or outdoor
- Small, lightweight, wireless and easy to transport
- Many are waterproof and some can store data at very low temperatures
- Instant feedback can be motivational
- Allow tracking of personal goals
- Accelerometers are a good alternative to self-reporting of physical activity by children under 10 years, who often cannot accurately recall their behaviour
- Assess dimensions of intensity, frequency and duration
- Can store data for extended periods
- Can assess physical activity that is difficult to capture (such as children's physical activity, incidental or light-intensity physical activity, sedentary time)

Limitations of wearable devices

At the time of writing these were some of the issues limiting the use of smart wearable devices to measure physical activities:

- Far more research is required to determine the validity of the devices for many brands.
- User input is required for accurate tracking.
- Many devices are not user friendly.
- Physical activity indicator can be affected by the activity type.
- High-speed networks are not available everywhere.
- Confidentiality of data is not assured – privacy can be breached.
- The cost of the device and data costs can be high.
- The technology is moving so fast it dates very quickly.
- They are not sensitive to low-impact physical activities, and therefore underestimate movement during cycling and rollerblading, or activities that are mostly upper-body.
- Energy expenditure may be inaccurately estimated when movement is not horizontal (e.g. when climbing uphill or climbing stairs).

Jon Carter/CartoonStock.com

FIGURE 10.14 It's important to understand the limitations of wearable technology.

DID YOU KNOW?

Wearables such as smart watches include an accelerometer function, which measures the rate and magnitude at which the body's centre of mass changes during movement. This is generally measured in gravitational acceleration units (g-forces, where 1 g-force equals 9.8 metres per second squared), or in movement counts per minute or during any given epoch. Some accelerometers can respond to gravity to provide tilt sensing.

lordn/Adobe Stock

FIGURE 10.15 Wearable technologies contain accelerometers that track movement in every direction.

REAL WORLD APPLICATIONS

Interview with Professor Amanda Telford

Amanda Telford

FIGURE 10.16 Amanda Telford is a Professor at ACU.

Professor Amanda Telford has used wearables with thousands of young people during her research on physical activity and sedentary behaviour.

How do physical activity researchers measure all dimensions of physical activity?

Ideally, we could measure everything using the one measure, and while some wearables enable users to capture the frequency, intensity and duration of their physical activity as they include an accelerometer, capturing the type of physical activity they are engaging in can be problematic. There is still much work to be done to determine the validity of commercially available wearable devices. Some wearables have pattern recognition technology, and are getting better at identifying if you are rowing, cycling, walking, jogging, running, on an elliptical or swimming, but if you were playing tennis, baseball or basketball, or weight training, for example, the user would still need to enter this data into an app. So sometimes researchers will get people to wear an accelerometer/wearable device and then also get them to complete an online recall survey or diary or via an app on their smart device to capture the type and context of the physical activity they are engaging in.

What are some of the major advances in wearable technology over the past few years?

The ubiquitous nature and rapid advancement of wearable technology is phenomenal, and the functionality and potential to capture, process and synchronise with recording options either via apps or online means data can be shared live and continuously, and be monitored by the individual but also by healthcare professionals, trainers and exercise physiologists working within performance teams. Out on a run, a smart watch can detect if you have had a fall or a heart attack and will automatically call an ambulance and relay your location.

Where is the future of wearables headed?

It is almost impossible to predict what will be possible in 10 years' time. A decade ago we would have laughed at suggestions of what wearables can do now. It is likely technology will continue to get smaller and smarter, more accessible and continue with an emphasis on gamification. I have been doing some research using Augmented reality (AR) glasses which can connect to apps on your phone enabling you to simulate pretty much any sport, you can interact with the virtual equipment within the physical activity areas but unlike virtual reality (VR) you can still see around you. Commercial companies are investing millions in understanding how to ensure consumers become addicted to using their products. Artificial intelligence, sensors in clothing, jewellery, shoes, accessories and integration with augmented reality are all likely to play a role in physical activity assessment, planning, implementation and monitoring and evaluation of individual physical activity programs and group interventions. Some futurists even predict the use of contact lenses, microchips positioned either internally or in nail polish, and in-built GPS within the buttons of your clothing to monitor everything you do. There is no doubt the ethical, moral and security concerns associated with wearable technology will need to be continually monitored.

QUESTIONS

1 **Discuss** why do researchers use a combination of measures when assessing physical activity?

2 **Describe** what may future wearables look like?

Chinnapong/Adobe Stock

FIGURE 10.17 Wearable technology is part of our daily lives.

Pedometers

Most personal wearable devices contain a pedometer function. For people who cannot afford the modern and expensive wearable technologies, electronic pedometers are an excellent alternative. Standalone pedometers (those not integrated within a wearable with an accelerometer) are low-cost, easy to use and are considered to be the simplest form of motion sensor for physical activity assessment. There are many models available, offering a wide variety of functions. In addition to assessing the total number of steps taken, some models can estimate total distance covered (kilometres), energy expenditure (kilojoules or kilocalories) and total movement time (minutes). Pedometers are usually worn on the wrist or hip and are designed to respond to vertical forces. A step registers in response to the impact of a foot strike. Pedometers will also measure other non-walking activities that involve hip movement, such as going up and down stairs, getting up from a chair or jumping rope.

While there are no step count guidelines for Australians as part of the physical activity guidelines, the US Centers for Disease Control and Prevention (CDC) recommends people try to accumulate 10 000 steps per day, which is the equivalent of approximately 8 kilometres. An estimate of the total distance covered can be obtained by programming the individual's stride length into the pedometer, which multiplies this by the number of steps.

Pedometers are potentially the most cost-effective means of bridging the gap between science and practice. They can be worn within a wide range of settings, and have enormous potential for increasing an individual's awareness of their physical activity levels. Wearing a device with a pedometer function is one of the most powerful behavioural change strategies, as it can provide the wearer with visible goals, reinforcement via constant monitoring, motivation and increased awareness. (Refer to Table 10.10 for the advantages of pedometers.)

DID YOU KNOW?

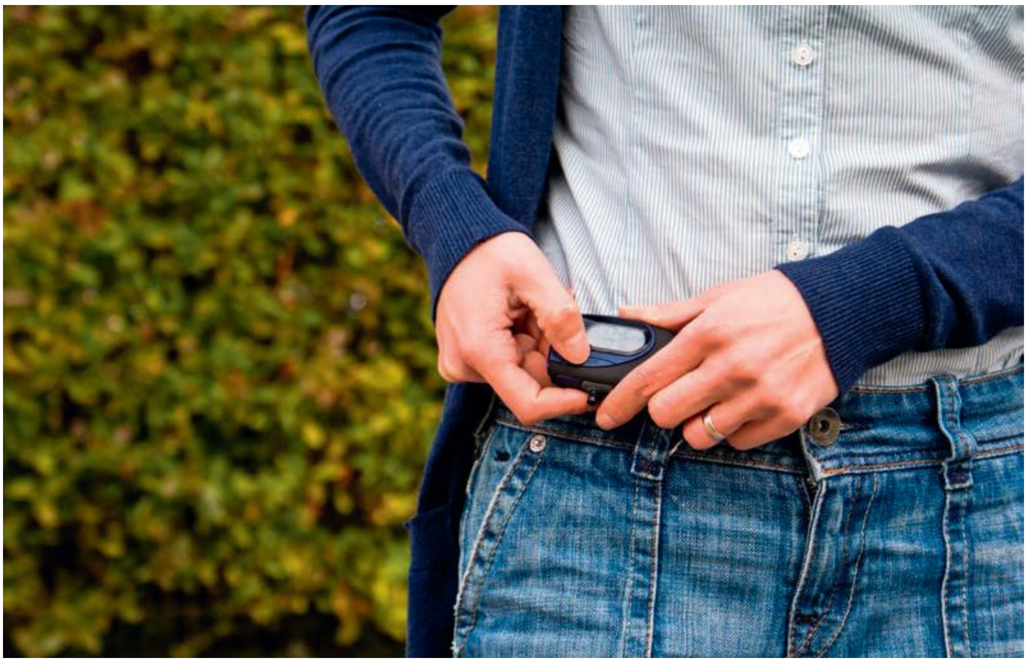
For centuries, people have used pedometers to measure distances travelled on foot. Leonardo da Vinci is believed to have invented the pedometer. He was one of the first people to take a scientific approach to understanding how our world works, and produced the first anatomical studies. He also studied flying machines, geometry, mechanics and architecture.

Limitations of pedometers

Standalone pedometers cannot detect stationary activities or isometric exercises, or activities that involve only the arms (refer to Table 10.10 for limitations of pedometers). However, the pedometer's main limitation is that it cannot measure the intensity of physical activity. For example, it takes much more energy to walk 100 steps up a flight of stairs than it would to walk 100 steps on flat ground. The only way to assess intensity is to compare the time it took the person to reach their step score on various occasions. For example, a person who accumulates 1500 steps in 10 minutes is exercising at a high intensity, while someone who accumulates 1500 steps over 90 minutes is exercising at a low intensity.

TABLE 10.10 Advantages and disadvantages of using a pedometer to assess physical activity

Advantages	Disadvantages
• Inexpensive • Small, lightweight and non-invasive • Easy to administer to large groups • Useful for detecting change (between pre- and post-tests) in the daily average number of steps taken, or to identify changes in rank order among groups • Objectively measures the most common physical activity behaviour (walking) • Appropriate for use in a range of settings (workplaces, the community and schools) • Provides immediate feedback and has the potential to promote behaviour change	• Assesses only one type of physical activity behaviour (walking or running) • Cannot record and store data in real time • Unable to record the magnitude of movement detected (a step is recorded regardless of the intensity or mode during walking, running or jumping) • Provides no information about frequency, intensity or duration of physical activity • Not an appropriate choice for comparing children with different levels of physical maturity because of the influence of body size and speed of locomotion on step count • Although it can provide estimates of energy expenditure, these are based on studies of adults and are not accurate for children



Andrew Haddon/Shutterstock.com

FIGURE 10.18 A pedometer is a useful wearable technology for walking.

REAL WORLD APPLICATIONS

How many steps should we take per day?

In a meta-analysis of 15 studies of just under 50 000 people, researchers found that taking more steps per day was associated with progressively lower mortality risk. Older adults benefited from 6000–8000 steps per day, while the risk for younger adults (aged under 60 years) plateaued at approximately 8000–10 000 steps per day (Paluch et al., 2022).

COLLABORATIVE TASK
Lab activity

Introduction to pedometry

AIM

To become familiar with the use of pedometers; you could even use a wearable device with a pedometer function

EQUIPMENT

Pedometers, cones and a 20-metre tape measure

Task A: Determining your stride length

Your stride length is defined as the distance between the toe of the front foot and the toe of the back foot, when walking. You need to determine your stride length before you can program your average stride length into your pedometer.

The most accurate way to measure stride length is to count the steps it takes to walk a certain distance (measured accurately using a tape measure) and then divide that distance by the number of steps taken.

Stride length = distance ÷ number of steps

For example, if it takes 25 steps to cover 20 metres, then the stride length is:

20 m ÷ 25 = 0.8 m or 80 cm

METHOD

1 Measure out a distance of 20 metres and mark it with a cone at each end.

2 Walk from one cone to the other, counting the number of steps (in your head).

3 Repeat, but at a running pace.

4 Record your results in a table like the one below and calculate your stride length each time.

All the forms in this activity are available on Nelson MindTap.

RESULTS

Template
Determining your stride length

Distance of 20 m	Number of steps	Stride length
Walking		20 m ÷ steps = m = cm
Running		20 m ÷ steps = m = cm

Task B: Comparing intensity – walking versus running

To work at a moderate intensity, a person's heart rate should be between 50 and 70 per cent of their maximum heart rate (% maxHR). Maximum heart rate (maxHR) is age-related and can be estimated in beats per minute (bpm) by:

MaxHR (bpm) = 208 – 0.7 × age (years)

For example, the maximum heart rate for a 30-year-old would be approximately:

208 – 0.7 × 30 = 187 bpm

To work at a moderate intensity, the target heart rate for this individual would need to be between 94 and 131 bpm. Working above 70% maxHR is considered vigorous intensity.

METHOD

1 Before you start the activity, measure your heart rate either manually or using a wearable device and record it in a table (see over).

2 Walk for one minute, wearing a pedometer, then record your heart rate again.

3 Run hard (preferably uphill) or climb stairs for one minute, then measure and record your heart rate again.

4 Calculate the increase in your heart rate from rest to walking, and from walking to running.

>

5 Calculate the percentage of your maximum heart rate for walking and running.

6 Record whether you were working at a moderate or vigorous intensity level.

RESULTS

	Number of steps taken	HR (bpm)	Increase in HR	% maxHR	Intensity
Before activity	n/a		n/a	n/a	n/a
Walking					
Running					

n/a = not applicable

Template
Comparing intensity – walking versus running

Task C: Estimating your step count

1 Estimate the number of steps you think it will take you to walk around the school oval, and record your estimate in a table like the one below. Reset your pedometer so that the step count is 0. If you are not able to reset it, then just record the current step count on your wearable device so you can calculate the difference later.

2 Walk around the oval and then record your pedometer reading in the table.

3 Without resetting the pedometer, carry out similar steps for the other two walking tasks. Complete the table, including the total number of steps walked.

RESULTS

Walking task	Estimated number of steps	Step count at start of activity	Step count at finish of activity	Actual steps taken for activity
Around the oval				
Around the school buildings				
Around the perimeter of your school campus				

Template
Estimating your step count

Task D: Estimating total distance covered

Most pedometers allow you to enter your stride length and estimate total distance covered in kilometres. Alternatively, you can use the formula:

Distance (km) = stride length (m) × number of steps ÷ 1000

For example, for 3450 steps at a stride length of 80 centimetres (0.8 metres):

Total steps = 3450 × 0.80 = 2760 m or 2.76 km

Find the total number of steps you walked for Task C. Using your walking stride length from Task A, calculate the total distance covered in Task C.

RESULTS

Total steps (Task C)	Walking stride length (Task A)	Estimated distance covered (km)

Template
Estimating total distance covered

DISCUSSION

1 **Describe** what happened to your stride length when you ran 20 metres, compared with when you walked that distance.

2 **Compare** your estimated step count for various walking tasks with your actual steps (according to the pedometer). For which walking task was the number of steps easiest to estimate, and why?

3 **Explain** why pedometers are a powerful tool for changing people's awareness of their level of physical activity.

4 Could you use pedometry to determine whether you meet the national physical activity guidelines? **Discuss**.

Setting a step-count goal

By using a pedometer, is it easy to set a baseline and goals for increasing the number of steps you take per day.

- To determine your baseline (current activity level), wear the pedometer for up to a week and then divide the total number of steps by the number of days to find your current daily average. The more days you record this over, the more accurate your estimate will be.
- Your goal should be to increase your baseline by around 10 per cent. For example, for a baseline of 6000, your goal could be to increase your daily number of steps by 600, every two weeks (see Table 10.11).

LEARNING HACK

Baseline + 10% of baseline = 6000 + 600 = 6600 steps

TABLE 10.11 Step-count goals

Weeks	1 & 2	3 & 4	5 & 6	7 & 8	9 & 10
Goal (steps per day)	6600	7200	7800	8400	9000

Stride-length ready reckoner

Instead of calculating your stride length, you could look it up in Table 10.12.

LEARNING HACK

Increasing your daily step goal by 10 per cent every two weeks is underpinned by the basic overload principle of never increasing current workloads and exercise volumes by more than 10 per cent in future sessions. You will study overload in detail in Unit 4.

TABLE 10.12 Number of steps versus stride length for walking a distance of 20 metres

Number of steps	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Stride length (cm)	100	95	91	87	83	80	77	74	71	69	67	65	63	61	59	57

Direct observation

Direct observation involves watching people's behaviours within specific settings (such as parks, workplaces, schools or physical education classes) and recording activities and events of interest. Direct observation is a highly time-intensive technique, both in terms of training observers and collecting data. However, this technique provides rich, detailed and accurate information about several dimensions of physical activity.

Trained observers watch participants using a real-time sampling technique, which involves documenting aspects of physical activity for a specific time interval (for example, two minutes) followed by a brief break (for example, 30 seconds). Computer software programs have been developed to assist researchers in using time-sampling techniques, storing data and completing analyses quickly on digital devices. This process allows for the collection of both **quantitative data** (for example, the number of minutes a child is engaged in running activities during recess) and contextual **qualitative data** – for example, which classmates children play with during various activities at recess (who), what behaviours they are engaging in (what), what part of the schoolyard the students are in (where), and at what point during the break the activity is occurring (when).

Direct observation is most commonly used to assess physical activity among children, but can also be used with adults. Commonly used instruments include the System for Observing Play and Leisure Activity in Youth (SOPLAY), the System for Observing Fitness Instruction Time (SOFIT) and the System for Observing Play and Recreation in Communities (SOPARC). All three instruments were developed by Professor Tom McKenzie and colleagues at San Diego State University in the United States.

quantitative data
Measures of values or counts, expressed as numbers; data about numeric variables

qualitative data
Data representing information and concepts that are not represented by numbers

TABLE 10.13 Using direct observation to assess physical activity

Advantages	Disadvantages
• Captures excellent quantitative and qualitative information • Allows for the collection of contextual information (including environmental conditions, the presence of significant others or the availability of physical activity cues such as toys or equipment) • Useful in a variety of community and school-based settings • Computer software makes data collection and analysis simpler than in the past	• Difficult to use with large populations • Intrusive • Highly labour-intensive and time-consuming • Only allows specific physical activity behaviours to be observed • The presence of an observer or cameras may bias the behaviour of those being observed (reactivity) • Training to establish between-observer and within-observer reliability is time-intensive

System for Observing Play and Leisure Activity in Youth (SOPLAY)

The methods of assessing physical activity described so far in this chapter were designed to measure physical activity in individuals only. SOPLAY can be used to assess the physical activity of groups of people. It was designed to be used in school settings, recording the number of students and their physical activity levels during play and leisure opportunities in a specified activity area (target area). SOPLAY uses time-sampling techniques, making systematic scans of individuals and contextual factors within designated and clearly defined areas. This allows for comparisons to be made across different schools or within the same school over different time periods (for example, before school, during lunchtime and after school).

jason freeman/Alamy Stock Photo

FIGURE 10.19 SOPLAY can be a highly reliable and valid measure of young people's physical activity.

Weblink
SOPLAY

COLLABORATIVE TASK
Lab activity

Using SOPLAY to observe physical activity

To learn more about the System for Observing Play and Leisure Activity in Youth, visit the SOPLAY website.

Template
Observation form

SOPLAY recording procedures

Here is an example of a recording procedure you could use with an adapted version of the SOPLAY instrument while observing a specific target area.

1 On the observation form on Nelson MindTap enter the date, start time and area being scanned (observed). You will need your login code.

2 Circle N (no) or Y (yes) for each of the following contextual variables (conditions):

A = Area is accessible (for example, not locked).
U = Area is usable for physical activity (for example, not excessively wet or windy).
S = Area is supervised by a teacher or adult on yard duty. (The supervisor must be directly in the target area and available to respond to student emergencies, but does not have to be coaching or umpiring.)
O = There is organised physical activity (activity that is scheduled and led by the school, such as a sports training session, fitness session or sporting competition).
E = Equipment (such as balls, skipping ropes) is provided by the school or coaches. Do not circle Y if the equipment is permanent (such as basketball rings).

3 Scan the entire target area for girls. Count and record how many girls are currently sedentary, walking, very active or playing an active sport.

4 Classify the predominant type of activity occurring in the target area using the activity codes on the SOPLAY data recording form.

Repeat steps 3 and 4 for boys. Always scan left to right. Observe each student in the area once. If a student reappears in the scan area, do not record them a second time. Do not backtrack to count new students entering the scan area.

SOPLAY observation form

Date: ____/____/____		Observer: __________		Period: BS LU AS (circle)
Start time	**Area**	**Condition** **A U S O E**	**Girls** **S W V**	**Boys** **S W V**
___ : ___	1	N N N N N Y Y Y Y Y	_ _ _	_ _ _
___ : ___	2	N N N N N Y Y Y Y Y	_ _ _	_ _ _

Form codes:	**Activity codes:**
BS = Before school LU = Lunchtime AS = After school A = Accessible area U = Usable area S = Supervised area O = Organised activity E = Equipment provided S = Sedentary W = Walking V = Very active	0 = No identifiable activity 1 = Aerobics 2 = Baseball or softball 3 = Basketball 4 = Dance 5 = Football 6 = Gymnastics 7 = Martial arts 8 = Racquet sports 9 = Soccer 10 = Swimming 11 = Volleyball 12 = Weight training 13 = Other playground games 14 = None of the above

>

Laboratory report

Refer to the SOPLAY recording procedures and the observation form on the previous page.

1 Using a school map, divide the school into different areas for observation. You might even complete this exercise within a nearby primary school if you have approval from the principal. Determine who will observe each of the target areas.

2 Using the SOPLAY recording procedures, record physical activity data onto the data recording form.

3 Complete a scan of the selected target areas during different time periods (for example, before school, during lunchtime and after school).

4 **Compare** the data with that collected for other target areas. In which areas does most of the physical activity occur? Does this vary by gender? Present your results in table or graph form.

5 Throughout a typical school day, when did most of the physical activity occur (that is, before school, during lunchtime or after school)? Provide examples using evidence from your data collection.

6 **List** the most common activities observed in each of the target areas.

7 **Outline** where and when organised activity occurred. Include contextual information in your response (conditions such as whether the area was under supervision, the equipment available and so on).

8 Which subgroup appears to be the most sedentary, based on your data collection? What strategies would you suggest to encourage these individuals to be more active? (**Describe** the when, where, what and why, and **suggest** how they could be encouraged to be more active.)

System for Observing Fitness Instruction Time (SOFIT)

The SOFIT tool assesses physical education classes by enabling the researcher to simultaneously collect data on student activity levels, the lesson context, and teacher behaviour. The system enables researchers, teachers, and supervisors to make judgements about physical education lessons, particularly as they relate to program goals. The main outcome variable is student physical activity levels, and these can be reported in number of minutes and percentage of lesson time spent in MVPA (moderate-to-vigorous physical activity); VPA (vigorous physical activity); lying down, sitting, standing and walking; and estimated energy expenditure per lesson (kcal/kg).

Weblink
SOFIT

COLLABORATIVE TASK
Lab activity

Using SOFIT during Tchoukball

FIGURE 10.20 Why would SOFIT rather than SOPLAY be used in this setting?

AIM

To introduce students to the use of SOFIT

EQUIPMENT

You will need handballs, three sets of 12 colour bands and two Tchoukball (rebound) nets. Play takes place on a netball court.

METHOD

In a 50-minute session, half the students participate in Task A and the rest in Task B. After 20 minutes, students swap over to complete the other task.

Task A: using SOFIT

Use the following steps to observe two Task B participants. You will be recording student activity and lesson context on a modified SOFIT recording sheet (instructor behaviour categories are omitted for the purpose of this task). The observations for each individual will take a total of four minutes.

1. Select a Task B participant.
2. Observe the participant for 10 seconds. Spend the next 10 seconds filling in the modified SOFIT recording sheet from Nelson MindTap.
3. Repeat until you have observed the same student 12 times (12 × 20 seconds = 4 minutes).
4. Repeat for another student.

Template
SOFIT recording sheet

Modified* SOFIT recording sheet

Date: ____ /____ /________ School: ________________ Location: _________________

Observer: _______________ Number of students: _______ Number of observations: _______

Start time: _______________ End time: ________________ Lesson length (min): __________

Student, gender	Interval	Student activity					Lesson context		
	1	1	2	3	4	5	M	S	G
	2	1	2	3	4	5	M	S	G
	3	1	2	3	4	5	M	S	G
Student 1 (circle)	4	1	2	3	4	5	M	S	G
	5	1	2	3	4	5	M	S	G
M	6	1	2	3	4	5	M	S	G
F	7	1	2	3	4	5	M	S	G
	8	1	2	3	4	5	M	S	G
	9	1	2	3	4	5	M	S	G
	10	1	2	3	4	5	M	S	G
	11	1	2	3	4	5	M	S	G
	12	1	2	3	4	5	M	S	G
Totals									
	1	1	2	3	4	5	M	S	G
	2	1	2	3	4	5	M	S	G
	3	1	2	3	4	5	M	S	G
Student 2 (circle)	4	1	2	3	4	5	M	S	G
	5	1	2	3	4	5	M	S	G
M	6	1	2	3	4	5	M	S	G
F	7	1	2	3	4	5	M	S	G
	8	1	2	3	4	5	M	S	G
	9	1	2	3	4	5	M	S	G
	10	1	2	3	4	5	M	S	G
	11	1	2	3	4	5	M	S	G
	12	1	2	3	4	5	M	S	G
Totals									

Student activity
1 = Lying
2 = Sitting
3 = Standing
4 = Walking
5 = Very active

Lesson context
M = Management
Not involved in knowledge or movement (e.g. splitting into teams, changing equipment, moving from one activity to the next)
Motor content (moving)
S = Skill practice
Activities primarily to improve or practise skills
G = Game play
Application of skills in game or competition

* Note: this modified version omits the instructor behaviour categories altogether
Source: Adapted from TL McKenzie, SOFIT Description and Procedures Manual, May 2015, School of Exercise and Nutritional Sciences, San Diego State University

Task B: Playing a modified version of Tchoukball

Participate in a five-minute warm-up (throwing at the rebound nets) and a 10-minute session learning how to play Tchoukball. (Teaching points include follow through towards the net; throw the ball hard; the lower the ball hits the net, the higher it will rebound in the air; don't make a throw until the pair of players in front of you are safely out of the way.)

1 Participants form two teams of up to 10 students, one at each end of the court. No-one is allowed inside the goal circle at any time.

2 One thrower runs in towards the rebound net, bouncing the ball every two or three steps. (You can hold the ball for only three seconds.) One rebounder runs in at the same time as the thrower.

3 The thrower has a shot at the rebound net from outside the goal circle. To score, the ball must rebound and land outside the goal circle within the goal third. (Alternative rules: the ball must be caught on the full by a teammate outside the goal circle.)

4 The rebounder collects the ball on the rebound and swaps sides to become a thrower. (A shot at goal caught on the full by the opposition team results in a turnover.)

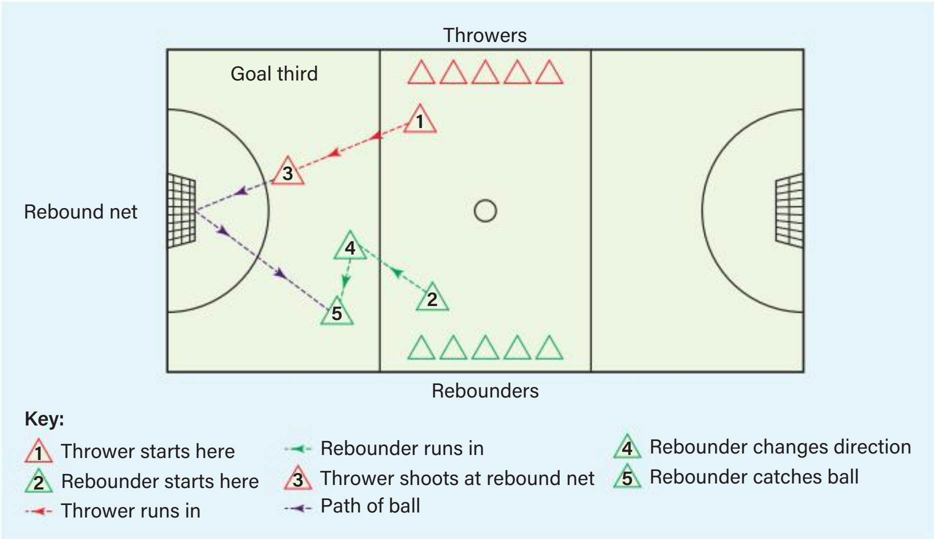


FIGURE 10.21 Sample play for Tchoukball

RESULTS

At the bottom of each recording sheet (a template is available on Nelson MindTap), calculate the total observation time for each column. Remember, each entry on the recording sheet represents 10 seconds of activity. Then fill in a table like the following for each of the students you observed, estimating how many seconds were spent on different student activities and contexts. A blank table is also available online, included below the recording sheet. (Lesson context does not need to be recorded in this table.)

Template
Student activities and contexts

Activity or context		Time (seconds)		
		Student 1	Student 2	Total
Student activity	Lying down			
	Sitting			
	Standing			
	Walking			
	Very active			
Motor content	Skill practice			
	Game play			
	Fitness			
	Free play			

QUESTIONS

1 Rank the student activities from the most to least time spent during the observation period.
2 What was the predominant student activity classification?
3 In what motor content mode did the students spend most of their time during this particular physical activity session?
4 How could this instrument be used in school settings to assess physical activity?

REAL WORLD APPLICATIONS

System for Observing Play and Recreation in Communities (SOPARC)

SOPARC is a validated direct observation tool for assessing park and recreation areas, including park users' physical activity levels, gender, activity modes/types, and estimated age and ethnicity groupings. It also collects information on park activity area characteristics (for example, accessibility, usability, supervision and organisation).

Weblink
SOPARC

WORKED EXAMPLE

CHOICE OF PHYSICAL ACTIVITY MEASURE IS INFLUENCED BY THE AGE OF THE PERSON BEING ASSESSED

Question 1
Describe one limitation of using a proxy-reported recall survey with a parent/carer to assess whether an eight-year-old met the physical activity guidelines.
Question 2
Explain a major limitation of using self-report to measure the physical activity of a 30-year-old.
Question 3
Discuss whether wearables could be used to determine whether a 16-year-old met the physical activity guidelines for their age group.

Suggested responses:
Question 1
The parent/carer cannot accurately report the physical activity the child engaged in during the school day.
Rationale: Proxy reports are useful when the person completing the survey is present with the child during the recall/diary window of time.
Question 2
There can be associated reliability and validity problems associated with over-reporting due to social desirability bias or memory limitations.
Rationale: The question is about a 30-year-old, so cognitive limitations affecting understanding of the questions are unlikely, unless the person has an intellectual or learning disability. Answering what you think you should say rather than what you do is a common contributor to over-reporting among adults.
Question 3
Most wearables will capture frequency, intensity and duration; however, you would also need the individual to enter the type of physical activity into an app or diary synced from the wearable to a smart device to determine whether they met the strength component of the guidelines three days per week.
Rationale: While most people will answer yes, you would need to be explicit about how physical activity type is measured to capture the strength requirement. Alternatively, you could also mention in your discussion that they would need to complete a self-reported recall survey or diary in addition to the data collected via the wearable.

Summary of objective measures

Table 10.14 provides a summary of the dimensions and domains each objective measure can assess, along with information about their capacity to assess physical activity in relation to physical activity guidelines.

TABLE 10.14 Assessment of physical activity dimensions, guidelines and domains using objective measures

Measure		Wearables	Pedometer[2] (stand-alone)	Direct observation
Dimensions	Type	×[1]	×	✓
	Frequency	✓	×[2]	✓
	Duration	✓	×	✓
	Intensity	✓	×	✓
METs energy expenditure		✓	×	✓
Physical activity guidelines for children/youth	Physical activity	✓	×	✓
	Sedentary behaviour	✓	×	✓
Physical activity guidelines for adults		✓	×	✓
Sedentary behaviour of adults		✓	×	✓
Contextual data		×	×	✓
Total physical activity		✓	✓[3]	✓
Domains	Leisure time	×	×	✓
	Occupation/school	×	×	✓
	Household/gardening	×	×	✓
	Active transport	×	×	✓

[1] Only some models can be integrated with apps or smart devices or online to enable activity type to be entered apart from some captured via pattern recognition (e.g. running, rowing, elliptical, cycling, swimming).
[2] Measures steps only. [3] Only some models estimate total activity time of moderate- to vigorous-intensity physical activity.

Appropriate assessment instruments for the target group

When selecting a physical activity measure, it is important to consider the population subgroup being assessed (see Table 10.15). For example, many children under the age of 10 cannot provide a valid (accurate) or reliable (consistent) account of their physical activity behaviour, due to cognitive and memory limitations. While children may not have the cognitive skills to understand the survey items, older people may understand, but may not be able to accurately recall their behaviour due to memory limitations. People with limited understanding of English would have difficulty with a survey or log unless it had been translated.

Accelerometers within wearables can be poor measures of physical activity for people with intellectual disabilities, due to long hours of sedentary behaviour or slow movements. Some models interpret low movement counts or g-forces as an indication that the accelerometer is not being worn. As previously discussed, proxy reports (recall surveys, global surveys or diaries or logs) are commonly used to assess physical activity for those groups who are not capable of reporting their own behaviour accurately.

TABLE 10.15 Suitability of measures for assessing physical activity among population subgroups

Subgroup	Self-reported recall survey	Self-reported diary or log	Proxy report	Pedometer	Wearables	Direct observation
Children 0–9 years	No	No	☺☺☺	☺☺	☺☺	☺☺☺
Children 10–12 years	☺	☺	☺☺	☺☺	☺☺	☺☺☺
Adolescents	☺☺	☺☺	☺	☺☺	☺☺☺	☺☺☺
Adults	☺☺☺	☺☺☺	☺	☺☺	☺☺☺	☺☺
Older adults 65 years	No	☺☺	☺	☺☺	☺☺	☺
People with an intellectual disability	No	☺	☺☺☺	☺	☺	☺☺☺
People from a NESB[1]	No[2]	No[2]	☺☺	☺	☺	☺☺☺

Key: No = Not at all suitable, ☺ = Somewhat suitable, ☺☺ = Suitable, ☺☺☺ = Highly suitable

[1] NESB = non-English-speaking background

[2] Only appropriate when translated into the language spoken

COLLABORATIVE TASK
Activity

What can be used to assess physical activity and sedentary behaviour guidelines?

Review Table 10.16, which outlines which measures can be used to assess the various aspects of the guidelines for physical activity, sedentary behaviour and sleep for children and young people.

TABLE 10.16 Measures for assessment activity guidelines for different age groups

Description of guideline	Self-report	Proxy-report	Diary	Direct observation	Wearables
Physical activity					
Under 12 months Interactive floor-based play, and at least 30 minutes of tummy time for babies per day	No	Yes	No	Yes	No
1 to 2 years and 3–5 years At least 3 hours (180 mins) of energetic play per day	No	Yes	No	Yes	Yes
5–17 years At least 1 hour (60 mins) of moderate to vigorous activity involving mainly aerobic activities per day. Vigorous activities to be incorporated at least three days per week Several hours of light activities per day	No (under 10) Yes (over 10 years)	Yes	No (under 10) Yes (over 10 years)	Yes	Yes
Strength					
5–17 years At least three days per week	No (under 10) Yes (over 10 years)	Yes	No (under 10) Yes (over 10 years)	Yes	No*

Description of guideline	Self-report	Proxy-report	Diary	Direct observation	Wearables
Sedentary time					
Under 12 months, 1–2 years and 3–5 years Do not restrain for more than 1 hour at a time	No	Yes	No	Yes	No
5–17 years Minimise and break up long periods of sitting	No (under 10) Yes (over 10 years)	Yes	No (under 10) Yes (over 10 years)	Yes	Yes
Sedentary recreational screen time					
Under 12 months None	No	Yes	No	Yes	No
Under 2 years None **2 years** No more than 1 hour per day	No	Yes	No	Yes	No
3–5 years No more than 1 hour per day	No	Yes	No	Yes	No
5–17 years No more than 2 hours per day	No (under 10) Yes (over 10 years)	Yes	No (under 10) Yes (over 10 years)	Yes	Yes
Sleep					
0–3 months 14 to 17 hours **4–11 months** 12 to 16 hours Includes naps	No	Yes	No	Not practical	No
1–2 years 11 to 14 hours, including naps	No	Yes	No	Not practical	No
3–5 years 10–13 hours; some still need naps	No	Yes	No	Not practical	No
5–13 years 9–11 hours **14–17 years** 8–10 hours	No (under 10) Yes (over 10 years)	Yes	No (under 10) Yes (over 10 years)	No (under 10) Yes (over 10 years)	Yes

*Some wearables and apps enable the type of physical activity to be recorded

QUESTIONS

1 **Compare** and contrast the use of self-report and wearable devices in the assessment of physical activity and sedentary behaviour.

2 What are the limitations of proxy-report? Consider the contexts in which they would need to be used and who might need to complete them.

3 **Discuss** the limitations associated with the use of direct observation. Consider the contexts in which they would need to be used.

4 Create another table using the same structure, this time for people aged 18+ years. **Explain** why a combination of measures are required to assess all aspects of the recommendations for people aged 18 years and over.

10.2 CHECK-IN QUESTIONS

1 **Outline** the difference between a recall instrument and a diary.
2 **List** two limitations of using self-report surveys.
3 **Outline** the difference between moderate-intensity and vigorous-intensity physical activity.
4 **Describe** two disadvantages of the use of direct observation for assessing physical activity.
5 **Explain** the trade-off between the accuracy and practicality of a physical activity measure.
6 When would SOPLAY and SOFIT be used to assess physical activity?
7 **Explain** why pedometers are powerful behavioural change tools.
8 Contrast the purpose of measuring physical activity at the population level to the individual level.

Assessment
10.2 Check-in questions

Command terms

outline
Provide an overview or the main features of an argument, point of view, text, narrative, diagram or image

explain
Give a detailed account of why and/or how with reference to causes, effects, continuity, change, reasons or mechanisms; make the relationships between things evident

ABOVE AND BEYOND THE STUDY DESIGN

MODULE 10.1, p. 322

Sedentary behaviour

Sedentary behaviour is completely independent of physical activity behaviour and includes activities that require around 1–2 (or less than 1.6) METs to perform (where 1 MET is the amount of energy you expend at rest and 2 METs is twice that). As discussed in Chapter 7, research has shown a clear association between sedentary behaviour and various health consequences. For example, a high level of television viewing has been linked with excess weight, regardless of the viewer's activity level. Someone who is highly active can also be highly sedentary. Sedentary behaviours such as watching television, commuting by car, using a computer or reading are activities that expend low amounts of energy.

FIGURE 10.22 Are you sometimes a couch potato?

MODULE 10.2, p. 329

Measurement of sedentary behaviour

The main methods for assessing sedentary behaviour are:

- diaries
- wearable technologies that include accelerometers and inclinometers
- self- or proxy-reported recall surveys
- direct observation.

Although these methods can all be used to assess the amount of time a person is sedentary, not all can determine whether someone meets the sedentary behaviour guidelines. The sedentary behaviour guidelines for young people specify no more than two hours per day of recreational screen time. Although a wearable device with an accelerometer can assess sedentary time, it can't assess contextual data such as what a screen is being used for. If you were designing your own survey to measure sedentary behaviour, you could ask how many minutes or hours the person engages in various behaviours while sitting quietly.

All these methods allow researchers to record the number of minutes or hours spent in sedentary behaviours each day or week, and to assign appropriate METs. Survey instruments usually ask about multiple sedentary behaviours, such as television/streaming viewing, computer use, gaming and reading. Although there are dozens of other sedentary behaviours, screen-based activities and reading are among the most common, and give a good indication of overall time spent in sedentary behaviour.

The main objective measures for assessing sedentary behaviour are wearables that contain an accelerometer or inclinometer, direct observation and devices.

FIGURE 10.23 How would you assess the number of minutes Ed is sedentary during work time?

- **Wearables containing an accelerometer** can detect low-intensity or sedentary behaviour using movement counts or g-forces below a certain threshold, although there is little difference between standing and sitting data, despite a difference in energy expenditure.
- **Wearables containing an inclinometer** are electronic devices that can differentiate between standing and sitting. Modern wearables are able to estimate sitting and standing time. Traditional inclinometers can be worn on a person's thigh to measure the amount of time they spend sitting. While you can be considered sedentary when you are standing, the health consequences associated with sitting for many hours are more detrimental than long hours spent standing.
- **Direct observation** can also be used to assess sedentary behaviour. While this method is useful in school or workplace settings, it is not very practical for use in people's homes.
- **Devices** can also be fitted to computer or television screens to measure usage and viewing time. However, these are rarely used in sedentary behaviour research. The fact that a television is on doesn't mean anyone is watching it. Similarly, a person watching television is not necessarily sedentary – they might be working out on a treadmill, elliptical machine or stationary bicycle. Measurement of physical activity and sedentary behaviour has been made more complex by the popularity of active electronic games such as Nintendo, Wii Sports and Wii Fit.

CHAPTER SUMMARY

Resource
Self-assessment checklist

Video
Masterclass: Chapter 10

10.1 Physical activity and sedentary behaviour guidelines

- Governments set national physical activity guidelines and monitor what proportion of the population meets these guidelines. Australia's physical activity, exercise and sedentary behaviour guidelines outline how much physical activity you should do, the importance of reducing the time spent sitting or lying down and how much sleep children and young people should get. These guidelines vary by age.
- The dimensions of physical activity that are commonly measured are activity type, frequency, intensity and duration.

10.2 Measuring physical activity and sedentary behaviour among individuals and populations

- The method used to assess physical activity will depend on whether activity is being measured within large-scale populations or among individuals.
- Subjective measures of physical activity rely on a person's recall, whereas objective measures employ the use of a device or another person to assess physical activity.
- Proxy reports are usually completed on behalf of a person unable to reliably or accurately self-report, such as very young children, the elderly or the intellectually disabled.
- Not all subjective and objective measures can assess physical activity dimensions across all domains (such as leisure time, house or garden, active transport and work).
- Objective measures are not associated with the limitations of subjective measures such as social desirability bias, recall or cognitive limitations.
- Although wearables containing an accelerometer can assess sedentary time, they cannot capture context, and therefore cannot be used to assess whether a young person has met the sedentary behaviour guidelines.
- Sedentary means staying in the same place for much of the time and expending low amounts of energy. Someone who is highly active can also be highly sedentary (at other times). Sedentary behaviours such as television viewing, computer use and reading can be assessed using measures similar to those used to assess physical activity.

CHAPTER REVIEW

1 Which of the following is an example of a subjective measure of physical activity?
- A Direct observation
- B Pedometer
- C Keeping a diary
- D Accelerometer

2 Which of the following could be used to assess who an adolescent is being active with during a lunch break within a school setting?
- A Accelerometer
- B Pedometer
- C Inclinometer
- D Direct observation

3 **State** one measure that would be highly suitable to assess the physical activity of a person with an intellectual disability or a person from a non-English-speaking background.

4 **Outline** three reasons for measuring physical activity at a population level.

5 How much physical activity per week is recommended for adults?

6 Most wearables have multiple functions. **Discuss** a limitation associated with wearables.

7 **State** the sedentary recreation screen time guideline for a 16-year-old and comment on whether you would meet this guideline.

8 **Explain** two advantages of using a wearable device that contains an accelerometer rather than using a recall instrument to measure the physical activity of an eight-year-old child.

9 **Explain** how an individual can be highly sedentary and yet still meet the physical activity guidelines.

10 Select a method of assessment you could use to determine whether you meet the physical activity guidelines for your age group.

11 **Justify** why you selected the measure/method chosen in question 9.

Assessment
Chapter 10 Review

Command term

justify
Show, prove or defend, with reasoning and evidence, an argument, decision and/or point of view using given data and/or other information

CHAPTER 11

PROMOTION OF PHYSICAL ACTIVITY

UNIT 2 – AREA OF STUDY 1

Cavan Images/Alamy Stock Photo

FIGURE 11.01 Changing our physical activity behaviour can provide lifelong benefits.

Quizzes

Chapter 11 Pulse check

11.1 Check-in questions

11.2 Check-in questions

Chapter 11 Review

Videos

Masterclass: Chapter 11

11.1 In focus: Multiple levels of influence within the social-ecological model

11.1 In focus: Critique of a physical activity program

11.1 The social-ecological model - Jo Salmon

Resources

11.1 Template: Social-ecological framework

11.2 Template: Summary of initiative using the social-ecological model

Chapter 11 Self-assessment checklist

Nelson MindTap

To access resources above, visit **cengage.com.au/nelsonmindtap**

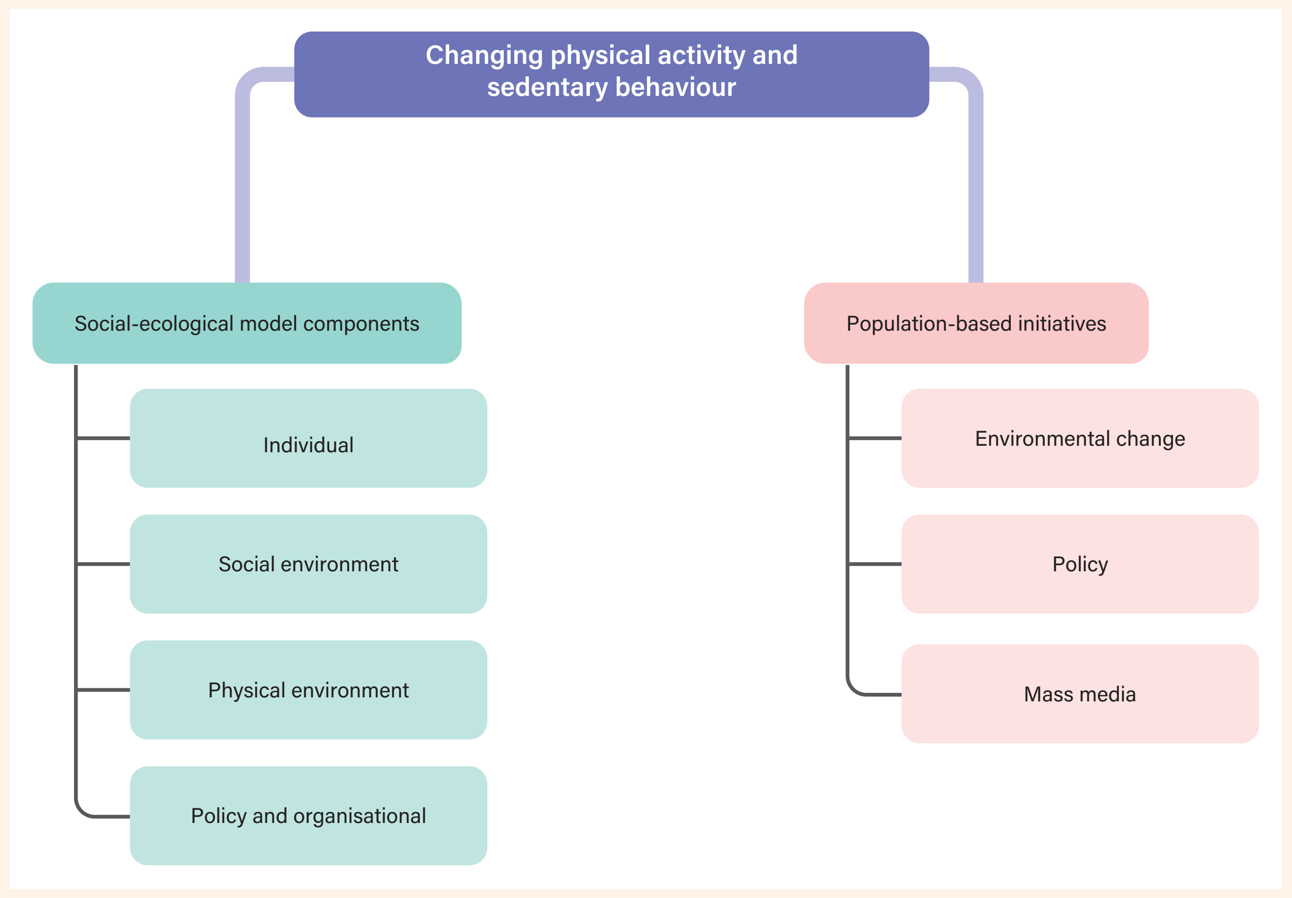
KEY KNOWLEDGE

- components of the social-ecological model (individual, social environment, physical environment and policy)
- a range of population-based initiatives that target enablers of and barriers to physical activity

KEY SKILLS

- apply the social-ecological model to critique and create physical activity initiatives and strategies aimed at increasing physical activity and/or reducing sedentary behaviour

Source: VCAA VCE Physical Education Study Design (2025–29)



Video
Masterclass: Chapter 11

Assessment
Chapter 11 Pulse check

In this chapter we will explore how we go about changing physical activity behaviour and encouraging people to reduce their sedentary behaviour. While there are lots of models and frameworks that attempt to explain physical activity and sedentary behaviour, for this study we are using the social-ecological model, which is made up of individual, social environment, physical environment and policy components. We will also explore a range of physical activity initiatives and strategies aimed at increasing physical activity and/or reducing sedentary behaviour.

PULSE CHECK

Take the pulse check quiz to check your knowledge and prior understanding of the concepts covered in this chapter.

1 **Identify** two factors within the social environment that may influence your physical activity level.
2 **Describe** what is meant by the term 'intervention.'
3 **List** two population-based promotion strategies that aim to increase the levels of physical activity within your community.
4 **State** an example of a policy relating to physical activity in your school.
5 **Describe** two example strategies that could be implemented within the physical environment to promote physical activity.

11.1 PHYSICAL ACTIVITY BEHAVIOUR CHANGE

In this module you will learn about:

- components of the social-ecological model (individual, social environment, physical environment and policy)

and learn to:

- apply the social-ecological model to critique and create physical activity initiatives and strategies aimed at increasing physical activity and/or reducing sedentary behaviour.

mediators
Mechanisms through which an intervention (strategy) is believed to influence physical activity behaviour

As discussed in Chapter 8, enablers and barriers of physical activity and sedentary behaviour are the factors that influence how active a person is. For example, in Figure 11.02, the second box describes an intervention designed to encourage a teenager to ride their bicycle more often. The third box depicts the mechanisms that led to a change in cycling behaviour (**mediators**). The last box shows changes to the young person's cycling behaviour.

It is important to understand that physical activity mediators can also influence other mediators. For example, self-efficacy and reminding yourself to be active may also be mediators. If a person is taught strategies to remind themselves to be more active, this might also lead to improved self-efficacy. The combined improvement in these mediators may increase the chance of behavioural change occurring.

It can be difficult to determine which elements or strategies of an intervention program, if any, result in changes to physical activity behaviour. In Figure 11.02, notice that physical activity behaviours (total physical activity and cycling) and potential influences (self-efficacy, social support) are measured both pre- and post-intervention. If cycling behaviour was only assessed post-intervention, it would not be possible to determine whether there had actually been a change in behaviour.

REAL WORLD APPLICATIONS

Intervention and evaluation

Figure 11.02 relates to the planning, implementation and evaluation of interventions on a large group scale as well as those used for individual activity plans.

Baseline measures (pre-intervention)

- Asses total physical activity.
- Assess cycling:
  - frequency (trips per week)
  - duration (minutes per week)
  - distance covered (kilometres per week).
- Assess self-efficacy for cycling.
- Assess perceived social support for cycling.

↓

Intervention program

- Participate in a school-based bicycle education program.
- Ride with an after-school cycling club.
- Ride to school with a friend at least twice per week.
- Program facilitated by active role models.

↓

Change in mediators

- Increased competence on bicycle
- Increased social support for cycling
- Enhanced self-efficacy to ride to school

↓

Post-intervention measures of behavioural change

- Increased total physical participation
- Increased cycling frequency, duration, distance
- Increased number of trips to school
- Increased number of bike paths used
- Increased self-efficacy to ride to school
- Increased perceived social support for cycling
- Association between social support and cycling

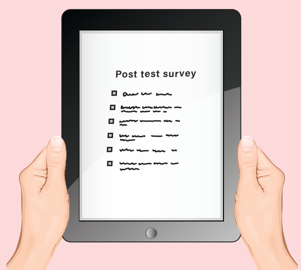


FIGURE 11.02 Assessing behavioural change within a school-based cycling intervention program

LOOKING FORWARD
Individual activity plans
Chapter 13
We will look more closely at individual activity plans in Chapter 13.

The social-ecological model

At best, research on individual-level factors that influence physical activity levels only explains 20–40 per cent of the variance. This has led to a shift to broader, multilevel, ecological approaches to physical activity promotion.

Theoretical models of behavioural change may incorporate several of these factors in an attempt to better understand physical activity behaviour. While there are a range of theories of behaviour change in relation to physical activity, in this unit we will be focusing on the social-ecological model.

An individual's social and physical environment (family, workplace, community or school) can directly and indirectly affect their beliefs and physical activity behaviour.

Over the past two decades there has been a shift towards developing environmental-level physical activity programs in schools, community and workplace settings. This shift originated in the late 1970s, when Urie Bronfenbrenner proposed the first ecological model in an attempt to 'describe the multiple levels of influence in the environment including interpersonal relationships, organisations and institutions that affect individual's behaviour' (Bauer et al., 2004).

reciprocal causation The interaction between the individual and the environment

An ecological perspective suggests **reciprocal causation** between the individual and the environment. In other words, individual behaviour can influence the environment, and the environment can influence individual behaviour.

It is important to understand that no single factor on its own can lead to behavioural change. Behavioural change is a complex process that involves a number of variables. For example, increasing someone's physical activity may require all of the following factors: more social support from their partner, enhanced self-efficacy, introduction of a weekly ride-to-work day at their workplace and a warning from their GP about their high blood pressure. Even in this simple example, a combination of factors interacts, eventually leading to behavioural change. An ecological model can explain the multiple levels of influence that interact, resulting in an increase in physical activity behaviour.

Two important points to remember are:

1 **Ecological models** of physical activity reinforce the interplay of demographic, psychological, social and environmental variables influencing physical activity behaviour. Therefore, if you make a change at one level, it could affect all other influencing factors.
2 **Social-ecological models** of physical activity are characterised by multiple levels of influence on behaviour and an emphasis on environmental and policy influences.

Table 11.1 outlines the levels of influence on an individual or group and lists sample components making up these levels of influence. Each level will be described in more detail later in this chapter.

TABLE 11.1 The social-ecological model of influences on physical activity

Individual factors	Social environment factors	Physical environmental factors		Policy and organisational factors
		Natural environment	Constructed environment	
• Demographics • Biological • Cognitive or affective • Behavioural	• Supportive behaviours • Social climate • Culture	• Weather • Geography	• Information environment • Urban/suburban environment • Architectural environment • Transportation environment • Entertainment infrastructure • Recreation infrastructure	• Policies governing incentives for activity or inactivity • Policies governing resources and infrastructure related to activity or inactivity

Note: Social and physical environments need to be considered within key behaviour settings, such as home, neighbourhood, school, workplace, parks, public buildings and facilities for recreation and sports.

There are many ways a social-ecological model could be depicted. Within some ecological models, individual factors, social environment, physical environment and policy are all separate. In others, policy is integrated within the social and environmental level. The most fundamental depiction of the social-ecological model is shown in Figure 11.03.

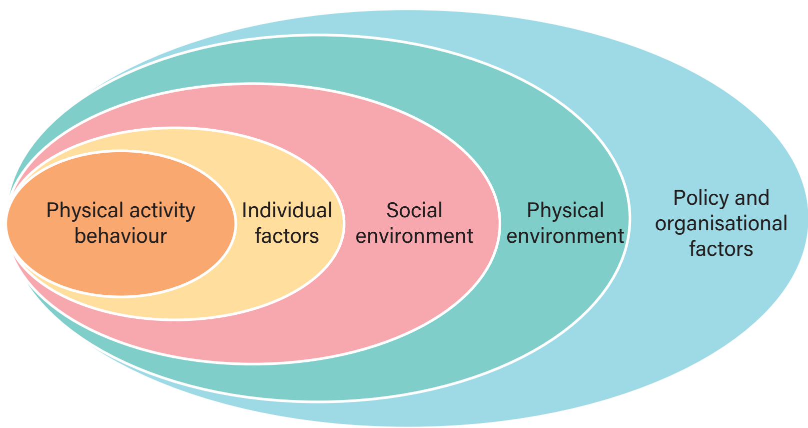


FIGURE 11.03 Components of a social-ecological model for promoting physical activity

Let's unpack some example factors that could be included within the multiple levels of the social-ecological model. You will notice that Figure 11.04 represents each level in a linear fashion; however, a more appropriate representation uses rings to depict moving from individual factors right through to the physical environment and policy factors.

LOOKING BACK

Enablers and barriers

In Chapter 8, we referred to determinants as factors that influence how active a person is; they can be enablers or barriers. These factors do not usually influence behaviour in isolation; instead, a combination of factors may be at play.

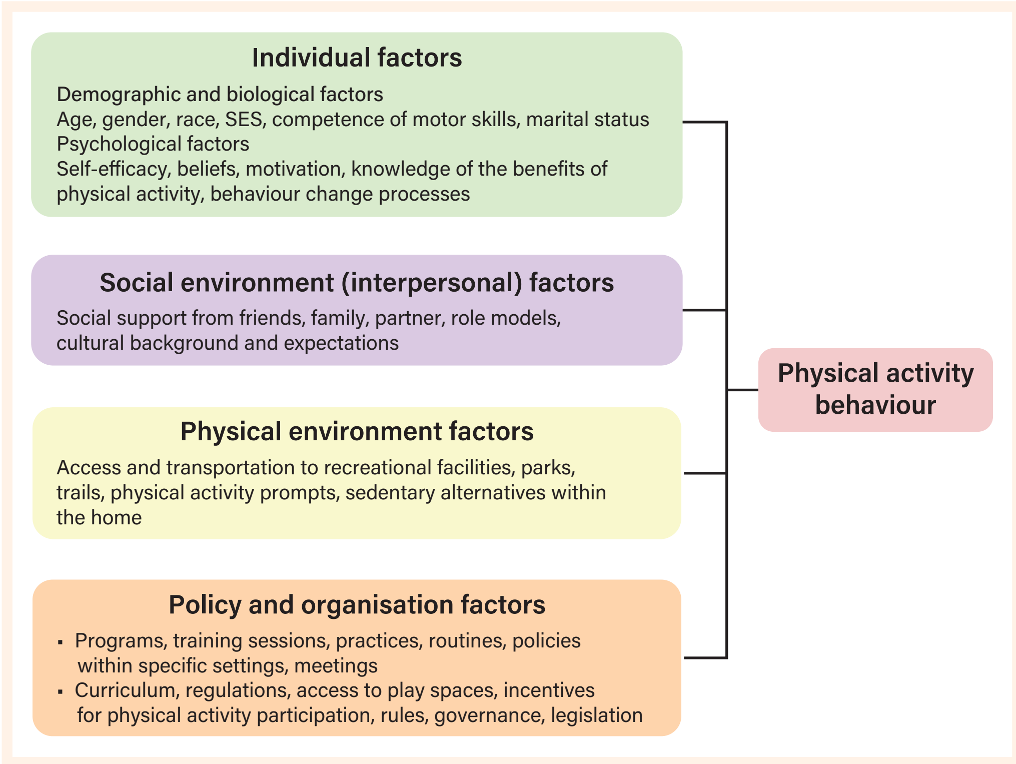


FIGURE 11.04 A social-ecological model of physical activity

Source: Adapted from Salmon, J. & King, A. (2005). 'Population approaches to increasing physical activity among children and adults,' in D. Crawford & R. Jeffrey (eds), *Obesity Prevention in the 21st Century: Public health approaches to tackle the obesity pandemic*. Oxford University Press.

Figure 11.05 shows another example of a social-ecological model of physical activity. Note that it is aimed at a wide range of settings (community, schools etc.), and there are multiple levels of influence (environmental/policy, sociocultural and individual factors) on physical activity. Each factor within each level of influence has been identified as a determinant of physical activity, and it is these factors that need to be targeted when developing intervention strategies. Some factors are more relevant to children, while others relate more to adolescents and adults.

As an example, consider parental physical activity from the sociocultural level of Figure 11.05 as an influence on children's physical activity. Knowing that this factor is a key influence on children's physical activity, an intervention strategy used within a community-based program may be to encourage more parents to be active role models for their children.

Let's examine the levels of influence in more detail.

DID YOU KNOW?

There are many ways to present a social-ecological model for promoting physical activity. Some models, for example, use community, institutional, built environment, natural environment, cultural or societal. For this unit, we simply use four levels: individual, social environment, physical environment, and policy.

ABOVE AND BEYOND THE STUDY DESIGN

Enablers and barriers to physical activity during COVID-19, p. 403

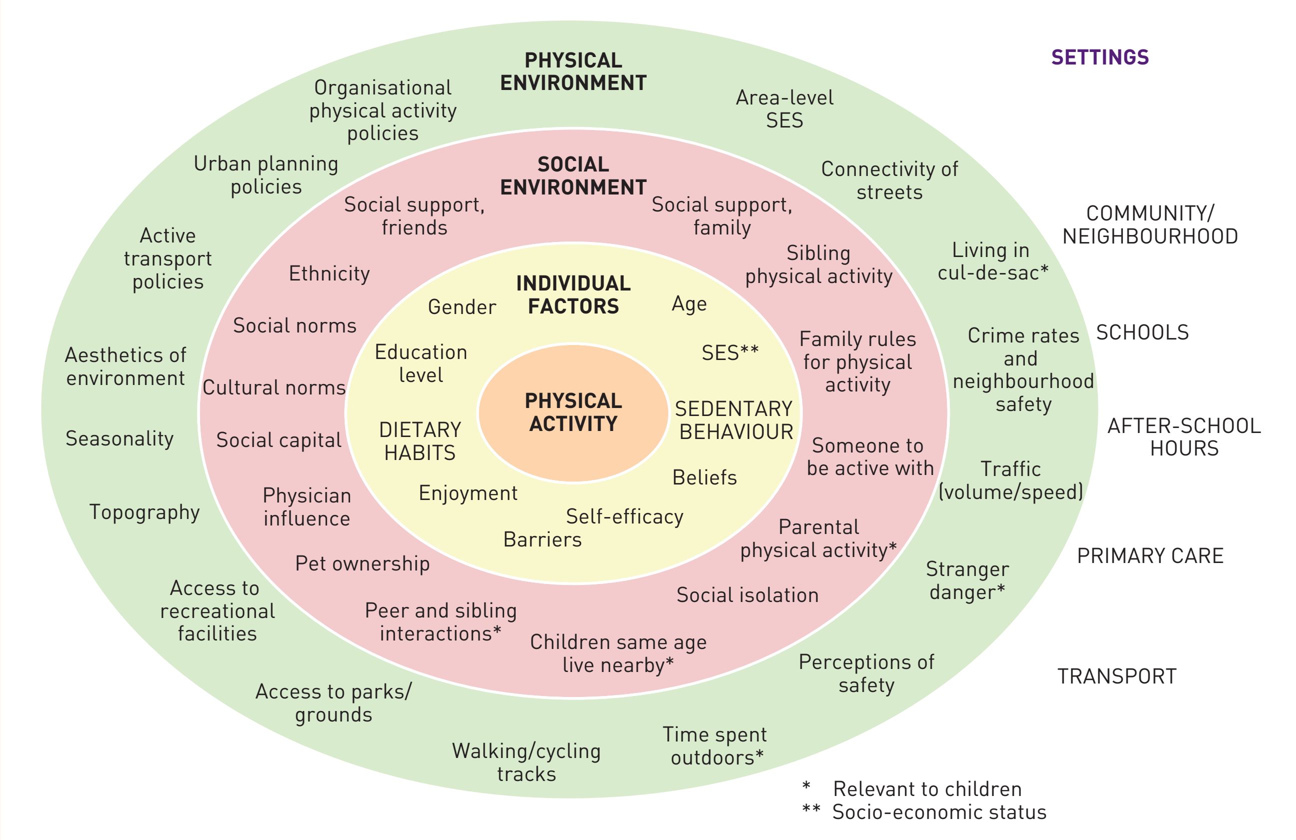


FIGURE 11.05 Social-ecological model of physical activity

Source: Salmon, J. & King, A. (2005). 'Population approaches to increasing physical activity among children and adults.' In D. Crawford & R. Jeffrey (eds), *Obesity Prevention in the 21st Century: Public health approaches to tackle the obesity pandemic* © Oxford University Press.

Multiple levels of influence

Within the social-ecological model, physical activity behaviour is determined by factors at four levels: individual, social environment, physical environment and policy. These are the factors that physical activity intervention programs need to target. This section looks in more detail at these four levels of influence, and a range of strategies that can be tailored to each of these levels (see Table 11.2).

Jose Luis Pelaez Inc/DigitalVision/Getty Images

FIGURE 11.06 Participating in a team sport provides social and emotional support. What are some of the other benefits associated with team sports?

iStock.com/ti-ja

yamasan/Adobe Stock

FIGURE 11.07 Physical activities also have their own culture. Think about surfing, alpine sports or skating, for example.

Video
In focus: Multiple levels of influence within the social-ecological model

Individual (intrapersonal) level

Factors in the individual (intrapersonal) level are individual characteristics, such as attitudes, behaviour, self-concept, behavioural skills (e.g. goal setting) or fundamental motor skill confidence and knowledge (e.g. comprehending the benefits of being active). Table 11.2 outlines a range of strategies that can be implemented at the individual level within various settings.

Stockpict Indonesia/Shutterstock.com

FIGURE 11.08 Increasing people's confidence to be active is an important individual-level strategy.

TABLE 11.2 Individual-level strategies

Setting	Example intervention strategies
Schools	• Increasing physical literacy, self-efficacy, knowledge about the importance of physical activity and competence in fundamental movement skills during school physical education and sport programs
Workplace	• Increased knowledge and awareness of physical activity options and active opportunities • Teaching behavioural skills such as goal-setting and problem-solving • Technology that provides individuals with virtual coaching or guidance through text messaging, telephone, internet or computer-tailored mailings
Community	• Educational programs (e.g. enrolling in a spin or Zumba class or Pilates) • Individuals can wear activity monitors that provide them with immediate feedback combined with goal-setting and coaching

REAL WORLD APPLICATIONS

Strategies to increase physical activity

The Centers for Disease Control and Prevention (CDC) in the United States suggests communities can implement evidence-based strategies to increase physical activity across sectors and settings. The CDC states that the provision of equitable and inclusive access is foundational to each strategy.

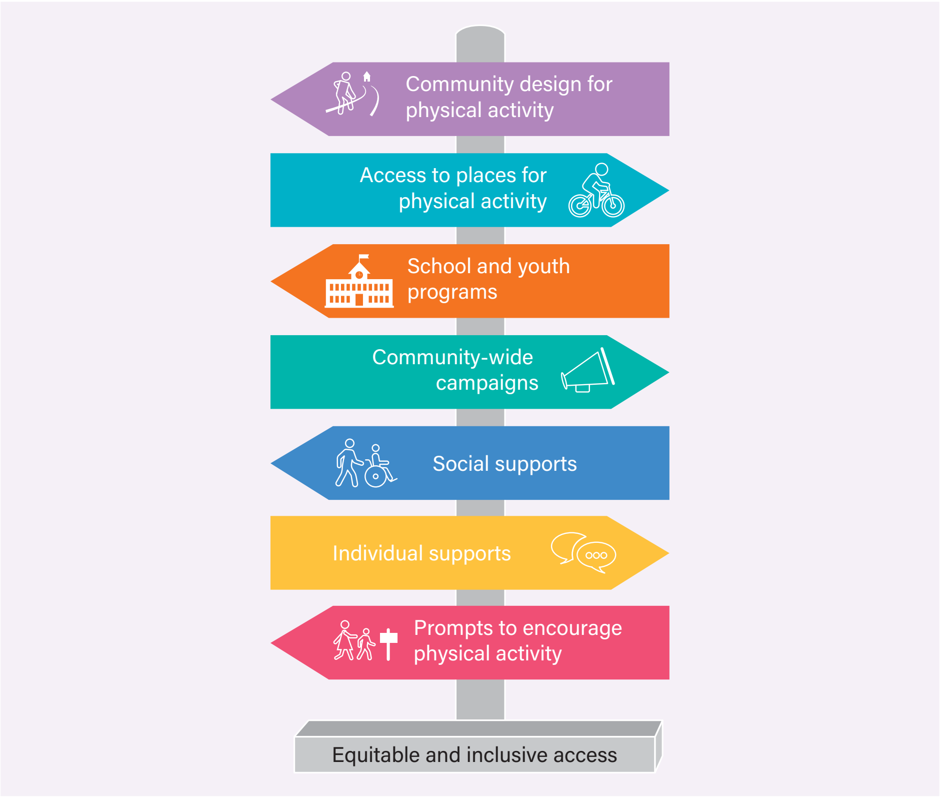


FIGURE 11.09 Strategies to increase physical activity. To explore each of the signposts and the base of this figure, go to the CDC website.

Source: CDC (2023). 'Strategies to increase physical activity.' Centers for Disease Control and Prevention. https://www.cdc.gov/physicalactivity/activepeoplehealthynation/strategies-to-increase-physical-activity/index.html.

Weblink
Strategies for increasing physical activity

Social environment level

The social environment level refers to the formal and informal social climate and support network and systems surrounding an individual (e.g. single or dual parents, siblings, extended family, peers). Supportive behaviours can come from primary groups, which include the family, work group and friendship circle. Supportive behaviours include providing or sharing transport to sport or a park, encouraging someone to be active, offering to be active with someone, and helping to pay fees. Table 11.3 outlines a range of strategies that can be implemented at the social environment level within various settings.

Strategies should focus on changing the culture (the nature of the existing social relationships) to encourage and provide support for physical activity. While the ultimate target of the strategies may be to increase physical activity in individuals, the interim targets are the social norms and social influences. For example, to increase the physical activity of individuals in a community aged-care facility, the interim target is to create a lifestyle activity culture within the facility.

Paul Hakimata Photography/Shutterstock.com

FIGURE 11.10 Having an active role model is a powerful strategy to encourage children to be active.

TABLE 11.3 Social environment strategies

Setting	Example intervention strategies
Schools	• Conduct student-led classes, to improve students' experiences, skills and ability, develop student leaders and enhance social connections across the school • Hold outdoor walking classes • Introduce a common-interest group or school working party of staff, students, families and organisations to develop sustainable ideas to promote physical activity • Ensure adequate supervision during lunch breaks • Train teachers to prompt and encourage students to engage in active play • Set up a peer-support program in which older students gather and play games, activities and sports with younger students • Establish after-school activity groups or clubs for a variety of activities such as tennis, cycling, aerobics, weight training, circus skills and dance. The emphasis should be on fun and on social interaction • Run physical activity events or activities and invite parental involvement; for example, fun runs, Great Victorian Bike Ride, camps, hiking, canoeing, volleyball, tennis or badminton round robins • Foster links between local community clubs/programs and school physical education • Ensure that teachers encourage students to join activity-related organisations
Workplace	• Run large activity events such as a workplace 'ride to work day' or enter a work team into corporate/community events such as fun runs, corporate lawn bowls, softball or social tennis • Implement lunchtime walking groups • Train supervisors, leaders, directors and coordinators in the importance of physical activity and strategies for encouraging other staff to be active • Encourage staff to seek social support from like-minded co-workers who are keen to be more active • Where possible, involve employees' partners and families in physical activity events, such as family days at the park, tenpin bowling, lawn bowls or a barbecue at the beach • Encourage staff to organise a walking or activity buddy to go for lunchtime walks, have a hit of squash or go for a bike ride with • Encourage managers to foster an environment that promotes activity at lunchtime or during breaks
Community	• Organised social competitions (e.g. tennis, indoor sports) • Encourage the development of, and participation in, walking clubs/groups at community centres or parks • Run 'come and try days' to provide opportunities for people to try new and different physical activities for a day or for an event; for example, a community walking event • Organise a 'meet the expert' day so people can hear about new physical activity programs or skills – for example, golf professionals, a Pilates instructor, a celebrity athlete • Introduce some community clubs/groups that do not focus on fitness; for example, fishing or gardening groups • Encourage people to seek and find an activity buddy to be active with • Train important community leaders and social groups to promote physical activity; for example, peer group counsellors, church leaders, elders • Encourage personal challenges, contracts between friends and family; for example, a competition to reach 10 000 steps per day, measured on a pedometer, on the greatest number of days in a week • Set up a community hotline that people can call for more information about physical activity programs • Implement family- or peer-focused sessions, activities or programs to encourage people to bring someone • Work with local healthcare providers to encourage patients to be active and to become involved in community programs • Run programs for people with similar conditions or needs; for example, older people or those with diabetes, cancer or disabilities • Implement community-based interventions that have had a focus on walking and transport

Physical environment level

PeopleImages.com – Yuri A/Shutterstock.com

FIGURE 11.11 Aesthetically pleasing environments enable physical activity.

Influencing factors

The physical environment plays a huge role in influencing physical activity behaviour. Having safe, accessible and aesthetic places to be active, such as parks, safe streets, walking and cycling trails, is vital to enable physical activity. Introducing ramps and smooth surfaces so that people using wheelchairs can access the various activity areas is essential. Being able to safely walk, ride or take public transport to everyday destinations such as shops, homes, workplaces, schools, parks, healthcare, pharmacies and food outlets is essential to encourage people to be active daily. Natural environment relates to topography (mountains, coasts, bush), weather and climate, and features that can create an attractive environment in which to be active, such as trees, water (beaches, rivers, lakes and creeks), grasslands and wildlife.

The built environment includes buildings, roads, public open spaces, public transport, parks, home and yard, ovals, gymnasiums, court areas, fields, grandstands, changing facilities, pools and car parking. It also includes walking trails, boardwalks and cycling paths. All these natural and built environment factors can be enablers and barriers at the physical environment level. Table 11.4 outlines a range of strategies that can be implemented at the physical environment level within various settings.

Many new housing estates build walking trails, cycling paths, parklands and even water features to incorporate opportunities to be active.

TABLE 11.4 Physical environment strategies

Setting	Example intervention strategies
Schools	• Introduce pop-up play spaces to provide new play experiences • Use a variety of equipment or objects, such as car tyres, to stimulate creative play • Develop well-equipped playgrounds with playground equipment, line markings on courts, walls, grassed areas, goal posts • Establish walking/cycling paths around the school perimeter for use by students, families and the community • Ensure adequate traffic calming measures (such as speed humps, signage, roundabouts) in streets around schools to increase safety for pedestrians and cyclists • Introduce a bike shed or bike-lockable area with racks • Ensure outdoor fields and courts have lights for evening use by community groups • Have an extensive range of movable equipment available for student use, such as basketballs, frisbees, tennis balls and skipping ropes
Workplace	• Put up posters in staff areas listing the consequences of inactivity, the health benefits of regular physical activity, or how to perform specific exercises such as stretches • Put up posters in staff areas demonstrating how to exercise while sitting at a desk or standing at the photocopier • In a variety of places, display newsletters, booklets, pamphlets, brochures, flyers and bulletin boards promoting physical activity programs at work and in the local area • Provide employees with a safe and secure location to lock up their bicycles • Provide changing facilities, showers, lockers and exercise facilities • Post signs publishing distances from place to place around the building, or to various destinations in the surrounding area • Construct walking and cycling paths/trails around worksite grounds • Display signage promoting the use of stairs. Stairwells should be accessible, well-lit and with music where possible
Community	Town planners should: • maximise walkability and rideability of community streets • have footpaths and ensure trails and paths link important destinations such as public transport, schools, housing, parks and shops • ensure parks include shade, seating and drinking water • plant trees and other vegetation and water features to encourage activity • incorporate traffic calming strategies, lighting, benches, public bathrooms, shade, landscaping • include a mix of land use such as residential, office, commercial (cafes, retail) and industrial

CartoonStock.com/Arnaldo Almeida

FIGURE 11.12 Choosing the stairs over an escalator will expend significantly more energy over an extended period, which for some people in the workplace could make a healthy difference.

REAL WORLD APPLICATIONS

Changes to the physical environment are more effective when accompanied by supportive policy

Many communities are putting an increased emphasis on factors that enable and prevent travel-related physical activity largely focusing on the built environment. While there is evidence of a consistent positive relationship between walkability and the existence of facilities that support active travel, we know from research that travel behaviour, including active travel, is complex and shaped by multiple levels of influence. If there is a disproportional emphasis on making changes at the built environment level (physical environments) without considering other influencing factors, this will be insufficient to design effective active travel promotion strategies.

Regardless of what modes of transport are available to travel somewhere, often the decision about how you travel is based upon the purpose of the journey. Even workplace policies can be a barrier to active commuting, especially if staff cannot bring their bikes into the office. A barrier at the individual level might be someone not feeling confident and safe walking to the train station after work, so instead relying on car use. More research is needed in order to gain a better understanding of enablers and barriers in domain-specific physical activity such as travel to inform the design of initiatives and programs to encourage active transport (Garcia et al., 2022).

Policy and organisational level

Policies include laws, regulations, formal and informal rules or understandings that are adopted to guide individual and collective behaviour. Curriculum and national guidelines for physical activity, sedentary behaviour and sleep for different population groups are examples of policy.

Organisational factors are organisational characteristics of social institutions, including rules (formal and informal), regulations, guidelines and governance of operation. These can relate to incentives, resources and infrastructures for activity or inactivity. The policy and organisational factors can be both enablers and barriers at the policy level. Table 11.5 outlines a range of strategies that can be implemented at the policy level within various settings.

TABLE 11.5 Policy and organisational strategies

Setting	Example intervention strategies
Schools	• Encourage multiple uses of spaces for a variety of sports, games and activities, such as putting temporary tennis nets on a basketball court • Share trained teachers, sports equipment and temporary play facilities with nearby schools to reduce costs and enhance physical activity opportunities for students • Foster links with sports and recreation clubs, local councils, or creating new non-traditional community partnerships, for example, with local workplaces • Strengthen relevant school policies to support physical activity • Incorporate outdoor activities and projects in subjects such as maths, science and geography • Use sport, dance, active play or walking in delivering the school curriculum • Use standing lessons to break up extended sitting time • Engage students in the design and provision of safe and secure bike parking • Ban all staff from using physical activity as a form of punishment • Ensure the recommended time (mandate) for physical education and sport is met by timetabling • Allocate funds for staff professional development in the areas of physical activity promotion and physical education • Incorporate lifetime physical activity throughout the school curriculum, not just for team sports • Establish rules around the use of portable devices during break periods • Seek and obtain funding from government and non-government organisations for new or improved physical activity facilities • Incorporate SunSmart policies into physical activity planning • Make changes to the school day to extend lunch breaks • Ensure school grounds, facilities, fields and gymnasiums are accessible to the community during non-school periods; for example, at night-time and holiday periods
Workplace	• Implement organisational incentives directed at individuals (e.g. subsidised gym memberships for staff who go to the gym at least once per week) • Close escalators or lifts (other than to people using wheelchairs, crutches, walkers or who have physical conditions) for one week and replace with increased signage encouraging use of stairs • Develop a promotional strategy: name of program, logo, T-shirts, pens, magnets. Launch the program with a celebrity or CEO and invite the press • Send organisation-wide emails regularly, encouraging staff to move around for a few minutes each hour; for example, go for a short walk or stretch • Negotiate a discount with health insurance providers for active employees • Ensure work hours are flexible so employees can include physical activity time within their workday; for example, have a longer lunch to attend a class and finish later • Establish a workplace health and wellbeing committee that provides recommendations to management relating to physical activity promotion • Negotiate discounted rates for employees at several physical activity facilities and program providers
Community	• Develop a community directory (resource list) that lists all the local physical activity facilities and programs, including sporting clubs; provide people with costs and contact details • Regularly distribute brochures of Australian physical activity and sedentary behaviour guidelines • Encourage recreation and leisure centres to offer single- or multiple-session introductory activity classes for gym, swimming and aerobics

DID YOU KNOW?

The terms 'access' and 'availability' should not be used interchangeably. As an example, a wonderful facility may be available around the corner from where you live, but if you cannot access it due to cost or opening hours, then it will not be an enabler.

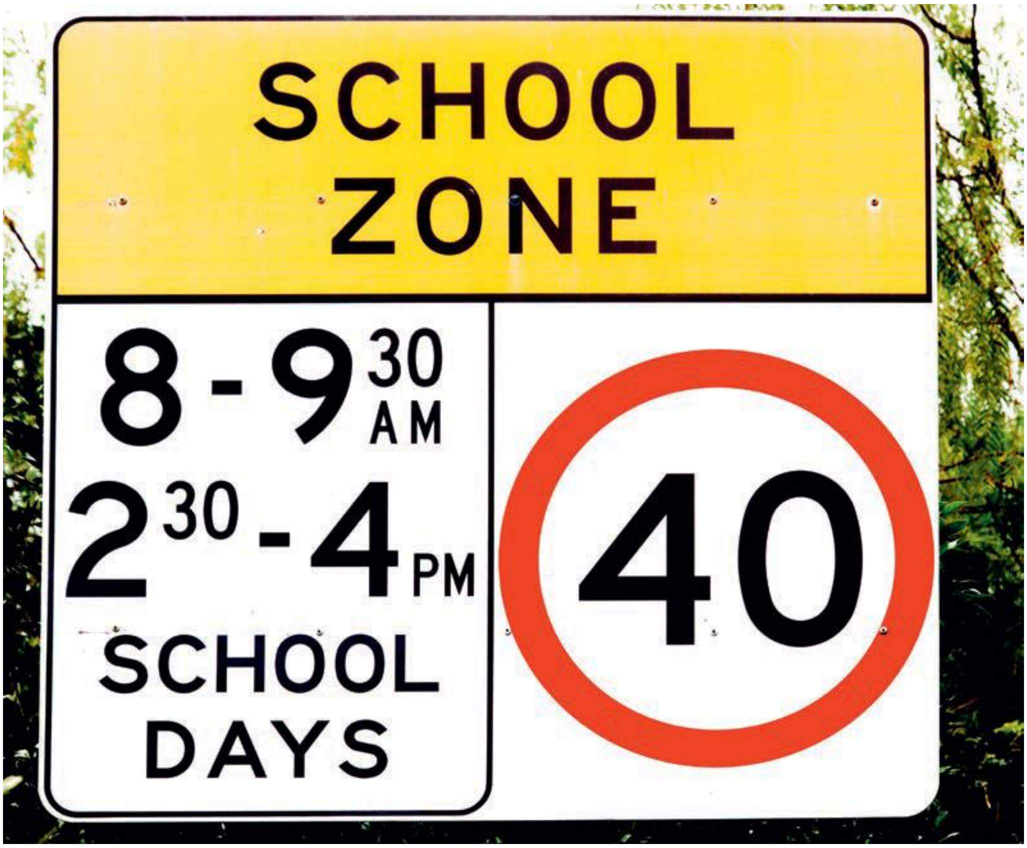


FIGURE 11.13 School zones are designed to keep children safe during peak school travel times. There are heavy penalties for drivers exceeding school zone laws.

WORKED EXAMPLE

BUILD IT AND THEY WILL COME ... OR WILL THEY?

Question 1

a Introducing new resources and facilities can be a useful environmental strategy for the promotion of physical activity. Would building a set of bike racks on an unused car parking space be a change to the natural environment or the constructed environment? **Explain** your answer.

b **Describe** four examples of changes that could be made to facilities in a workplace to promote physical activity.

c **Describe** an educational program that could support these environmental changes.

d Provide an example of a **policy** that could also accompany the environmental changes you proposed in part b.

Suggested responses:

a *Building a set of bike racks on an unused car parking space would be a change to the constructed environment, as a car park is constructed.*

In this question, students need to be able to understand the difference between the natural and constructed environment. If a set of bike racks were placed at the start of a woodland walking trail, requiring the natural environment to have trees or vegetation removed or levelling of soil etc. that would be a change to the natural environment. Whereas if the bike racks were placed in an unused car parking space, that is a change to the constructed environment.

>

>

b Responses need to describe four examples describing changes to the physical environment. Examples include:
- installing shower and changing facilities to promote active transportation to the workplace
- placing signage near elevators encouraging people to take the stairs, which can raise awareness of easy ways to increase incidental physical activity
- installing bike racks to encourage active transportation to work
- installing gymnasium equipment such as exercise bikes and treadmills
- establishing an 'activity room' containing a table tennis table, which may act as a physical activity prompt for employees.

c *To support the environmental change of installing bike racks, employers could conduct a quality bicycle education program within the workplace. This might include information about safe routes to work, road safety, cycling technique and bicycle maintenance.*

Any educational program that increases people's knowledge and skills in relation to bike riding would be appropriate.

d A policy to accompany the environmental changes proposed in part b could involve allocating one day per week when those who have used active transportation to get to work can finish work 20 minutes *earlier*.

Any change to policy, laws that would increase access or safety in relation to workers using the bike racks and commuting to work would be appropriate.

REAL WORLD APPLICATIONS

Victorian Physical and Sport Education Mandate

Another example of organisational policy affecting physical activity is the Physical and Sport Education Mandate. This policy was introduced in all government schools in 1993 by the Department of Education and Training. Since its inception, all state governments have supported it. The mandate states that all government schools must meet compulsory time requirements for sport and physical education for students from Prep to Year 10. This means that all government schools are expected to timetable:
- Prep to Year 3: 20–30 minutes of physical education per day
- Years 4–6: 3 hours a week of physical education and sport with a minimum of 50 per cent of that time for physical education
- Years 7–10: 100 minutes per week each for physical education and sport.

The physical education and sport mandate is an extremely important policy, and it makes up a significant proportion of many children's and adolescents' weekly physical activity. Unfortunately, many schools do not meet this mandate.

QUESTIONS

1. **Discuss** whether your school meets the mandate for physical education and sport at various year levels.
2. **Describe** how the Department of Education and Training could monitor and enforce this policy.
3. **Explain** three key strategies that primary schools with no designated physical education teacher could implement to support classroom teachers in providing quality physical education and to ensure the mandate is met each week.

COLLABORATIVE TASK

Prac activity

Audit of school physical activity behaviours and environment

1. Go for a walk around your school. Create a map of your school, and identify the physical activity areas. Develop an appropriate legend to denote various facilities and features. You should take some photos to help you complete your audit when you return to your classroom.
2. Also on your map, identify potential barriers to people being active (for example, out-of-bounds areas, unsafe surfaces, areas that are inaccessible for wheelchairs).
3. Identify the natural and built environmental features within your school that enable physical activity or are potential barriers to physical activity. Also consider what features foster sedentary behaviour.
4. Make a list of the policies within your school that may either encourage or be a barrier to physical activity opportunities.
5. From your observations, suggest six strategies that could be employed in your school to further promote physical activity. These strategies should be easily sustained and inexpensive to conduct. Identify whether each strategy is a short- or long-term strategy and how it would be implemented. Try to suggest at least one strategy within each of the following categories: social environment, physical environment, policy and organisation.
6. Discuss which strategies address the recommendations for school and community programs promoting physical activity among young people.

Critiquing physical activity programs

Video
In focus: Critique of a physical activity program

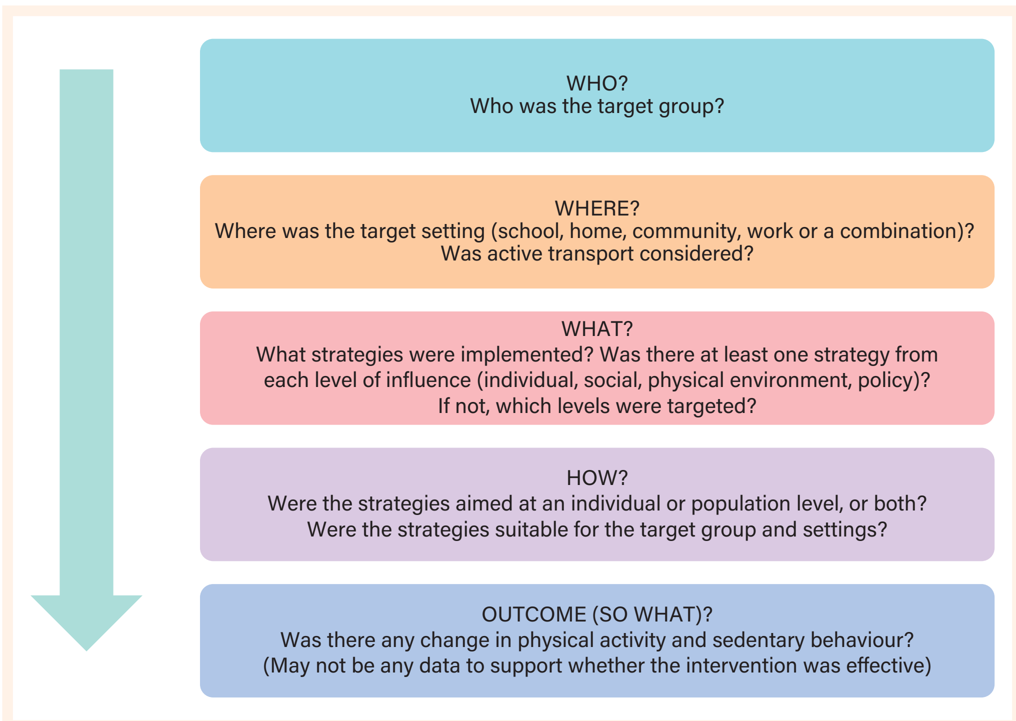


FIGURE 11.14 A framework for critiquing physical activity intervention programs based on the social-ecological model

CASE STUDY — CULTURALLY APPROPRIATE STRATEGIES AND INITIATIVES TO PROMOTE PHYSICAL ACTIVITY AMONG OLDER FIRST NATIONS PEOPLES

CONNECTING AND RECONNECTING TO A COMMUNITY, WITH A SENSE OF BELONGING – EXPLORING ABORIGINAL ELDERS' PERSPECTIVES OF ENGAGING IN A PHYSICAL ACTIVITY PROGRAM

15 FEBRUARY 2022

FIGURE 11.15 The Ironbark Tree, showing Elders' perspectives about the benefits experienced from participation in the Ironbark program.

Source: Gidgup, M. J. R., Kickett, M., Hill, K. D., Francis-Coad, J., Weselman, T., Coombes, J., Ivers, R., Bowser, N., Palacios, V. & Hill, A. M. (2022). 'Connecting and reconnecting to a community, with a sense of belonging – Exploring Aboriginal Elders' perspectives of engaging in a physical activity program', *Health Promotion Journal of Australia*, 28 Oct, Vol. 33, Issue S1, pp. 138–49. DOI: 10.1002/hpja.582.

An essential part of designing physical activity programs for specific target groups is to ensure they are tailored, culturally appropriate and the programs have values and principles that respect local community culture and knowledge. A qualitative exploratory study (Gidgup et al., 2022) looked at how engaging in a culturally appropriate physical activity program impacted on the lived experience of Aboriginal Elders living in Noongar Country in Western Australia. The Elders participated in a community-based program known as the 'Ironbark program', which consisted of:

- weekly exercises with a focus on strength, balance and functional exercise using a range of physical activity and exercise equipment under the supervision of physiotherapists
- intermittently dancing and walking to background music
- a **yarning** circle, in which people shared about health-related information relating to full prevention.

To interview Elders about their experiences, a local Noongar Wadjuk researcher used a yarning circle.

QUESTIONS

1 **Describe** why yarning was used as part of the Ironbark program.
2 **Identify** two benefits of the program perceived by participants that could be classified as: (a) mental and emotional health benefits and (b) physical health benefits.
3 **Describe** an example strategy used at the (a) individual level, (b) social environment and (c) physical environment in the Ironbark physical activity initiative.
4 **Discuss** why you think the Ironbark Tree was selected as the name for this particular physical activity initiative. You may need to watch the YouTube clip about this program.
5 Using the social-ecological model, **critique** the Ironbark program.
6 **Explain** why tailoring the program to the needs of First Nations peoples was critical to its success.

yarning
An informal conversation that is culturally friendly and recognised by Aboriginal and Torres Strait Islander peoples as meaning to talk about something or someone or provide and receive information. Yarning circles are designed to allow all participants to have their say in a safe space without judgement


Stephen Dwyer/Alamy Stock Photo

FIGURE 11.16 Yarning has been used by First Nations Australians for thousands of years. It allows information to be shared in a culturally safe manner.

Weblinks
Ironbark Project
The Ironbark Project video

SIGNPOST

Visit the Ironbark Project website to read more about the program, including a video.

COLLABORATIVE TASK
Laboratory report

Applying social-ecological models

The most effective interventions will incorporate at least one strategy from at least three different levels of influence within the social-ecological model.

AIM

Using a social-ecological model, critique strategies aimed at promoting physical activity or reducing sedentary behaviour among certain target groups

METHOD

1 Identify an intervention program or initiative being implemented to promote physical activity or reduce sedentary behaviour within a school, workplace or community setting. What is the name of this program?
2 Describe the target group the intervention is aimed at and identify the setting.
3 Use the social-ecological framework template below to identify strategies used by your chosen intervention program. A template is available on Nelson MindTap. You will need your login code. Tick the appropriate boxes for the strategies used and factors being targeted within each level of influence.

Resource
Template: Social-ecological framework

DISCUSSION

1 Describe whether the program you critiqued has employed a social-ecological framework.
2 Discuss two strategies used within each of the levels of influence.
3 Explain how you could evaluate whether the intervention has been effective.

>

Social-ecological framework template			
Name of intervention program:			
Are the following factors used in the program's strategies? Write Y (yes), N (no) or n/a (not applicable) in each box.			
Individual (intrapersonal) factors	**Environment**		**Policy and organisational factors**
	Social (interpersonal) environment factors	**Physical environment factors**	
☐ Increases knowledge attitude towards physical activity. ☐ Increases self-efficacy. ☐ Enhances behavioural skills (e.g. goal-setting, reward systems, reminder systems). ☐ Builds fundamental motor skill confidence. ☐ Implements education programs. ☐ Uses mass media. ☐ Uses counselling. ☐ Involves support groups. ☐ Uses incentives.	☐ Considers family. ☐ Considers peer group, friends. Considers social support via: ☐ someone to be active with ☐ someone to encourage physical activity ☐ someone to drive to venues for physical activity. ☐ Considers relationship with work colleagues. ☐ Considers neighbours. ☐ Provides access to role models. ☐ Provides new social networks and/or opportunities. ☐ Provides new social roles (e.g. player, coach). ☐ Includes social events, meetings, training.	☐ Changes the built environment (e.g. new walking trails, traffic calming). ☐ Removes barriers in the environment. ☐ Considers the natural environment (e.g. coastal area, climate). ☐ Includes new facilities (e.g. gymnasium, tennis courts, oval). ☐ Provides access to showers and changing facilities. ☐ Increases accessibility. ☐ Introduces signs. ☐ Provides new equipment (e.g. playground equipment, balls). ☐ Provides shelter near activity areas (e.g. shade cloth).	☐ Creates organisational change (e.g. timing, programming, changes to Physical Education). ☐ Changes rules, guidelines, governance, policy. ☐ Uses new resources and funding. ☐ Forms new partnerships or networks. ☐ Changes the power structure. ☐ Targets changes in social norms or beliefs.
☐ At least one factor above has been addressed.	☐ At least one factor above has been addressed.	☐ At least one factor above has been addressed.	☐ At least one factor above has been addressed.

FIGURE 11.17 Template for critiquing strategies within a social-ecological framework

REAL WORLD APPLICATIONS

Interview with Professor Jo Salmon

FIGURE 11.18 Professor Jo Salmon

Jo Salmon is Alfred Deakin Professor and Director of the Institute for Physical Activity and Nutrition in the School of Exercise and Nutrition Sciences, Deakin University. Professor Salmon has previously been supported by a Principal Research Fellowship (National Health and Medical Research Council), a Career Development Award (National Heart Foundation of Australia) and a VicHealth Public Health Research Fellowship.

Jo, how did you get into this career path? What is your background?
I have an academic background in psychology and behavioural science and a practical background in dance and the fitness industry. I worked in gyms for about 13 years. So, I was able to 'marry' my two loves, being physically active with understanding the psychology of why people are or are not active.

Can you explain in plain language what is meant by an ecological model?
An ecological model provides a useful framework for explaining the many levels of influence on participation in physical activity, including: the individual level (for example, biological and cognitive factors such as age or weight status and physical activity preference or motivation); the social level, such as social networks and influences (for example, family and peers); the cultural level (for example, ethnicity); the physical level (for example, the presence of a nearby park or access to public transport); the policy environment (for example, restricting dog walkers on a beach to certain hours of the day); and the economic environment (for example, funding provision for development of new sports complexes). All of these levels of influence interact and combine to help us understand facilitators and barriers to being active.

What is the key benefit of ecological frameworks over individual models of physical activity?
Individual models of physical activity only focus on what a person thinks or believes about activity. They are not a reflection of real life which, as noted above, is influenced by factors external to a person in addition to cognitive factors (that is, what is going on in a person's head). For example, a person might be highly motivated to participate in physical activity; they might have high self-efficacy and positive beliefs about the benefits of being active. However, the environment in which they live may be very unsupportive and make being active very difficult. There are also hybrid models and theories available, such as the Youth Physical Activity Promotion model that incorporates social influences (reinforcing the behaviour), individual influences (Am I able? Is it worth it?), enabling influences (fitness, skills, access) and personal demographics (age, sex).

Could you describe an example of how you have employed a social-ecological framework in your research within schools, workplaces or the community?
We developed a comprehensive primary school-based initiative, Transform-Us!, that successfully reduced children's sitting, promoted their physical activity and benefited children's health over a 2.5-year period. The program was based on an ecological framework and incorporated changes to the physical environment inside and outside the classroom, changes to pedagogical practice, and engaged teachers and parents in supporting children's active play during school and active homework after school hours.

Please explain how you employed a social-ecological approach to design and implement and evaluate an intervention program.
As described in the Transform-Us! program, this incorporated an ecological model and also drew on social cognitive theory and behavioural choice theory. One of the significant outcomes of this study was that the results got stronger over time. It is rare for an intervention study to show strengthening of results in this way, and this suggests that changes to the environment and teaching practices in this instance led to changes being sustained, rather than diminishing, over time.

QUESTIONS

1 **Identify** examples of factors Professor Salmon listed within each level of the social-ecological model.
2 **Explain** how the Transform-Us! study employed a social-ecological approach.

SIGNPOST

Watch a short interview with Professor Jo Salmon on the social-ecological model.

Video
The social-ecological model – Jo Salmon

COLLABORATIVE TASK
Prac activity

Auditing physical activity environments

An excellent population-level promotion strategy is to enhance the built environment to improve its walkability.

EQUIPMENT

One pedometer or activity tracker (e.g. a smart watch with a pedometer function) per person

AIM

To become familiar with the skill of auditing physical environments (built environments) within a community setting to identify factors encouraging physical activity and potential barriers to physical activity

BACKGROUND

In urban design, 'walkability' is the measure of the overall walking conditions in an area. Factors that commonly make up walkability indices include shade, aesthetics, lighting, crossings, access to footpaths, traffic calming, driver behaviour, safety and crime. In this activity, you will explore factors affecting the walkability of your local community setting.

WALKABILITY EXERCISE

1 Go for a walk around your community.
2 Using the neighbourhood walkability checklist produced by the Australian Heart Foundation, rate the walk. You can find the checklist on the Australian Heart Foundation website.
3 Refer to the section that outlines what can be done to improve walkability of communities. Identify five barriers to walking and five strategies to address these issues based on your assessment of this area.
4 Total distance ______________ and total steps _____________.

Weblink
Neighbourhood walkability checklist

REAL WORLD APPLICATIONS

Albert Park Lake

The iconic Albert Park Lake in Melbourne is a magnificent place to be physically active. You could go for a jog, cycle, walk with your dog or enter one of the many fun runs organised at this location. A full lap of the lake is 4.8 kilometres. The track is mostly flat and is made up of a mix of concrete, gravel and sand in various sections. The path is dotted with water fountains. Albert Park Lake has swimming, diving and other indoor sports facilities and fitness gyms at the Melbourne Sports and Aquatic Centre. Lakeside Stadium also features an athletics track and a FIFA-sized football pitch. You can sail, canoe, kayak or row on the lake, or visit one of the playground areas. The Albert Park Golf Course also runs adjacent to the lake. There is something for everyone in this incredible activity precinct.

>

>

allan/Adobe Stock

FIGURE 11.19 Walkability is influenced by safety and aesthetics.

QUESTIONS

1 **Outline** aspects of the physical environment would enable physical activity in the Albert Park Lake area?
2 **Discuss** what about this area might be a barrier to physical activity, and for whom.
3 Give some possible suggestions to reduce the barriers you identified in question 2.

Tailoring the social-ecological models

Social-ecological models need to be tailored to each behaviour or health condition. They must also be tailored to the needs, attitudes, interests and behaviours of a specific population. Different populations require different implementation strategies, even if they have common components across the social-ecological model. For example, children and adults will perform different physical activities in different settings using different equipment.

Dziurek/Adobe Stock

FIGURE 11.20 A one-size-fits-all approach to designing physical activity initiatives is destined to fail.

COLLABORATIVE TASK
Activity/Prac activity/Lab activity

Active schools framework

'The active schools framework describes the relationship between the active school priorities that support a student to be active. An active school encourages physical activity through a whole school approach that goes beyond traditional physical education and sport to promote physical activity at every opportunity' (Department of Education Victoria, 2024).

FIGURE 11.21 Active schools framework

Victorian Government, Active schools framework, https://www.schools.vic.gov.au/active-schools-framework

The active schools framework 'describes the relationship between the active school priorities that support a student to be active. These key priorities recognise that there is no single solution to shifting inactivity; it takes a multifaceted effort.' The priorities of an active school are outlined in Table 11.6.

TABLE 11.6 Active schools framework priority areas

Priority area	Description
Quality physical education	Quality physical education involves: • meeting minimum time for Physical Education for Foundation–Year 10 • delivery of a Victorian Curriculum aligned teaching and learning program • teachers who are competent and capable in Physical Education instruction • a safe, inclusive and encouraging learning environment for students of all ages and abilities.

Priority area	Description
Quality school sport	Quality school sport provides opportunities for all students to participate in a format suitable to their age, skill and ability while also linking students with local sporting clubs. It is: • inclusive and accessible • encourages participation over performance • creates links with local community sports clubs • teaches resilience, teamwork and fosters a sense of school pride • includes a diverse range of sporting activities to cater to varying interests. There are many options for year-round school sport delivery within schools including: • sport education programs • intra-school sports events (e.g. school swimming carnivals) • inter-school sport • inter-state school sport opportunities.
Active classrooms	Active classrooms incorporate movement into classroom learning helping them retain knowledge in a meaningful way. Small changes in the classroom can have a big impact on student learning, health and contribution to their daily activity levels. An active classroom involves: • active breaks between and within learning activities • learning activities which involve movement • working at benches, standing desks, on the floor, or in combination to create movement between work areas • learning outdoors.
Active travel	Being active on the way to and from school contributes significantly to a student's daily physical activity and increases social and community connectedness. It also has many other benefits including: • increasing social interactions with family and friends • fostering school and community connectedness • supporting mobility independence and familiarity with the neighbourhood • reducing road and public transport congestion and pollution. Schools can support active travel by: • encouraging parents to support their children to actively travel to school • providing facilities that support active travel to and from school for students, staff and families (e.g. bike racks, bike shelters) • offering bicycle education programs and guidance on safe routes to school • working with families and local councils to provide safe and convenient routes to schools.
Active recreation	Active recreation includes active play and recreation before, during and after school (inclusive of recess and lunch), outdoor learning, incursions, excursions and school camps. Unstructured, leisure-based physical activity is vital to children and young people's daily activity levels. Providing access to a range of developmentally appropriate, fun and non-competitive active recreation options allows all children and young people to find activities they enjoy. Schools can support active recreation by: • encouraging outdoor play and recreation to help students develop fundamental movement skills and physical strength whilst being adventurous and having fun • using outdoor learning to increase physical activity by connecting classroom-based learning with field-based experiences • offering and promoting active recreation options to students who are disinterested in traditional organised school sports • appropriate provision of free time and unstructured lunch and recess breaks.

As described on the Active Schools website:

A supportive school environment that provides space and encourages students to be active is also required to shift physical activity outcomes.

The core of the framework acknowledges the importance of schools, family and community as influences of a student's level of physical activity. Families and communities are crucial in supporting students to continue their participation in physical activity beyond the school environment.

An active school is a school that values and commits to promoting physical activity through curriculum, general school life and the local community, and can support a child to become **physically literate** and active for life.

An active school encourages physical activity through a whole-school approach, which goes beyond traditional physical education and sport, to promote physical activity at every opportunity throughout the day.

This toolkit provides guidance and practical strategies that schools and teachers can use to help them become an active school.

Many schools may already be taking action in some of these areas, but many also need support to enhance their current approach.

The active schools framework will support schools to begin this conversation and start taking action. It also provides guidance to stakeholders in the sector, the community and government when making decisions on physical activity interventions.

QUESTIONS

1 Use the social-ecological model to critique the active schools framework.
2 Use Table 11.6 to **evaluate** which elements of the active schools framework are being addressed and which areas could be addressed.

physical literacy
Involves holistic lifelong learning through movement and physical activity. It delivers physical, psychological, social and cognitive health and wellbeing benefits

11.1 CHECK-IN QUESTIONS

1 **Identify** the four levels of influence within the social-ecological model.
2 **List** the suggested evidence-based strategies to increase physical activity across sectors and settings for communities recommended by the CDC.
3 **Identify** three examples of policy intervention strategies.
4 **Describe** what the term 'reciprocal causation' refers to.
5 **Outline** three traffic-calming strategies that communities could introduce around schools to encourage more active commuting to school, and justify why these are necessary.
6 **Describe** one example of a policy change a school could introduce to reduce sedentary behaviour during breaks.
7 **Explain** the difference between the natural and constructed environment and recommend an example intervention strategy for each that would enable more children to be active within a community setting.
8 **Explain** why it is important for social environment strategies to focus on changing culture when trying to encourage communities to be active.

Assessment
11.1 Check-in questions

Command terms

describe
Provide characteristics, features and qualities of a given concept, opinion, situation, event, process, effect, argument, narrative, text, experiment, artwork, performance piece or other artefact in an accurate way

outline
Provide an overview or the main features of an argument, point of view, text, narrative, diagram or image

11.2 PHYSICAL ACTIVITY PROMOTION

In this module you will learn about:
- a range of population-based initiatives that target enablers of and barriers to physical activity

and learn to:
- apply the social-ecological model to critique and create physical activity initiatives and strategies aimed at increasing physical activity and/or reducing sedentary behaviour.

So far, this chapter has discussed components of the social-ecological model, which uses a combination of approaches at both the individual level and the population level. As physical activity is an extremely complex health behaviour, the most effective interventions target changes in multiple levels of the social-ecological model:
- individual (intrapersonal)
- social (interpersonal)
- physical environment
- policy.

Varying approaches to health promotion are commonly used when promoting physical activity. Physical activity promotional strategies can be classified into two major categories: individual approaches and population-based approaches. Different strategies are used depending on the level being targeted. This section explores population-level strategies used to promote physical activity and reduce sedentary behaviour.

LOOKING FORWARD

Individual-level strategies

Chapter 13

In Chapter 13 we will explore individual-level strategies for promoting physical activity and reducing sedentary behaviour.

LOOKING BACK

Settings-based approach to physical activity promotion

One, or several, individual-level and/or population-level strategies may be applied within a **settings-based approach** to physical activity promotion. The setting or focus, for example, might include primary schools, a specific community, families or workplaces. Earlier in this chapter we explored intervention strategies used to promote physical activity within school, workplace and community settings.

settings-based approach
A strategy in which promotional strategies are delivered within a defined setting (geographical area or institution)

DID YOU KNOW?

According to the Global Action Plan on Physical Activity 2018–2030, the World Health Organization's target is to achieve 'a 15% relative reduction in the global prevalence of physical inactivity in adults and in adolescents by 2030.'

Population-based approaches

In contrast to individual-level approaches, population-based approaches are designed to influence the population en masse, or at scale, by reaching and enabling large numbers of people within specific population groups. Population-level approaches usually relate to one or a combination of the following three things: (a) environmental change, (b) mass media and (c) policy.

The World Health Organization (WHO, 2007) made the following recommendations for population-based approaches to increasing levels of physical activity. These are considered important elements of successful policies and plans. In order to succeed, a population-based approach must:

- have a high-level political commitment
- integrate with national policies, have **SMART goals** and objectives and have national physical activity guidelines
- be funded sufficiently and sustainably rather than being short term
- foster collaboration and support from stakeholders across all sectors
- be culturally sensitive, socially inclusive and consider cultural ties, customs, family ties, gender roles, social norms, languages and dialects
- consist of a coordinating team that represent multisectoral areas and leverage existing infrastructure to coordinate different stakeholders and sectors, mobilise resources, plan, implement and evaluate interventions at national, regional and local levels
- employ multiple strategies aimed at supporting the individual and at creating a supportive environment. To target different populations, a combination of strategies is needed, such as community-wide mass media campaigns to raise awareness about the importance and benefits of physical activity; enhancing accessibility of places for people to be active (i.e. provision of local play facilities for children, building walking trails, enabling active transport to work; primary care providing educational counselling to provide advice for older persons; formation of social networks that foster physical activity
- target the whole population as well as specific population groups
- have a clear identity by having a common program name, logo, mascots, and other branding that can be used in mass media campaign and local initiatives
- include implementation at different levels within the 'local reality'
- include upskilling of leadership and workforce development to provide information from a range of stakeholders; and motivating and rewarding local initiatives for their achievements
- disseminate the national action plan; programs and strategies need to be widely disseminated including the primary messages and materials via print media, electronic media, regional/local events, influential individuals, role models, famous/popular individuals, advocates
- use ongoing monitoring and evaluation to evaluate the effectiveness of the plans and strategies implemented. Outcome evaluation may occur via the use of standardised measures of physical activity through national surveys and monitoring systems (as discussed in Chapter 10). Process evaluations will document the type of programs and strategies used (i.e. mass media-based promotions, dissemination of educational materials to schools/worksites, provision of local physical activity programs, provision of training sessions).

SMART goals
Specific, Measurable, Achievable, Relevant and Timely

LOOKING BACK
Measuring physical activity

Chapter 10

In Chapter 10 we looked at the use of national surveys and monitoring systems to evaluate physical activity.

CASE STUDY GLOBAL ACTION PLAN ON PHYSICAL ACTIVITY

GLOBAL ACTION PLAN ON PHYSICAL ACTIVITY 2018–2030: MORE ACTIVE PEOPLE FOR A HEALTHIER WORLD

2018

The new WHO global action plan to promote physical activity responds to the requests by countries for updated guidance, and a framework of effective and feasible policy actions to increase physical activity at all levels, this is referred to as a **systems-based approach**. It also responds to requests for global leadership and stronger regional and national coordination, and the need for a whole-of society response to achieve a paradigm shift in both supporting and valuing all people being regularly active, according to ability and across the life course. The action plan was developed through a worldwide consultation process involving governments and key stakeholders across multiple sectors including health, sports, transport, urban design, civil society, academia and the private sector.

systems-based approach
Involves applying systems thinking, methods and practice to better understand the promotion of physical activity behaviour and identify challenges and collective actions

Physical activity and the Sustainable Development Goals 2030

Investing in policies to promote walking, cycling, sport, active recreation and play can contribute directly to achieving many of the 2030 Sustainable Development Goals (SDGs). If you are also studying Health and Human Development you will notice that policy actions on physical activity have multiplicative health, social and economic benefits, and will directly contribute to achieving SDG3 (good health and well-being), as well as other Goals including SDG2 (ending all forms of malnutrition); SDG4 (quality education); SDG5 (gender equality); SDG8 (decent work and economic growth), SDG9 (industry, innovation and infrastructure); SDG10 (reduced inequalities); SDG11 (sustainable cities and communities); SDG12 (responsible production and consumption); SDG13 (climate action); SDG15 (life on land); SDG16 (peace, justice and strong institutions) and SDG17 (partnerships).

Vision

More active people for a healthier world.

Mission

To ensure that all people have access to safe and enabling environments and to diverse opportunities to be physically active in their daily lives, as a means of improving individual and community health and contributing to the social, cultural and economic development of all nations.

Target

A 15% relative reduction in the global prevalence of physical inactivity in adults and in adolescents by 2030.

Framework for action

Effective national action to reverse current trends and reduce disparities in physical activity requires a 'systems-based' approach with a strategic combination of 'upstream' policy actions aimed at improving the social, cultural, economic and environmental factors that support physical activity, combined with 'downstream', individually focused (educational and informational) approaches. This global action plan sets out four strategic objectives achievable through 20 policy actions that are universally applicable to all countries, recognizing that each country is at a different starting point in their efforts to reduce levels of physical inactivity and sedentary behaviour.

Four strategic objectives (Table 11.7) provide a universally applicable framework for the 20 multidimensional policy actions, each identified as an important and effective component of a population-based response to increasing physical activity and reducing sedentary behaviour. In combination, they capture the whole-of-system approach required to create a society that intrinsically values and prioritizes policy investments in physical activity as a regular part of everyday life.

>

TABLE 11.7 Global Action Plan on Physical Activity 2018–2030: four strategic objectives

Objective no.	Strategic objective	Description of related policy actions
Objective 1	**Create active societies**	Four policy actions are proposed which aim to create positive social norms and attitudes and a paradigm shift in all of society by enhancing knowledge and understanding of, and appreciation for, the multiple benefits of regular physical activity, according to ability and at all ages.
Objective 2	**Create active environments**	Five policy actions address the need to create supportive spaces and places that promote and safeguard the rights of all people, of all ages and abilities, to have equitable access to safe places and spaces in their cities and communities in which they can engage in regular physical activity.
Objective 3	**Create active people**	Six policy actions outline the multiple settings in which an increase in programmes and opportunities can help people of all ages and abilities to engage in regular physical activity as individuals, families and communities.
Objective 4	**Create active systems**	Five policy actions outline the investments needed to strengthen the systems necessary to implement effective and coordinated international, national and subnational action to increase physical activity and reduce sedentary behaviour. These actions address governance, leadership, multisectoral partnerships, workforce capabilities, advocacy, information systems and financing mechanisms across all relevant sectors.

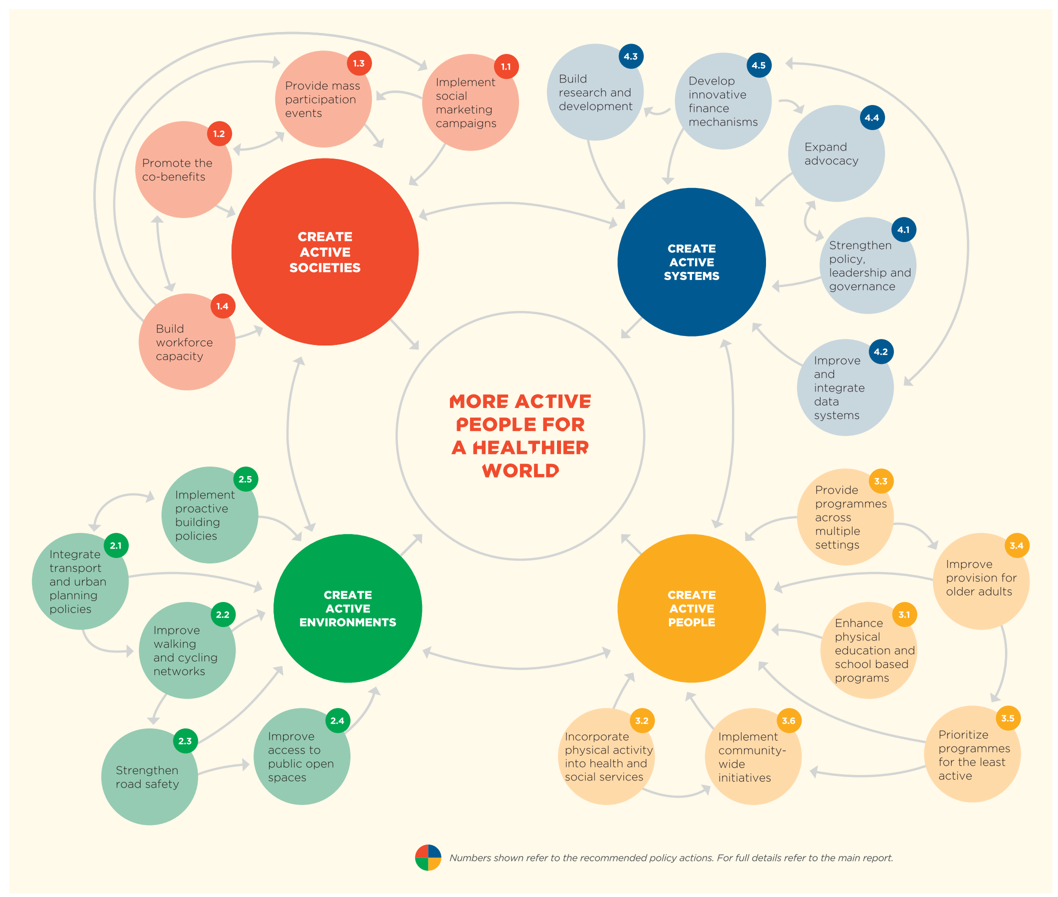


FIGURE 11.22 Whole-of-government solutions for physical inactivity

Source: *Global Action Plan on Physical Activity 2018–2030: More active people for a healthier world*. Geneva: World Health Organization, 2018. Licence: CC BY-NC-SA 3.0 IGO.

Member States

ministries of health, transport, education, sports, youth, urban planning, environment, tourism, finance, and labour

Development agencies

international financial institutions such as the World Bank, regional development banks, subregional intergovernmental organizations and development aid agencies

Intergovernmental organizations

UN agencies, UN Interagency Taskforce on NCDs (UNIATF) and others

International organizations

global health initiatives and agencies

Nongovernmental organizations

civil society, community-based organizations, human rights-based organizations, faith-based organizations

Professional associations

in medical and allied health areas, such as sports medicine, physical therapy, general practice, nursing, exercise and sports science, physical activity and public health and other relevant disciplines, including transport, sport, and education

Philanthropic foundations

that are committed to promoting global health and achievement of the SDGs

Academic and research institutions

across multiple disciplines including implementation science and the network of WHO collaborating centres

Industry leaders and private sector

committed to improving the health of employees, their families and communities

Media

journalists and media outlets, including both traditional and new media

City leaders and local government

mayors, governors and local officials

Community

representatives of faith-based, social and cultural groups

WHO

at all levels, headquarters, regional and country offices

FIGURE 11.23 Partners involved in the action plan to improve health

Source: *Global Action Plan on Physical Activity 2018–2030: More active people for a healthier world*. Geneva: World Health Organization, 2018. Licence: CC BY-NC-SA 3.0 IGO.

Partnerships for action

Given that the agenda of the action plan is beyond the scope of any single agency, implementation demands partnership. By working together to achieve the vision of the action plan and improve health for all, partners can also accelerate progress to achieve their own respective goals.

QUESTIONS

1 Identify what is meant by the 'upstream' policies and 'downstream' approaches to promote physical activity using the framework.
2 List three policy actions that could benefit a teenager to be more active and for one of those listed, explain why.
3 Describe how each of the four overarching objectives would align with the social-ecological model.
4 Select two the key partners and discuss what role they could play within the action plan.
5 Explain what is meant by a 'systems-based approach' based on this case study.
6 Justify why you think objective 2 explicitly mentions the need to have policies '… *that promote and safeguard the rights of all people, of all ages and abilities, to have equitable access to safe places and spaces in their cities and communities in which they can engage in regular physical activity.*'

Environmental strategies and tailoring

Since the late 1990s, research in physical activity has moved away from understanding change in physical activity levels among individuals and has become more focused on supportive environmental and policy interventions. These kinds of interventions have enormous potential, as they are designed to impact on large groups and populations. Physical activity intervention programs should be tailored to settings. For example, installing bike racks may encourage cycling to school in a rural area, if students live a reasonable distance way, but may be impractical in a suburban area where there are limited bike paths and heavy traffic. Table 11.8 outlines examples of strategies designed for removing impediments to being active and introducing new resources and families to enable physical activity.

TABLE 11.8 Environmental strategies to promote physical activity at the population level

Removing impediments to activity	Introducing new resources and facilities
Sometimes the goal of environmental intervention is to remove barriers to people being active (as discussed in Chapter 8), such as heavy traffic and 'stranger danger' or other street crime. Environmental changes, such as the installation of speed humps and reduced speed limits near school zones, can significantly reduce the volume and speed of traffic, increasing safety for pedestrians and cyclists.	Other environmental interventions aim to provide resources that facilitate activity, such as: • installing showers in the workplace • providing footpaths and bike trails in the community • installing a new or upgraded playground in a local park or school.
Karen Roach/Adobe Stock 	 ShapikMedia/Shutterstock.com

COLLABORATIVE TASK
Prac activity

Pitjau or Roundnet

Research and/or participate in a game of either Pitjau or Roundnet (also known as Spikeball – after the the brand of equipment that helped popularise the sport). Both are variations of small-sided volleyball using different modified equipment. In Roundnet you can play individually or in pairs, using up to three hits to hit the ball onto the Roundnet net. The aim it is for the ball to hit the ground without one of your opponents being able to return it.

In Pitjau you can play one on one or in pairs. The aim is to hit the modified ball through the hoop. After you serve, you have a maximum of three touches (you can use all body parts) to get the ball back through the ring. If you are closer than one metre to the ring you must hit upwards. Both activities could be played at school, at home, in workplaces or in the community.

makasana photo/Alamy Stock Photo

FIGURE 11.24 Roundnet can be played in any setting.

Pitjau Australia

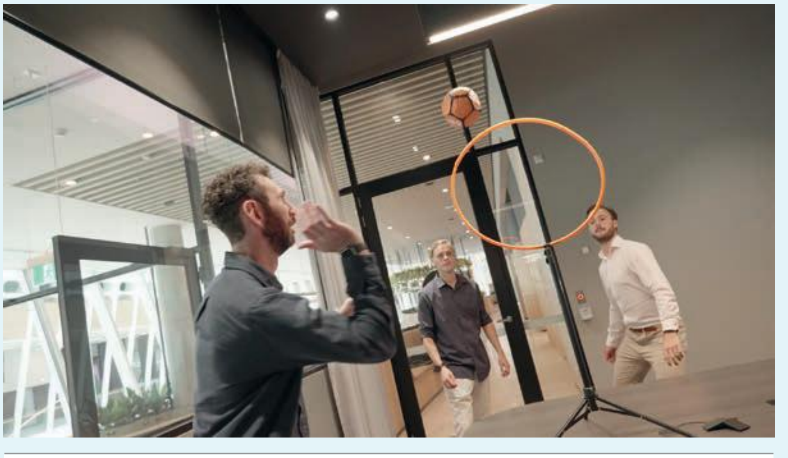


FIGURE 11.25 Pitjau encourages office workers to get up and have an active break from sitting at their desks.

QUESTIONS

1 If you were able to participate in one or both physical activities, **discuss** how you felt while participating in this activity. If you were unable to access this activity, discuss whether you would like to try Roundnet or Pitjau and explain why.

2 **Describe** two benefits of having Pitjau available within the physical environment in an office workplace.

3 **Explain** two impediments you may need to remove within the physical environment of an office to ensure safe participation in Pitjau.

Whenever possible, environmental interventions should precede educational programs. For example, a media campaign encouraging people to walk in their neighbourhood will have limited impact in an area where footpaths are poorly maintained and personal safety is at risk. Instead of a media campaign, the priority in this neighbourhood would be to reduce crime and provide a safe recreational environment for people to be active in. Only then can an educational program successfully encourage people to walk in their neighbourhood.


mark gusev/Shutterstock.com

FIGURE 11.26 Creating a safe recreational environment with lighting and well maintained paths is key to encouraging people to walk in their neighbourhood.

Environmental and policy interventions

Population-level physical activity interventions generally focus one or more of the following:

- natural environment
- constructed (built) environment factors
- policies related to incentives
- policies related to resources and infrastructure.

Making environmental and policy change is sometimes referred to as using a systems-based approach to physical activity promotion.

The natural environment, including terrain, climate and vegetation, is often a barrier to physical activity. For example, if you live in the alpine region of Victoria, your physical activities during winter are likely to include snow sports or indoor activities. This would be quite different for someone living in Mildura, which has higher winter temperatures and lower rainfall.

The constructed environment (sometimes referred to as the **built environment**) may also provide barriers to being physically active. For example, it is often difficult to locate the stairs in shopping centres, while the escalator or lift is easily identified.

built environment Buildings and other infrastructure built by human beings, including indoor and outdoor places for living, working and playing, and transportation systems

Nearly all interventions in the natural or constructed environment require funding, and this is usually accompanied by changes in policy. Unfortunately, these decisions are often made by agencies outside the health sector, whose primary concern is usually economic efficiencies, rather than the promotion of physical activity and healthy lifestyles.

ABOVE AND BEYOND THE STUDY DESIGN

Theoretical models to explain health behaviour, p. 403

DID YOU KNOW?

Over the past two decades, health promotion policy and programs to promote physical activity have relied on using social-ecological models to inform strategies at multiple levels, and involved key stakeholders from a range of government sectors and society (Nau et al., 2022). More recently, systems-based approaches to physical activity promotion are being used. These not only share some of the elements of social-ecological models, they also extend these by focusing on the interrelationships within and across levels of influence, as well as the use of established public health planning frameworks and strategies, and are grounded in systems thinking or systems science.

Policy

Policies may be defined as laws, regulations, formal rules, informal rules or understandings that are adopted on a collective basis to guide individual and population-wide behaviour. There are many policies that affect people's opportunities to be physically active; these policies can act as either enablers or barriers. Think about your own school: there may be policies such as no ball games in certain areas, or no access to the gym or other recreational areas before and after school – these are barriers. While the reasons might be quite legitimate (for example, safety concerns), these kinds of policies limit physical activity opportunities for thousands of students around Victoria. On the other hand, the mandated time for physical education and sport in government schools is an enabling policy, because this means schools are expected to provide physical education and sport for all students from Prep to Year 10. Policy can be classified as legislation or organisational policy.

Legislation

Legislation refers to formal, documented policies that are often governed by law-enforcement agencies and organisations. Having to wear a seatbelt in a car is an example of legislation based on an issue affecting public health. Speed bumps and speed limits, such as 40 km/hour zones around schools, are enablers for physical activity because they act to calm traffic, increasing safety for active commuting to and from school.

Organisational policies

Organisational policies are designed to establish an appropriate behaviour within a particular organisation. For example, many primary schools have a SunSmart policy that prevents children playing outside unless they are wearing a hat. Although this organisational policy is designed to reduce the incidence of skin cancer, it also has a direct influence on physical activity. Teachers should ensure that individual students are not deliberately forgetting their hat in order to avoid being active or playing outside.

When you critique strategies used at the population level to promote physical activity, think about:

- tailoring
- removal of impediments
- resources and facilities
- educational programs and policies to support environmental change.

Mass media

Another approach to physical activity promotion at the population level is the use of mass media. Mass-media interventions aim to reach groups of individuals using a medium other than personal contact or face-to-face meetings. Examples of mass media include:

- online advertising, pop-ups, social media, websites
- television and radio broadcasts and advertisements
- billboards, posters and commercials at cinemas
- print media such as newspapers, magazines and brochures
- web-based interactive information.

The main benefit of using a mass-media approach is the potential to reach large numbers of people at a lower cost per person than individualised approaches. The main purpose of a mass-media campaign is to raise awareness and increase motivation. Such campaigns are important, but on their own they are not enough to significantly influence the behaviour of individuals. Mass-media campaigns need to be combined with programs offered at a local community level.

Key roles of mass media in the promotion of physical activity

- Increasing awareness of physical activity as a public health issue
- Providing information about the health benefits associated with regular physical activity
- Providing information about other non-health benefits of being active
- Providing information about the consequences of inactivity
- Increasing interest in physical activity participation and raising awareness of community-based programs
- Motivating individuals to take action towards physical activity participation

FIGURE 11.27 The role of mass media in the promotion of physical activity

COLLABORATIVE TASK

Activity

Research an initiative

AIM

To research a range of strategies implemented to promote physical activity initiatives within different settings. You may even want to search the web for examples of mass media campaigns to promote physical activity.

METHOD

1. Using the prompts in Table 11.9 to guide your research, record your findings. You can copy the table or download a template from Nelson MindTap.
2. After collecting this information, evaluate the initiative using the following questions:
   a. Was there at least one strategy implemented at each level/construct of the social-ecological model?
   b. Can the outcomes be measured – for example, steps per day, minutes of active transport, total moderate to vigorous physical activity, reduced minutes of sitting during work hours?

Resource
Template: Summary of initiative using the social-ecological model

TABLE 11.9 Sample template for summarising an initiative using the social-ecological model

Name of program	Organisation and target (sub-population) group	Strategies used at different levels of influence based on the social-ecological model			
		Individual-level strategies	Social strategies	Physical environmental strategies	Policy and organisational strategies

COLLABORATIVE TASK

Activity

Multimedia presentation: promotion of physical activity

AIM

To design and create a 30-second video for social media, or a brochure, radio jingle, web page or slogan for a media campaign promoting physical activity or the reduction of sedentary behaviour among the target population

METHOD

1. **Identify** your target group (e.g. parents at home with toddlers, people aged 65+ years) and discuss why you selected this group to focus on.
2. Determine which medium you will use to present your promotion (e.g. video, audio recording, print, digital recording of a role-play).
3. Share your presentation with the rest of your class or present it to younger students in your school.
4. **Discuss** the potential advantages and disadvantages of using mass media to encourage people to be more active.

Key promotion groups

Encouraging people to increase their physical activity and reduce sedentary behaviour is in the best interests of all Australians. Promoting active lifestyles is the responsibility of a range of key organisations and groups, including:

- the Australian Government's Department of Health
- state and local governments
- government agencies
- non-government agencies and organisations

- national sporting organisations (NSOs) and state sport associations (SSAs)
- the Australian Sports Commission
- local sporting clubs and coaches
- sporting and recreational providers
- schools
- parents
- commercial industries
- allied healthcare providers
- researchers.

The Australian Government's Department of Health is responsible for the monitoring and surveillance of health behaviours, including physical activity. The department publishes a wide range of information about physical activity benefits, guidelines and initiatives (relating to healthy eating, regular physical activity and weight management) to support all Australians to lead healthy and active lives. Importantly, it also funds research and promotion initiatives.

Helene Rogers/Art Directors & TRIP/Alamy Stock Photo

FIGURE 11.28 Promoting physical activity at a community level is critical for children's health.

Assessment
11.2 Check-in questions

Command terms

describe
Provide characteristics, features and qualities of a given concept, opinion, situation, event, process, effect, argument, narrative, text, experiment, artwork, performance piece or other artefact in an accurate way

explain
Give a detailed account of why and/or how with reference to causes, effects, continuity, change, reasons or mechanisms; make the relationships between things evident

11.2 CHECK-IN QUESTIONS

1 **Identify** the three main approaches to population level physical activity promotion.
2 **Outline** the four strategic objectives within the Global Action Plan on Physical Activity redeveloped by the World Health Organization.
3 **List** four examples of mass media. Select one and describe an example of how this could be used to target a specific population group.
4 The World Health Organization recommends fostering collaboration and support from stakeholders across all sectors. Provide an example to illustrate this recommendation.
5 **Describe** what is meant by the concept of using a 'systems-based approach' to promote physical activity at a population level.
6 **Discuss** why a one-size-fits-all approach is not appropriate when designing interventions and initiatives to promote physical activity.
7 **Explain** the role of mass media to promote physical activity and provide three examples in your response.
8 Conduct online research to **identify** an initiative designed to reduce sedentary behaviour, and describe what strategies are recommended.

ABOVE AND BEYOND THE STUDY DESIGN

MODULE 11.2, p. 368

Enablers and barriers to physical activity during COVID-19

Although examining the potential enablers and barriers to physical activity during the COVID-19 pandemic is beyond the scope of the Study Design, Figure 11.29 provides examples of potential barriers to healthy behaviours across the 24-hour day using the social-ecological model. Sometimes the social-ecological model is also referred to as the socio-ecological model.

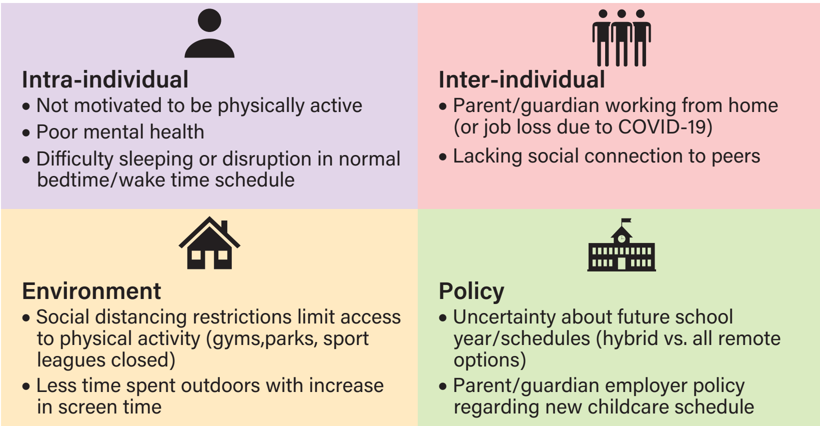


FIGURE 11.29 The social-ecological model: potential COVID-19-related barriers

Source: Bates-Fraser, L., Zieff, G., Stanford, K., Moore, J., Kerr, Z., Hanson, E., Gibbs, B., Kline, C. & Stoner, L. (2020). COVID-19 Impact on Behaviors across the 24-Hour Day in Children and Adolescents: Physical Activity, Sedentary Behavior, and Sleep. *Children*, 7. 10.3390/children7090138

MODULE 11.2, p. 397

Theoretical models to explain health behaviour

Several conceptual theories and models are used to explain health behaviour, and can be applied to predict what factors will lead to a change in certain health behaviours (such as physical activity, alcohol consumption, drug use or smoking). Theories and models of physical activity are used to explain:

- influences or determinants of physical activity
- the relationship between these factors (e.g. beliefs, barriers) and physical activity
- the conditions under which relationships with physical activity do and do not occur (e.g. the time, place and circumstances that lead to physical activity).

Theories and **theoretical models** are classified as either individual (intrapersonal) or interpersonal models of adult physical activity (see Table 11.10).

theoretical model
A model that allows us to understand a concept, such as participation in physical activity behaviour

TABLE 11.10 Classification, description and example theories of physical activity

Classification and description	Example theories
Individual (intrapersonal) theories explain health behaviour and behavioural change by focusing on individual factors. To design effective interventions requires an understanding of the role of the individual in physical activity behaviour.	▪ Health belief model ▪ Trans-theoretical model (includes stages of change and self-efficacy) ▪ Theory of reasoned action ▪ Theory of planned behaviour
Interpersonal (social environment) theories explain behaviour by focusing on the interaction between the individual and the environment.	▪ Social cognitive theory (includes self-efficacy) ▪ Ecological models (includes the social-ecological model)

CHAPTER SUMMARY

Resource
Self-assessment checklist

Video
Masterclass: Chapter 11

11.1 Physical activity behaviour change

- Social-ecological models of physical activity are characterised by multiple levels of influence on behaviour. They reinforce the interplay of the following types of factors influencing physical activity behaviour:
  - individual (or intrapersonal), including demographic and psychological factors
  - social (interpersonal) environment
  - physical environment
  - policy and organisational.
- Individual-level strategies focus on enhancing self-efficacy, knowledge, skills, understanding and awareness.
- Social environment strategies focus on formal and informal social climate and the support network and systems surrounding an individual.
- The physical environment plays a huge role in influencing physical activity behaviour, in terms of both the build and natural environments.

11.2 Physical activity promotion

- Policies can relate to the governance of incentives for activity or inactivity or the governance of resources and infrastructure related to activity or inactivity.
- Mass-media interventions aim to reach groups of individuals using a medium other than personal contact or face-to-face meetings. Examples of mass media include: online advertising, pop-ups, social media, websites, television and radio broadcasts and advertisements, billboards, posters and commercials at cinemas, print media such as newspapers, magazines and brochures, and web-based interactive information.
- An essential part of designing physical activity programs for specific target groups is to ensure they are tailored, culturally appropriate and have values and principles that respect local community culture and knowledge.
- In contrast to individual-level approaches, population-based approaches are designed to influence the population en masse, or at scale, by reaching and enabling large numbers of people within specific population groups.
- Population-level physical activity interventions generally target one or more of the following: environmental change (natural or constructed), mass media or policy.
- Making environmental and policy change is sometimes referred to as using a systems-based approach to physical activity promotion.

CHAPTER REVIEW

Assessment
Chapter 11 Review

1 Which of the following is an example of a population-level strategy to promote physical activity?
   A Print media distributed at a general practitioner's office
   B Change to policy
   C Counselling
   D Tailoring programs online

2 Which of the following would be an example of a social environment strategy that could be implemented within a school setting?
   A Installing traffic calming measures around the local area of the school to increase pedestrian safety
   B Establishing walking and bike riding paths around the school perimeter
   C Ensuring adequate supervision during lunch breaks
   D Introducing a bike shed or bike-lockable area with racks

3 **Explain** what is meant by tailoring, in relation to programs that promote physical activity. Include an example in your response.

4 a **Identify** the four key levels of the social-ecological model.
   b **List** three factors within each of the levels.
   c **Explain** one of these factors. Include an example in your response.

5 **Describe** what 'walkability' refers to and how it is measured.

6 The Victorian Department of Education and Training introduced a mandate for physical and sport education.
   a How much physical education time does this policy recommend schools should be providing?
   b **List** five factors that could be potential barriers to classroom teachers delivering physical education classes in primary schools.
   c **Describe** three strategies that could be implemented to assist primary schools in meeting this mandate and overcoming some of the barriers identified in part b.

7 a **List** six examples of media through which a campaign could be delivered to reduce sedentary behaviour.
   b **Describe** three key roles of mass media in the promotion of physical activity.

8 Review the Global Action Plan on Physical Activity 2018–2030.
   a **List** the four strategic objectives.
   b **Describe** the active environment-related policy, and provide an example of a policy that could address this objective.
   c **Explain** how policy 1.3 'Provide mass participation events' could be implemented (e.g. think about fun runs).
   d Provide an example to illustrate how two strategic objectives are interrelated.

CHAPTER

12

HEALTH-RELATED FITNESS AND FUNCTIONAL MOVEMENT

UNIT 2 – AREA OF STUDY 1

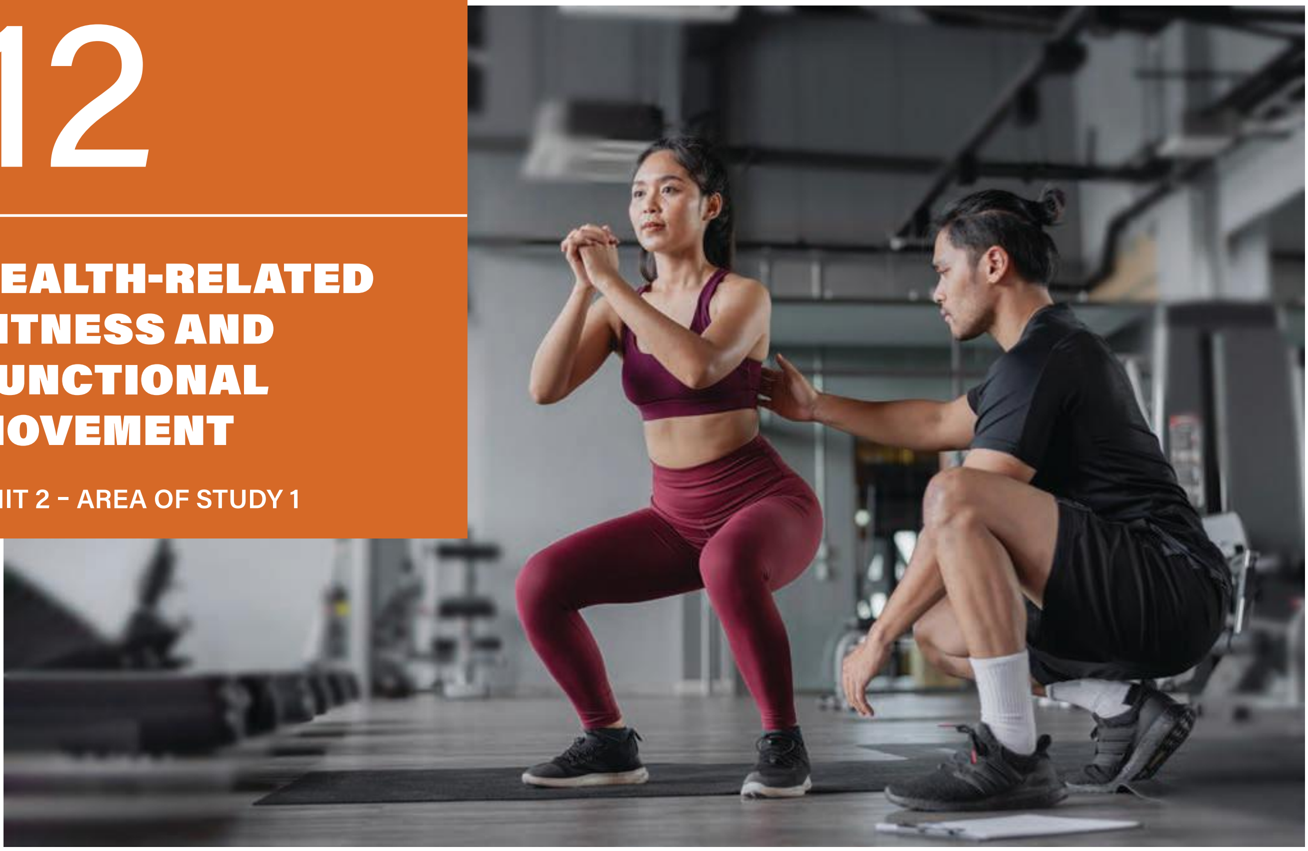


FIGURE 12.01 Functional Movement Assessments are tailored to each person's capabilities and needs.

Quizzes

Chapter 12 Pulse check

12.1 Check-in questions

12.2 Check-in questions

12.3 Check-in questions

Chapter 12 Review

Videos

Masterclass: Chapter 12

12.2 In focus: Functional Movement Assessment

Resources

12.3 Evaluation card: Squat

12.3 Evaluation card: Lunge

12.3 Evaluation card: Push-up

12.3 Evaluation card: Bench dips

12.3 Evaluation card: Modified pull-up

12.3 Evaluation card: Resistance band row

12.3 Evaluation card: Side hold

12.3 Evaluation card: Prone hold

12.3 Evaluation card: Active leg raise

12.3 Evaluation card: Shoulder mobility

12.3 Evaluation card: Overall

Template: Brainstorm

Chapter 12 Self-assessment checklist

Nelson MindTap

To access resources above, visit **cengage.com.au/nelsonmindtap**

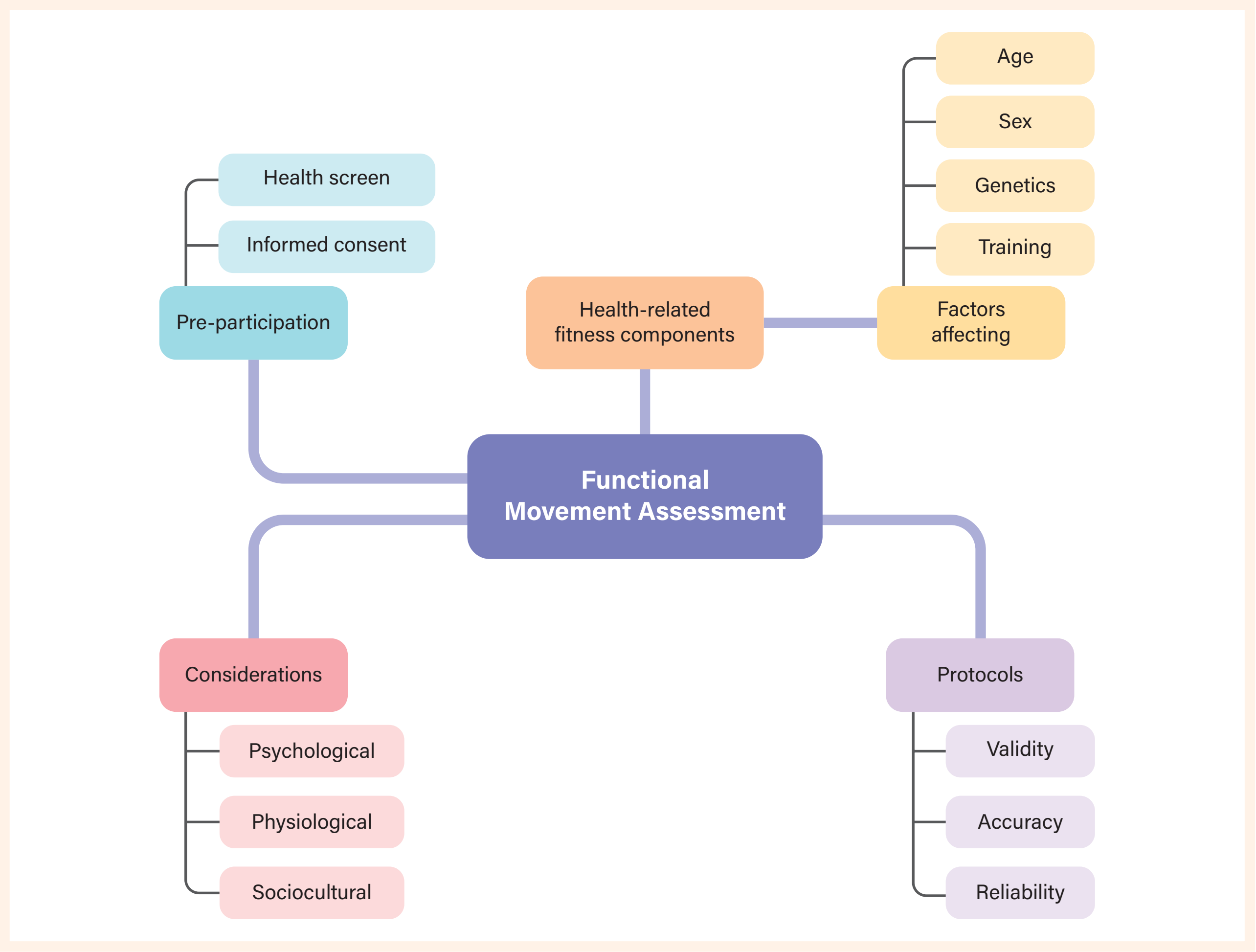
KEY KNOWLEDGE

- health-related fitness components and factors affecting aerobic power, muscular strength and endurance and flexibility
- Functional Movement Assessment (FMA):
  - physiological, psychological and sociocultural considerations
  - pre-participation health screening
  - informed consent
  - assessment reliability, validity and accuracy

KEY SKILLS

- justify an appropriate FMA for a targeted individual/group, from a physiological, psychological and sociocultural perspective
- conduct and evaluate an FMA using reliable, valid and accurate methodology

Source: VCAA VCE Physical Education Study Design (2025–29)



Video
Masterclass: Chapter 12

Assessment
Chapter 12 Pulse check

In this chapter you will define fitness and explore what fitness means to different people. You will learn the fitness components model from a health-related perspective and define appropriate fitness components. You will explain the purpose of a Functional Movement Assessment and select from a series of assessment tools, justifying your selection with consideration to your client's capabilities and needs. You will explore pre-assessment requirements and participate in an assessment using appropriate methodology.

PULSE CHECK

Take the pulse check quiz to check your knowledge and prior understanding of the concepts covered in this chapter.

1. Use one sentence to describe what fitness means to you.
2. Fitness consists of many parts. Make a list of the fitness components you know.
3. **Identify** some factors that impact individual fitness levels.
4. **Explain** the importance of a pre-participation health screen prior to participating in a physical activity program.
5. **Explain** the importance of conducting a warm-up prior to exercise.

12.1 PHYSICAL FITNESS AND HEALTH-RELATED FITNESS COMPONENTS

In this module you will learn about:

- health-related fitness components and factors affecting aerobic power, muscular strength and endurance and flexibility

  and learn to:

- explain health-related fitness components, including factors affecting each component.

physical fitness
The ability to get through daily activity tasks efficiently and effectively

Physical fitness refers to the ability to get through activities of daily living efficiently and effectively. This broad definition means physical fitness will look different for everyone, depending on age, occupation and leisure pursuits. As fitness requirements vary from person to person, a components of fitness model is used to categorise different aspects of fitness.

In this chapter we will be looking at the definitions and factors affecting health-related fitness components, sometimes called functional fitness components. These fitness components include aerobic power, muscular strength, endurance and flexibility. They are noted for their contribution to optimal health and daily function, compared to skill or sports-related fitness components, which have a larger role in performance. Having optimal functional fitness means you can carry shopping with ease, lift and play with a child and walk up stairs without pain or fatigue.

Ground Picture/Shutterstock.com

Westend61 GmbH/Alamy Stock Photo

FIGURE 12.02 Optimal levels of health-related fitness components support active and healthy living and function, including playing with children and occupational movement requirements.

LOOKING BACK
Injuries and illness
Chapter 2

Optimal capacity in the health-related fitness components can help prevent acute and chronic injuries and illness and manage chronic illness associated with the body systems. See Chapter 2 for more on this topic.

LOOKING FORWARD
Fitness components
Unit 4 – Chapter 8

In Chapter 8 of *Nelson Physical Education Units 3&4* you will focus on the fitness components required for performance as well as those needed for optimal health. These include muscular power, speed, agility and anaerobic capacity.

Aerobic power

Aerobic power is the rate of energy production from the aerobic energy system. In Units 1 and 2 of Physical Education, it is better understood as the ability of the respiratory, cardiovascular and muscular systems to take in, transport and utilise oxygen to produce energy. A high level of aerobic power is beneficial for endurance sports, but an optimal level is important for daily function when undertaking moderate or vigorous physical activity such as walking or jogging, bike riding and taking the stairs.

Aerobic power is influenced by the functioning of the body's systems. For example, having a large lung capacity enables more air to be taken into the lungs, which in turn enables a greater intake of oxygen across the alveoli capillary interface. A large volume of red blood cells in the cardiovascular system allows for more oxygen to be transported

Icon Sportswire/Icon Sportswire/Getty Images

FIGURE 12.03 Aerobic power is important for moderate-intensity bike riding.

to the working muscles, and a heart with a large left ventricle chamber will be able to pump more oxygenated blood around the body. In order to optimise aerobic power, it is recommended individuals meet their required physical activity guidelines, as stipulated in the National Physical Activity Guidelines (NPAGs). Additionally, a high level of sedentary behaviour can counteract the benefits of physical activity and should be limited, according to recommendations in the NPAGs. Other factors influencing aerobic power are listed in Table 12.1.

adaptations
The long-term changes as a result of stress placed on our body that increase the capacity of targeted fitness components

To build the **adaptations** in your body to improve aerobic power, moderate or vigorous movement is recommended. While someone beginning an exercise plan should always start slowly, to most effectively build aerobic power, it is recommended that exercise is sustained at an intensity of 70–85% of max heart rate. This is known as the aerobic training zone, and can be monitored by wearable technology as shown in Figure 12.04.

TABLE 12.1 Factors affecting aerobic power

Factors affecting	Influence
Genetics	Aerobic power has a heredity estimate of 90–95%.
Muscle fibre type	More slow-twitch fibres will be able to produce more energy aerobically.
Training status	Aerobic power is increased by adaptations as a result of aerobic training.
Age	Peaks at 25–28 years, then decreases as age increases. This is impacted by changes to the body systems that reduce the capacity to take in, transport and utilise oxygen.
Sex	Males generally have greater blood volume and lung capacity and therefore a greater capacity to produce energy aerobically.

Andrey Popov/Adobe Stock

FIGURE 12.04 Wearable technology can measure heart rate, which is an effective way to measure the intensity of the physical activity you are performing.

LOOKING FORWARD
Training principles
Unit 4 – Chapter 12

Units 1 and 2 explore the participation in physical activity that is required to meet the NPAGs for good health. In Chapter 12 of *Nelson Physical Education Units 3&4* you will explore training principles such as intensity, duration, frequency and specificity, which are used to develop adaptations and enhance performance in sport.

DID YOU KNOW?

To build aerobic power you should exercise three times a week (frequency), and a program should last a minimum of six weeks (duration). The most effective intensity is in the aerobic training zone from 70–85% max heart rate.

Muscular strength

Muscular strength is the peak force a muscle or group of muscles can produce in one contraction. It is required in physical activities such as rowing to grip the oar, yoga to hold an arm **balance** or rugby to hold out against an opponent. In daily activities, muscular strength will help when opening a heavy door, getting up and down from a seated position or even opening a jar of food. The importance of muscular strength for the general population has been an area of focus for healthcare professionals, as good muscular strength supports the following:

- **Posture** – adequate muscular strength helps support the spine, maintain proper alignment, and reduce the risk of musculoskeletal issues such as back pain.
- **Joint health** – muscles provide support to joints, acting as stabilisers. Strong muscles around joints help protect them from injuries and decrease the risk of conditions like arthritis. This also helps improve **balance**, which can be linked to falls and injuries.
- **Bone health** – strength training has been linked to increasing bone density, which can help prevent osteoporosis and fractures.
- **Weight management** – as muscles have a higher energy expenditure than fat tissue, increasing muscle mass through strength training can support weight management.

muscular strength
The peak force a muscle of group of muscles can produce in one contraction

balance
The ability to control equilibrium while stationary or moving

SIGNPOST

A popular way to assess muscular strength in adults is the 30-second chair test. Here, participants need to see how many times they can sit down and rise up from a chair within a 30-second period. It is a popular assessment tool for healthcare professionals as it contributes to functional fitness and uses the large leg muscles, which are especially important for balance.

Watch the video, 'How fit are you? The Chair Test' on the BBC channel on YouTube to see a demonstration of the test.

Weblink
The Chair Test

COLLABORATIVE TASK

Prac activity

Assessing functional muscular strength

AIM

To participate in the 30-second chair test

EQUIPMENT

- Chair
- Stopwatch

METHOD

Use the link provided in MindTap to participate in the 30-second chair test.
Record your number of successful repetitions in your Reflective Folio.

> **DISCUSSION**
> Use the results and your physiological experience to discuss the following questions:
> 1 Did you find this experience easy?
> 2 Why/why not?
> 3 Which demographic might use this test?
> 4 What sort of injuries would make this test challenging to perform?
> 5 **Discuss** why this movement is important for functional independence.

wavebreakmedia/Shutterstock.com

FIGURE 12.05 Muscular strength is required for daily tasks such as carrying heavy school bags.

bnenin/Adobe Stock

FIGURE 12.06 Strength is targeted in resistance training when a heavy load with low repetitions is performed.

80%1RM
RM stands for repetition maximum and refers to the maximum amount that can be lifted once. If someone is lifting a weight at 80%1RM and their RM is 10 kilograms, they will be lifting 8 kilograms

Methods to improve muscular strength include resistance training, where a heavy load is used to build muscle. In traditional strength training, when using weights to isolate a muscle group, a resistance greater than **80%1RM** is recommended. Functional strength training, which targets multiple muscle groups over multiple joint actions, is rapidly becoming a popular type of training and will be explored later in this chapter.

Key factors affecting muscular strength are explained in Table 12.2.

TABLE 12.2 Factors affecting muscular strength

Factors affecting	Influence
Cross-sectional area of muscle	Increased cross-sectional area increases force production.
Genetics	Genetics has a large influence on muscle fibre type.
Muscle fibre type	A greater percentage of fast-twitch fibres leads to more force production.
Age	Peaks at 20–30 years then declines due to changes in muscle size and mass.
Sex	Generally, males have greater cross-sectional area and therefore are able to produce more force.

DID YOU KNOW?

Functional strength training doesn't have to take place in a gym with large free weights. It is accessible in the home using body-weight exercises such as push-ups and sit-ups or by using cost-effective equipment such as resistance bands.

LOOKING FORWARD
Resistance training
Unit 4 – Chapter 13

In Chapter 13 of *Nelson Physical Education Units 3&4* you will explore training methods such as resistance training and learn how to prescribe exercises including reps, sets and load for different fitness components including muscular strength.

CASE STUDY THE IMPACT OF AGE ON FITNESS COMPONENTS

Age is one of the major factors affecting fitness components. There are several definitions of age which are important when considering the volume and type of exercises that are being prescribed in a personalised exercise plan, which you will explore as part of your assessment task for this area of study. Age can be defined as:

- **chronological age** – the number of years a person has been alive
- **functional/physiological age** – how well a person functions in daily life, including in their job
- **training age** – how long a person has been exercising on a regular basis.

Loss of muscle mass associated with ageing and some diseases is associated with increased risk of mortality. Chronologically, the loss of muscle mass starts to occur in our thirties but can take a dramatic dive after we turn 50. This process is known as **sarcopenia**, and it occurs due to muscle fibres shrinking in size, and the gradual loss of motor units. Interestingly, the loss of motor units occurs most significantly in fast-twitch muscle fibres. The smaller the muscle, the less force that it can produce, which means as we age, we become weaker. Additionally, the loss of fast-twitch muscle fibres means we also become slower and lose muscular power, which is a combination of speed and strength. These changes can be observed in the graphs shown in Figures 12.07 and 12.08.

sarcopenia
The loss of skeletal muscle mass and strength as a result of ageing

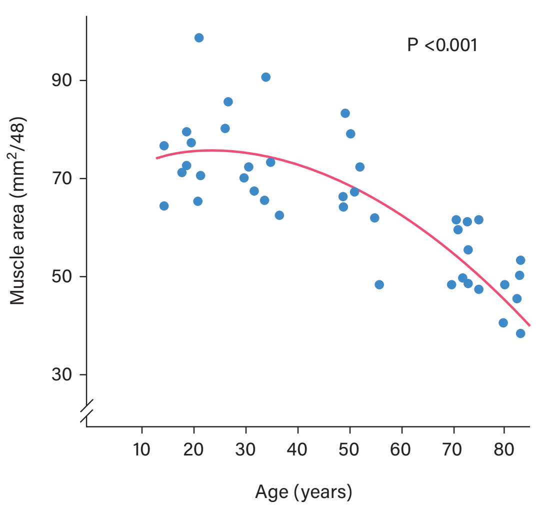


FIGURE 12.07 As we age, we lose muscle mass and motor units. This is observed as a loss of muscle area. The rate of muscle loss increases significantly after 50 years of age.

Source: Signorile, J.F. (2011). *Bending the Aging Curve: The complete exercise guide for older adults.* United Kingdom: Human Kinetics, p. 6.

In recent years, there has been an increased focus on maintaining muscular strength as we age. Importantly, this can be addressed using resistance training, which aims to slow down the loss of muscle. Having good muscular strength reduces the risk of illness and injury and, importantly, maintains functional independence, allowing people to live longer with the capacity to perform their daily tasks. The graph in Figure 12.08 demonstrates an example of the capacity of lifelong exercise to 'bend the ageing curve', which will improve functional age.

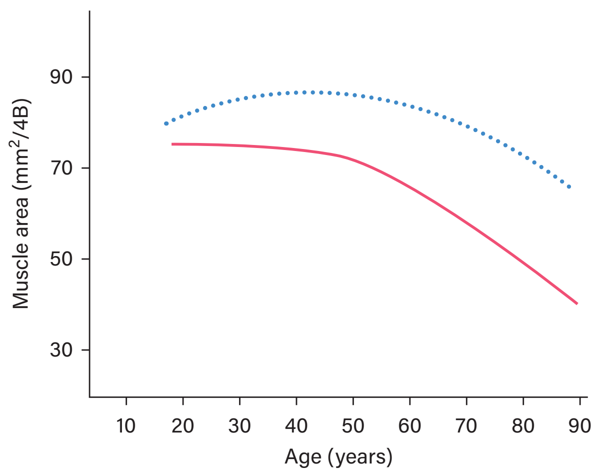


FIGURE 12.08 Through training, the age curve can be bent. The solid line represents typical muscle area loss, whereas the dotted line represents what the ageing curve might look like for someone who has participated in lifelong exercise and training.

Source: Signorile, J.F. (2011). *Bending the Aging Curve: The complete exercise guide for older adults*. United Kingdom: Human Kinetics, p. 6.

QUESTIONS

1 **Define** chronological age.
2 **State** the relationship between age and muscle cross-sectional area.
3 List the two changes that occur with sarcopenia and **explain** the impact it has on **muscular strength**.
4 **Explain** why a loss of fast-twitch fibres will result in a loss of force production and power output.
5 **Analyse** the changes to the ageing curve that can be made through participation in lifelong exercise. Use your analysis to predict some improvements to functional age and independence that might occur through involvement in lifelong exercise.
6 As a class, **discuss** the factors that contribute to sarcopenia. Consider biophysical factors such as hormones and psychosocial factors such as social support and opportunities for physical activity participation.

Command term

analyse
Identify components/elements and the significance of the relationship between them; draw out and relate implications; determine logic and reasonableness of information

DID YOU KNOW?

Strength training is the gold standard for preserving bone mineral density and offsetting muscle mass loss through menopause.

Muscular endurance

Muscular endurance is the ability to sustain repeated contractions in the face of fatigue. In sports it is easily observed during endurance events, or even when an athlete sustains a surge to the finish line at a higher intensity. It can be linked to full body movement such as hiking, or a localised muscle group such as the quadriceps when riding a bike.

Methods to improve muscular endurance include aerobic training methods such as continuous or **Fartlek training**. If a specific muscle group is targeted to build local muscular endurance, resistance training might be used. To effectively target local muscular endurance, high repetitions (>15) and a light weight is recommended.

muscular endurance
The ability of a muscle or group of muscles to sustain repeated contractions against a resistance for an extended period of time

Fartlek training
An aerobic training method that intersperses bursts of speed within steady aerobic work

Jacob Lund/Shutterstock.com

FIGURE 12.09 Hiking requires the ability to perform repeated contractions over a long period of time.

Prostock-studio/Shutterstock.com

FIGURE 12.10 To effectively target muscular endurance, a light load should be used and many repetitions performed.

TABLE 12.3 Factors affecting muscular endurance

Factors affecting	Influence
Training status	Aerobic training and resistance training can impact the ability to sustain repeated contractions.
Age	Peaks at 25–30 years then declines.
Muscular strength	A higher level of muscular strength positively influences the ability to contract muscles repeatedly.
Sex	Due to aerobic power and strength differences, males often have more muscular endurance.

Flexibility

The greater the range of motion, the greater the flexibility. **Flexibility** is highly dependent on the structure of the joint; a joint with great stability such as the knee joint will have less flexibility than the shoulder joint, which has a large range of motion but is less stable. Flexibility can be categorised into static or dynamic flexibility.

Static flexibility is moving through range of motion then holding a stretch, whereas **dynamic flexibility** is moving continuously through the range of motion. In sports, static flexibility is required in gymnastics holds, and is often an area of focus at the end of a training session as part of a cool-down. Dynamic flexibility is important in sports like Australian Rules football, to move the leg when performing a kick, and in tennis, where a great range of motion in the shoulder joint during a serve allows for more speed to be developed and a more powerful shot to be executed. Dynamic flexibility training is part of a three-phase effective warm-up before training or a match to maintain blood flow and neuromuscular activity.

flexibility
Flexibility refers to the range of motion around a joint.

static flexibility
moving through range of motion then holding a stretch

dynamic flexibility
moving continuously through the range of motion

iStock.com/Pedro Merino Higueras

FIGURE 12.11 Moving through the joint's range of motion and then holding a position is a static stretch, and is an important part of a program to develop flexibility.

Anela R/peopleimages.com/Adobe Stock

FIGURE 12.12 Dynamic stretching is moving a joint continuously through its range of motion and is an important part of a three-phase warm-up.

Weblink
Hypermobility in your backstroke catch with Kaylee McKeown

SIGNPOST

Swimmer Kaylee McKeown has a larger than normal range of motion in her joints, known as hypermobility. Watch the interview with McKeown when she discusses how she controls this range of motion and works it to her advantage in backstroke, in the video, 'Hypermobility in your backstroke catch with Kaylee McKeown' on YouTube.

LOOKING BACK
Joint structure
Chapter 1

In Chapter 1 you studied the different joint classifications and actions. You will know that circumduction in the shoulder joint requires great flexibility, whereas other joints that have only one type of movement, such as hinge joints, are less flexible.

LOOKING FORWARD
Warm-up
Unit 4 – Chapter 14

In Chapter 14 of *Nelson Physical Education Units 3&4* you will explore, participate in and prescribe a three-phase effective warm-up. These should include a general phase such as a jog, dynamic stretching, and sports- or activity-specific movement.

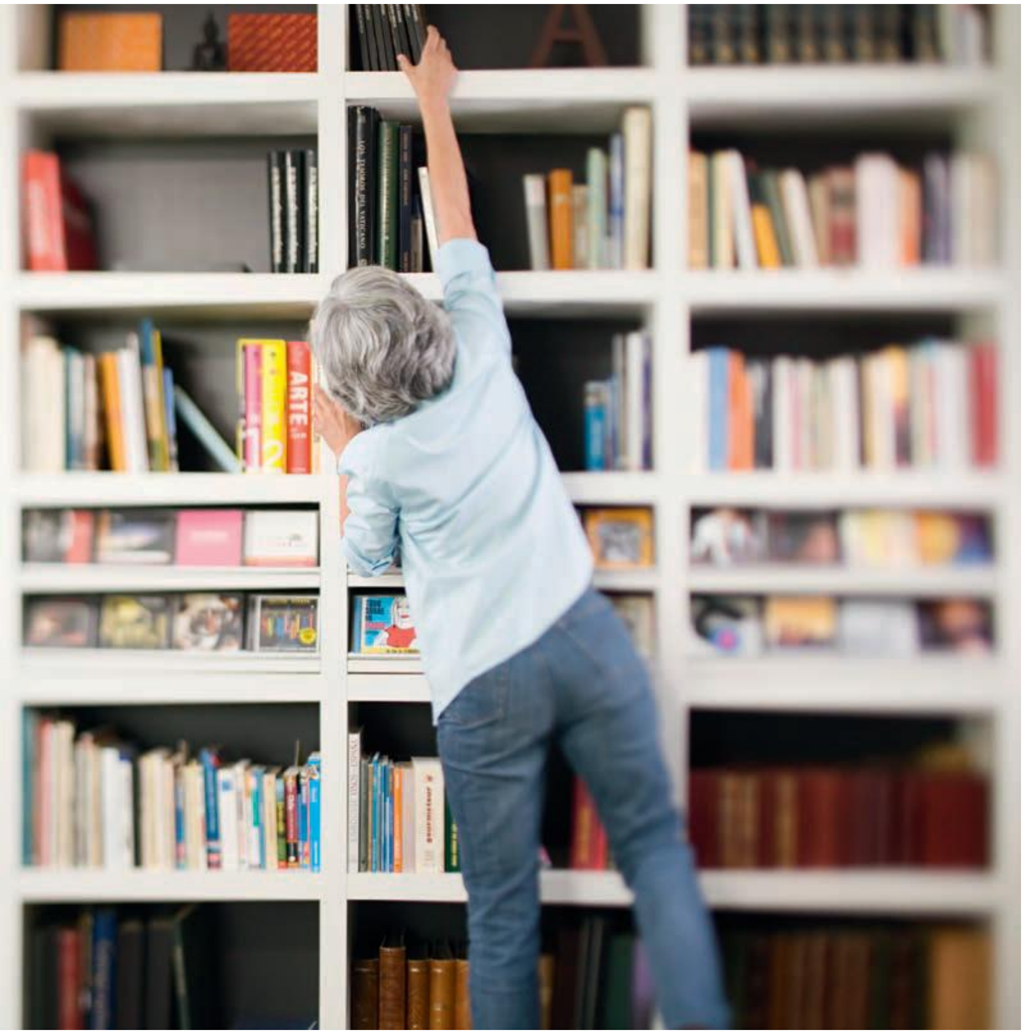
Functional flexibility

Functional flexibility is important for picking things up from the ground, reaching to make a bed, retrieving an item from a top shelf and even doing up shoes! It is an important aspect of functional independence and should be included in a personalised activity plan.

TABLE 12.4 Factors affecting flexibility

Factors affecting	Influence
Joint structure	A stable joint has great strength but is less flexible.
Temperature	A warm-up decreases **viscosity** of a joint, therefore increasing flexibility.
Age	Greatest range of motion is at 8–10 years.
Sex	There is some research to suggest that females have more flexibility in the sit and reach test, but research is ongoing.

viscosity (in joints)
The 'thickness' of synovial fluid around a joint



Fuse/Getty Images

FIGURE 12.13 A large range of motion is required for functional activities such as retrieving an item from a top shelf.

DID YOU KNOW?

Flexibility can be improved quickly. Dramatic changes to the flexibility of a joint can be made in just a few weeks of effective training.

COLLABORATIVE TASK

Prac activity

Daily activities and fitness components

AIM

To establish the importance of health-related fitness components for daily activities

EQUIPMENT

Reflective folio to record your activities

METHOD

1 Use 10–15 minutes of your lesson to fast forward quickly through a typical day.
2 Start at the school gate, then walk to your locker, then to each classroom, just like you would during a normal day. Don't forget to return to your locker and move to the space where you would eat lunch and spend your breaks. Include one minute of each sporting or exercise activity you would normally participate in.
3 Record each activity as you move through them, or return to the classroom and then record them. You could use a mud map or just write a list of all the activities and requirements.
4 Next to each activity, record the health-related fitness components you feel would be used to complete that task.

DISCUSSION

Use your reflections as a basis to discuss the following prompts:

1 Which fitness components were required for your daily activities?
2 How does each fitness component impact your ability to complete each task?
3 If you were older/less trained, would any of the tasks have been more challenging?
4 How could these be modified to meet diverse ability levels?
5 Would any of these activities have been more challenging 50 years ago? That is, has technology changed the ease of completing daily activities?

EXTENSION

As an extension task, keep a record of your daily activities at home before and after school. Use these reflections to revisit some of the questions above.

12.1 CHECK IN QUESTIONS

1 **Define** aerobic power.
2 **Identify** the health-related fitness components.
   a **List** two factors affecting aerobic power.
   b **Explain** how one of these factors influences aerobic power.
3 Use the definition of muscular endurance to **explain** why a high number of repetitions is recommended for effective training.
4 **Explain** why dynamic flexibility exercises, rather than static flexibility stretching, would be advised before a training session.

Assessment
12.1 Check-in questions

Command term

define
Give the precise meaning and identify essential qualities of a word, phrase, concept or physical quantity

12.2 FUNCTIONAL MOVEMENT ASSESSMENT

In this module you will learn about:

- Fundamental Movement Assessment (FMA): physiological, psychological and sociocultural considerations pre-participation health screening informed consent

and learn to:

- justify an appropriate FMA for a targeted individual/group, from a physiological, psychological and sociocultural perspective.

Video
In focus: Functional Movement Assessment

What is a Functional Movement Assessment?

A **Functional Movement Assessment (FMA)** is an important step in establishing a client's profile in preparation for prescribing safe and effective exercise within a personalised plan. Many healthcare professionals such as physiotherapists, osteopaths and chiropractors use movement assessment to effectively review movement competence, imbalances and treatment requirements. From a sports perspective, an FMA can fill the void between a pre-participation health screen and performance tests.

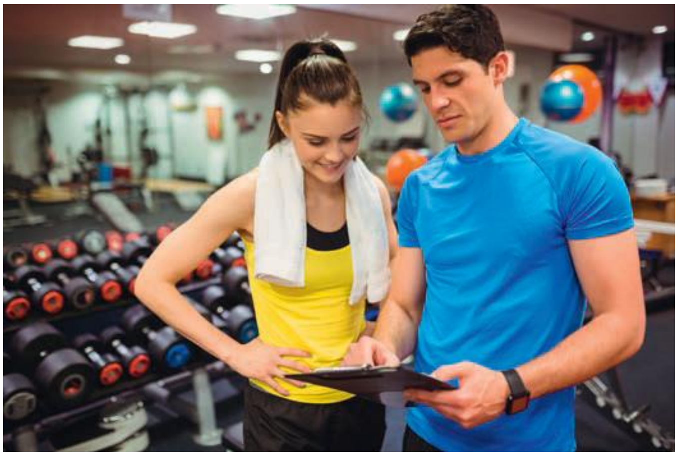
FMAs are designed to evaluate an individual's **functional movement** patterns, skills and stability, and can indirectly measure health-related fitness components. Movement assessment forms the basis for successful physical activity participation, injury management and prevention and functional independence.

Functional Movement Assessment (FMA)
A movement assessment undertaken prior to participating in a personalised plan which aims to evaluate an individual's functional movement patterns, and can indirectly measure health-related fitness components

functional movement
Movement that is required for functional day to day activities

Here are some key reasons why conducting an FMA is important prior to designing a personal plan.

- **Identify movement limitations:** An FMA helps identify limitations or imbalances in the body. It may help identify an area of concern that a health professional addresses to help prevent injuries and create a solid foundation for effective and safe movement.
- **Build a strong foundation:** Determining a client's competence in baseline movement gives a health professional confidence that their body is prepared for more complex movements in their plan.
- **Establish a baseline:** Observing technique or counting how many successful repetitions a client can complete provides a base from which to prescribe repetitions and to compare to future results.
- **Monitor progress over time:** Undertaking regular movement assessments allows comparison over time and gives feedback on the success of the program. It allows alterations or refinements to the plan, or appropriate progression to be applied (making it harder).
- **Prevent injuries:** An FMA helps to recognise movement concerns, and faulty movement patterns can be addressed as a proactive strategy to prevent injury.
- **Education:** An FMA gives the client an understanding of their strengths and areas to improve, engaging them in the process.



wavebreakmedia/Shutterstock.com

FIGURE 12.14 Among other things, an FMA can establish a baseline that can be used to prescribe activities within a personalised program.

A successful FMA supports personalised programming with achievable goals that is sustainable and exciting for the client to undertake, while also minimising the risk of overtraining or injury. If a program is started without first establishing movement competence, inefficient movement patterns are reinforced, it can lead to poor biomechanics and the potential for injury.

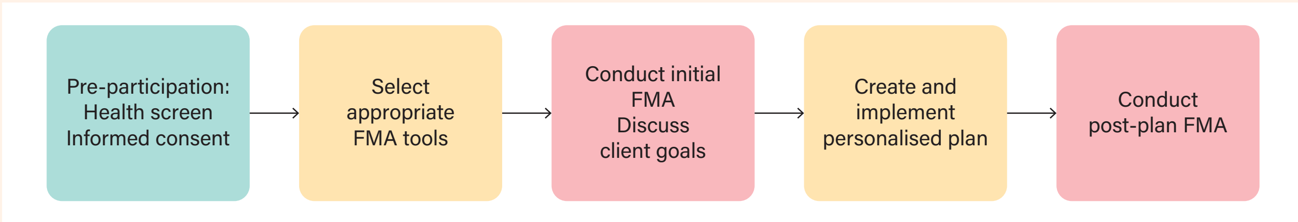


FIGURE 12.15 The stages of an FMA

DID YOU KNOW?

Over the last 20 years the rehabilitation sector has undergone a trend away from traditional isolated assessment and strengthening, towards an integrated, functional movement-based approach. The concept of functional movement is so important, the American Physical Therapy Association House of Delegates adopted the following vision statement: 'Transforming society by optimizing movements to improve the human experience.'

PR Library/Alamy Stock Photo

FIGURE 12.16 More complex FMAs are conducted by healthcare professionals such as physiotherapists.

LEARNING HACK

The importance of assessing can be summed up easily: 'If you're not assessing, you're guessing.'

Functional Movement Assessment for VCE Physical Education

Different types of FMAs are used widely for elite athletes, club sport and by trainers and healthcare professionals. There is no 'one-size-fits-all' approach; each facilitator will select the assessment tools that meet the requirements of the physical activity, and thus the movement demands.

In VCE Physical Education you will use a bespoke approach, choosing and conducting an FMA from six optional areas. You may analyse technique, look at the ability to repeat the correct movement successfully (the number of repetitions), or measure results against predicted normative data. You will then use this information to determine areas of strength and those that need improvement. You will also discuss goals with the individual and use these to inform the development of a personalised physical activity plan tailored to meet goals and optimise adherence to the National Physical Activity and Sedentary Behaviour Guidelines.

The six areas are:

- squat and/or lunge
- push
- pull
- brace/hold
- range of motion
- aerobic power.

Limitations of using an FMA

An FMA can be tailored to the needs of the client. Specificity is important when using FMAs, but this can also be a challenge, as the assessment options are plentiful and can be difficult to narrow down. The VCE Physical Education course selects some appropriate tools, but recognises there are many more that can and should be used by practising professionals.

While an FMA is an assessment tool, it is not a diagnostic tool. If, when you are conducting your FMA, a participant experiences pain or has a significant challenge with the movement pattern, they should stop the movement and be referred to an appropriate healthcare professional for more specific testing and treatment.

Selecting the appropriate assessment tools

Some recommendations of possible assessment tools are provided in Module 12.3 and can be accessed through MindTap resources. Other appropriate tools may be used; consult your teacher before finalising your assessment. Physiological, psychological and sociocultural factors need to be considered when selecting the most appropriate assessment tool.

Physiological considerations

The most important consideration when selecting an assessment tool is the physiological capabilities of your client. Selecting a type or intensity of activity that is too challenging for your client will not allow an appropriate evaluation of their movement. Conversely, if your client is very capable and the assessment doesn't give them the capacity to demonstrate their abilities, their personalised plan will not be **tailored** to their requirements. For example, if your client is fit and active and wants to work on their aerobic power, you might choose a more intense assessment, such as the multistage fitness test/20-metre shuttle run rather than the Rockport 1.6-kilometre walk. You might also want to establish their goals so that you can match the assessment tool to the muscle groups and actions they wish to assess and then develop.

tailoring
Ensuring exercise prescription matches the participant's physical capabilities, likes and interests

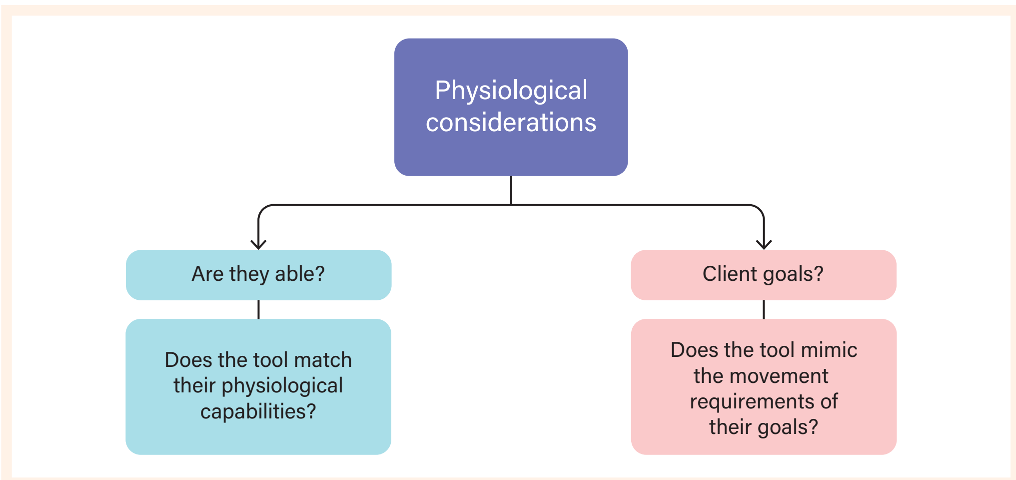


FIGURE 12.17 Physiological considerations when selecting an assessment tool

Regardless of the current fitness status of your client, before participating in any physical assessment, a pre-participation health screen should be conducted. There are a variety of options, including a Physical Activity Readiness Questionnaire (PAR-Q) or the Adult Pre-Exercise Screening System (APSS). These health screens identify any health risks that should be cleared with a doctor prior to participating in a program.

ADULT PRE-EXERCISE SCREENING TOOL

This screening tool does not provide advice on a particular matter, nor does it substitute for advice from an appropriately qualified medical professional. No warranty of safety should result from its use. The screening system in no way guarantees against injury or death. No responsibility or liability whatsoever can be accepted by Exercise and Sports Science Australia, Fitness Australia or Sports Medicine Australia for any loss, damage or injury that may arise from any person acting on any statement or information contained in this tool.

Name: ______________________________

Date of birth: ______________ Male ☐ Female ☐ Date: ______________

STAGE 1 (COMPULSORY)

AIM: To identify those individuals with a known disease, or signs or symptoms of disease, who may be at a higher risk of an adverse event during physical activity/exercise. This stage is self administered and self evaluated.

Please circle response

1.	Has your doctor ever told you that you have a heart condition or have you ever suffered a stroke?	Yes	No
2.	Do you ever experience unexplained pains in your chest at rest or during physical activity/exercise?	Yes	No
3.	Do you ever feel faint or have spells of dizziness during physical activity/exercise that causes you to lose balance?	Yes	No
4.	Have you had an asthma attack requiring immediate medical attention at any time over the last 12 months?	Yes	No
5.	If you have diabetes (type I or type II) have you had trouble controlling your blood glucose in the last 3 months?	Yes	No
6.	Do you have any diagnosed muscle, bone or joint problems that you have been told could be made worse by participating in physical activity/exercise?	Yes	No
7.	Do you have any other medical condition(s) that may make it dangerous for you to participate in physical activity/exercise?	Yes	No

IF YOU ANSWERED 'YES' to any of the 7 questions, please seek guidance from your GP or appropriate allied health professional prior to undertaking physical activity/exercise

IF YOU ANSWERED 'NO' to all of the 7 questions, and you have no other concerns about your health, you may proceed to undertake light-moderate intensity physical activity/exercise

I believe that to the best of my knowledge, all of the information I have supplied within this tool is correct.

Signature ______________________ Date ______________

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FIGURE 12.18 A PAR-Q or similar health screen is required prior to participating in a physical activity program.

EXERCISE INTENSITY GUIDELINES

INTENSITY CATEGORY	HEART RATE MEASURES	PERCEIVED EXERTION MEASURES	DESCRIPTIVE MEASURES
SEDENTARY	< 40% maxHR	Very, very light RPE# <1	• Activities that usually involve sitting or lying and that have little additional movement and a low energy requirement
LIGHT	40 to <55% maxHR	Very light to light RPE# 1–2	• An aerobic activity that does not cause a noticeable change in breathing rate • An intensity that can be sustained for at least 60 minutes
MODERATE	55 to <70% maxHR	Moderate to somewhat hard RPE# 3–4	• An aerobic activity that is able to be conducted while maintaining a conversation uninterrupted • An intensity that may last between 30 and 60 minutes
VIGOROUS	70 to <90% maxHR	Hard RPE# 5–6	• An aerobic activity in which a conversation generally cannot be maintained uninterrupted • An intensity that may last up to about 30 minutes
HIGH	≥ 90% maxHR	Very hard RPE# ≥7	• An intensity that generally cannot be sustained for longer than about 10 minutes

= Borg's rating of perceived exertion (RPE) scale, category scale 0-10

V1 (2011)

PAGE 2

ADULT PRE-EXERCISE SCREENING TOOL

STAGE 2 (OPTIONAL)

Name: ______________________

Date of birth: ______________ Date: ______________

AIM: To identify those individuals with risk factors or other conditions to assist with appropriate exercise prescription. This stage is to be administered by a qualified exercise professional.

		RISK FACTORS
1. Age ____ Gender ____	≥45yrs males or ≥55yrs females +1 risk factor	
2. Family history of heart disease (eg: stroke, heart attack) Relative / Age / Relative / Age ☐ Father ___ ☐ Mother ___ ☐ Brother ___ ☐ Sister ___ ☐ Son ___ ☐ Daughter ___	If male <55yrs = +1 risk factor If female <65yrs = +1 risk factor Maximum of 1 risk factor for this question	
3. Do you smoke cigarettes on a daily or weekly basis or have you quit smoking in the last 6 months? Yes No If currently smoking, how many per day or week? ____	If yes, (smoke regularly or given up within the past 6 months) = +1 risk factor	
4. Describe your current physical activity/exercise levels: Sedentary ☐ Light ☐ Moderate ☐ Vigorous ☐ Frequency (sessions per week): Light ___ Moderate ___ Vigorous ___ Duration (minutes per week): Light ___ Moderate ___ Vigorous ___	If physical activity level <150 min/ week = +1 risk factor If physical activity level ≥150 min/ week = –1 risk factor (vigorous physical activity/ exercise weighted x 2)	
5. Please state your height (cm) ____ weight (kg) ____	BMI = ____________ BMI ≥30 kg/m² = +1 risk factor	
6. Have you been told that you have high blood pressure? Yes No	If yes, = +1 risk factor	
7. Have you been told that you have high cholesterol? Yes No	If yes, = +1 risk factor	
8. Have you been told that you have high blood sugar? Yes No	If yes, = +1 risk factor	

Note: Refer over page for risk stratification.

STAGE 2 Total risk factors = ____

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FIGURE 12.18 Continued

9.	Have you spent time in hospital (including day admission) for any medical condition/illness/injury during the last 12 months? Yes No	If yes, provide details.
10.	Are you currently taking a prescribed medication(s) for any medical conditions(s)? Yes No	If yes, what is the medical condition(s)?
11.	Are you pregnant or have you given birth within the last 12 months? Yes No	If yes, provide details. I am ______ months pregnant or postnatal (circle).
12.	Do you have any muscle, bone or joint pain or soreness that is made worse by particular types of activity? Yes No	If yes, provide details.

STAGE 3 (OPTIONAL)

AIM: To obtain pre-exercise baseline measurements of other recognised cardiovascular and metabolic risk factors. This stage is to be administered by a qualified exercise professional. (Measures 1, 2 & 3 – minimum qualification, Certificate III in Fitness; Measures 4 and 5 minimum level, Exercise Physiologist*).

	RESULTS		RISK FACTORS
1. BMI (kg/m²)		BMI ≥30 kg/m² = +1 risk factor	
2. Waist girth (cm)		Waist >94 cm for men and >80 cm for women = +1 risk factor	
3. Resting BP (mmHg)		SBP ≥140 mmHg or DBP ≥90 mmHg = +1 risk factor	
4. Fasting lipid profile* Total cholesterol HDL Triglycerides LDL		Total cholesterol ≥5.20 mmol/L = +1 risk factor HDL cholesterol >1.55 mmol/L = –1 risk factor HDL cholesterol <1.00 mmol/L = +1 risk factor Triglycerides ≥1.70 mmol/L = +1 risk factor LDL cholesterol ≥3.40 mmol/L= +1 risk factor	
5. Fasting blood glucose*		Fasting glucose ≥5.50 mmol = +1 risk factor	
		STAGE 3 Total risk factors =	

RISK STRATIFICATION

Total stage 2

or

Total stage 3
Plus stage 2 (Q1 - Q4)

≥2 RISK FACTORS – MODERATE RISK CLIENTS
Individuals at moderate risk may participate in aerobic physical activity/exercise at a light or moderate intensity (Refer to the exercise intensity table on page 2)

<2 RISK FACTORS – LOW RISK CLIENTS
Individuals at low risk may participate in aerobic physical activity/exercise up to a vigorous or high intensity (Refer to the exercise intensity table on page 2)

Note: If stage 3 is completed, identified risk factors from stage 2 (Q1-4) and stage 3 should be combined to indicate risk. If there are extreme or multiple risk factors, the exercise professional should use professional judgement to decide whether further medical advice is required.

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Weblink
Adult Pre-Exercise Screening System

SIGNPOST

Download the APSS from the Exercise and Sports Science Australia website. There are also options for screening for young people on this site.

Psychological considerations

The key concept when considering assessment from a psychological perspective is motivation. One of your goals is to educate and excite your client about their personalised program. The assessment tool you use should motivate them to participate in the program you are designing. There are close links here with physiological considerations; selecting activities that are too challenging physiologically may decrease your client's motivation to participate. Before you select your tools, discuss your client's current physical activity levels and explain the tools you are planning on using. This will help them understand the methodology of the tools, as well as your expectations, and give them the opportunity to ask any questions in order to make them comfortable with the process. This discussion forms an important part of the assessment process: informed consent.

Informed consent

informed consent
A process designed to minimise the risk of assessment for the participant and the facilitator

Informed consent is important in society, and the same concept applies when undertaking an FMA. Prior to participation, a facilitator should sit down with the client and explain the following:

- what the assessment will involve
- benefits of participating
- that they can withdraw consent and stop the assessment anytime
- risks of the assessment.

Importantly, the informed consent process gives the participant many opportunities to ask questions, and the facilitator must get a signature prior to commencing the assessment.

If your client is under 18, parental consent is required before the client undertakes any assessment or screen. Parents are provided with the same information that is given to the participant and must sign their approval.

iStock.com/Wavebreakmedia

FIGURE 12.19 Prior to participating in any physical activity, a facilitator should gain informed consent.

FORM 2.4 Informed consent

I (print name), ________________________________, consent to participate in the physiological assessment on the following terms:

1. I have read the Explanation of Physiological Assessment Procedures attached and understand what I will be required to do. I have had the opportunity to ask questions and have received satisfactory explanations about the tests being conducted.
2. I understand that I will be undertaking physical exercise at or near the extent of my capacity and there is possible risk in the physical exercise at this level, such as episodes of transient light-headedness, fainting, abnormal blood pressure, chest discomfort and nausea.
3. I understand that this may occur although the staff in the laboratory will take all and proper care in the conduct of the assessment, and I fully assume the risk.
4. I understand that I can withdraw my consent, freely and without prejudice, at any time before, during or after testing.
5. I have told the person conducting the assessment of any illness or physical defect I have that may contribute to the level of that risk.
6. I understand that the information obtained from the test will be treated confidentially with my right to privacy assured. However, the information may be used for statistical or science reasons with privacy retained. (**Note**: Members of sports teams should have made special arrangements about treatment of individual data with team coach or manager.)
7. I release this laboratory and its employees from any liability for any injury or illness that I may experience during this assessment as well as any subsequent injury or illness that is connected to or to any extent influenced by the assessment.
8. I will indemnify this laboratory in respect to any liability it may incur in relation to any other person in connection with the assessment.
9. I hereby agree that I will present myself for testing in a suitable condition having abided by the requirements for diet and activity prescribed to me by laboratory staff.

Participant signature: ________________________________ Date ____________

Parent/guardian name (required if age less than 16):
Signature ________________________________ Date ____________

Witness name:
Signature ________________________________ Date ____________

Source: Australian Institute of Sport, 2013

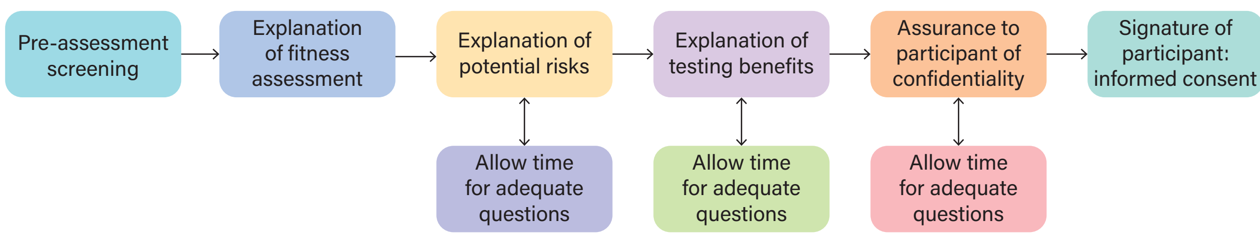


FIGURE 12.20 A sample informed consent form from the AIS, and the process of gaining informed consent.

Sociocultural considerations

Another perspective to consider when selecting assessment tools is the sociocultural factors that impact the tool selection and administration. Most assessment tools suggested in this text are low cost, which caters for differing socioeconomic status. However, filming clients for closer inspection will require technology that might be more expensive. Using a printed card and observing live will be a way to keep costs down. When working with your client, you may be required to demonstrate or touch part of their body during the process. Make sure any cultural or gender sensitivities are addressed to ensure your client is comfortable during the process.

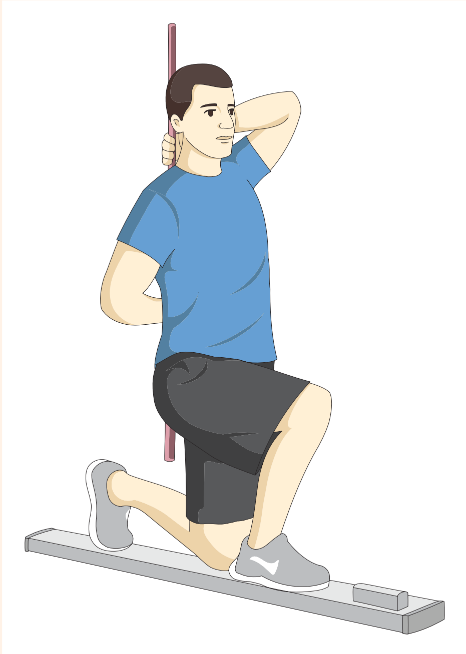


FIGURE 12.21 Soccer teams use the inline step as part of their pre-season screening.

FMA in sport

The information provided thus far has centred around a screening and assessment process for participation in a personalised plan designed to meet client goals and optimise adherence to the NPAGs. However, it is important to reflect on the rising use of FMAs in a sporting context. Various models of functional screening have been used as one way to prevent sports injury and evaluate an athlete's whole body movements prior to beginning a fitness training program or returning to sport after injury. A coach or fitness trainer will select a series of tools that best replicate the movement patterns and muscular groups and actions of that sport. For example, trunk stability is important to summate (build) momentum effectively in tennis and would therefore be a suitable tool for the trainer of a tennis player to use. The inline step is used by soccer teams (see Figure 12.21), as it uses movement that requires spine stabilisation as well as knee, ankle and foot mobility – all vital during a game of soccer.

CASE STUDY EFFECTS OF FUNCTIONAL MOVEMENT SCREEN TRAINING IN BASEBALL PLAYERS

In professional sport, movement screens have been widely adopted to assess readiness to return to matches and training following injury. They have also been used to identify poor biomechanics or weaknesses in stability and mobility. A few studies, including one in Japan, have targeted the effects of training specifically for the movement screen, measuring prior to the training program and following a 12-week intervention training program designed specifically to enhance scores on the movement screen. A selection of movements were analysed, including the trunk stability push-up. This movement was specifically chosen because a stable trunk is important to be able to summate (build) and transfer force successfully when batting or pitching in baseball.

Daniel Shirey/WBCI/MLB Photos/Getty Images

FIGURE 12.22 Japanese pitcher Roki Sasaki needs a high level of trunk stability to successfully transfer momentum during a pitch.

After the initial testing, a training program which included multi-joint exercises using kettle bells, cables and resistance bands was undertaken for 12 weeks. Figure 12.23 shows exercises that were used for two of the assessment movements.

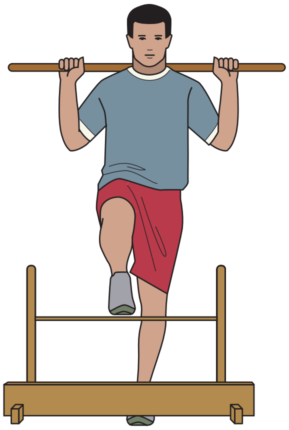
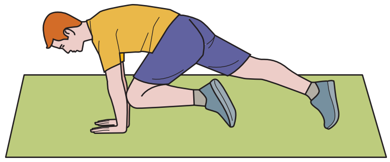
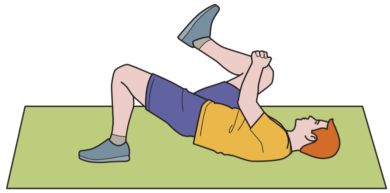
Assessment movement	Exercise #1	Exercise #2
Hurdle step 	Mountain climber 	Leg lock bridge 
Trunk stability push-up 	Push-up shoulder tap 	Side plank 

FIGURE 12.23 Exercises chosen to train assessment movements

As expected, the results showed an improvement in functional movement after the training program. Given that the baseball players were training specifically for these movement patterns, this would be expected. The other interesting observation was that ball speed in pitching increased significantly after 12 weeks of the program. This may be attributed to the increase in stability and therefore force summation of the players. There will be more attention to this sort of training for sports in the future.

QUESTIONS

1 **Identify** the purpose of this study.
2 **Identify** one type of movement in baseball that might be replicated by the hurdle step.
3 **Explain** why the trunk stability test was of particular interest to the researchers.
4 Select one of the example exercises and **justify** why it has been included as part of the training program.
5 Create another exercise using only body weight that could have been used by the researchers to target the same areas as the hurdle step and the trunk stability push-up. Perform this movement and record it in your Reflective folio. You don't need to know the name of the exercise, you can simply draw or describe it.

REAL WORLD APPLICATIONS

Australian Defence Force health and fitness

Many jobs require a high level of fitness to meet the demands of daily occupational tasks. Jobs in the Australian Defence Force require members to be agile, strong and have a level of aerobic power or endurance that would allow them to perform tasks such as patrols, training drills and rescues. Some tasks might require rapid movement from one place to another to secure safety for other force members or civilians. To be eligible for recruitment to the Army, for example, there is a health and fitness check that requires applicants to achieve a certain number of push-ups, sit-ups and to perform well in a test of aerobic power.

iStock.com/laflor

FIGURE 12.24 The Army requires applicants to have a fitness check and meet minimum fitness standards as part of their application.

Weblink
Army health and fitness

SIGNPOST

Many jobs require a minimum standard of functional movement due to the physical nature of the work. Recruitment processes require the applicant to reach certain scores in assessments. Visit the Army Health and Fitness page on the Australian Army website to see the requirements for push-ups, sit-ups and shuttle run scores, as well as information on the protocols of the assessment process.

Assessment
12.2 Check-in questions

12.2 CHECK IN QUESTIONS

1 **Identify** and explain three reasons why it is important to undertake an FMA before you prescribe a personal exercise plan.
2 **Identify** the name of a pre-participant health screen tool.
3 **Discuss** the limitations when using an FMA.
4 Using examples, **discuss** the three considerations of selecting assessment tools.
5 **Discuss** the importance of an FMA for athlete's confidence and risk of re-injury when returning to match play following an injury.

12.3 CONDUCTING A FUNCTIONAL MOVEMENT ASSESSMENT

In this module you will learn about:
- Fundamental Movement Assessment: assessment reliability, validity and accuracy

and learn to:
- conduct and evaluate an FMA using reliable, valid and accurate methodology.

Preparing for an FMA

You have now explored the pre-screening requirements for an FMA. Once you have established the health status of your client and taken into consideration physiological, psychological and sociocultural perspectives, you are ready to select appropriate tools. You will need to consider the suggested tools and select the most appropriate. As this FMA is designed to be specific to each client, you may like to consider alternative tools that are not listed here. Be sure to consult your teacher, and be ready with a clear justification of your choice.

Once you have researched and selected your assessment tools, you are ready to begin. There are four stages to an effective FMA, detailed below.

Stages of an FMA

A qualitative movement analysis is a type of movement analysis that is used widely by healthcare professionals and coaches. It involves non-numeric evaluation of technique of skills or movements. You will use these principles to review movement techniques when conducting your FMA, although you will also be giving a score or counting the number of successful repetitions that are performed. There are four stages to a qualitative analysis. Be sure to understand each stage before you commence the process – begin with the end in mind! The four stages are:
- preparation
- observation
- evaluation
- error correction.

TABLE 12.5 The four stages of a qualitative movement analysis

Stage	Requirements
Preparation	Research the assessment tools. Select the most appropriate. Develop the assessment criteria. Consider how you will instruct your client. Practise delivering the instructions. Arrange any media for filming. Print documents if required.
Observation	Administer the assessment. Watch your client undertake the movement and/or digitally record their movement.
Evaluation	Using your established criteria, identify which parts of the movement are successful and which need work. Give your client a score if relevant.
Error correction	Provide your client with feedback. Establish program goals. Develop their personalised plan to build strengths and address any weaknesses.

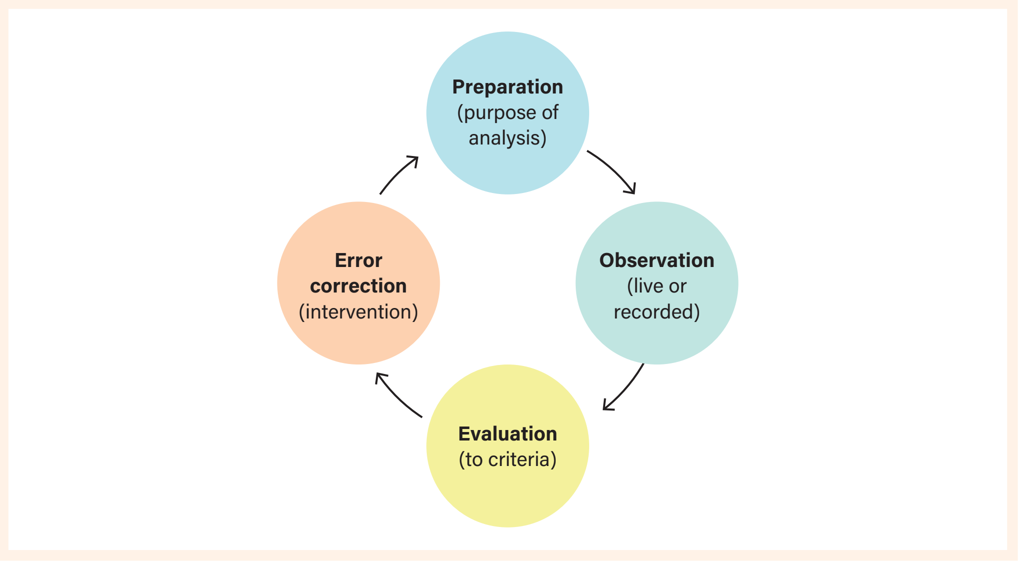


FIGURE 12.25 The stages of a qualitative movement analysis

LOOKING FORWARD
Qualitative skill analysis
Unit 3 (Chapter 5)

The stages used in your FMA will be used when analysing skills in Chapter 5 of *Nelson Physical Education Units 3&4*. Here, you will also use preparation, observation, evaluation and error correction when looking at motor skills such as a tennis serve, running or kicking.

iStock.com/ljubaphoto

FIGURE 12.26 An effective warm-up physiologically and psychologically prepares the body for exercise.

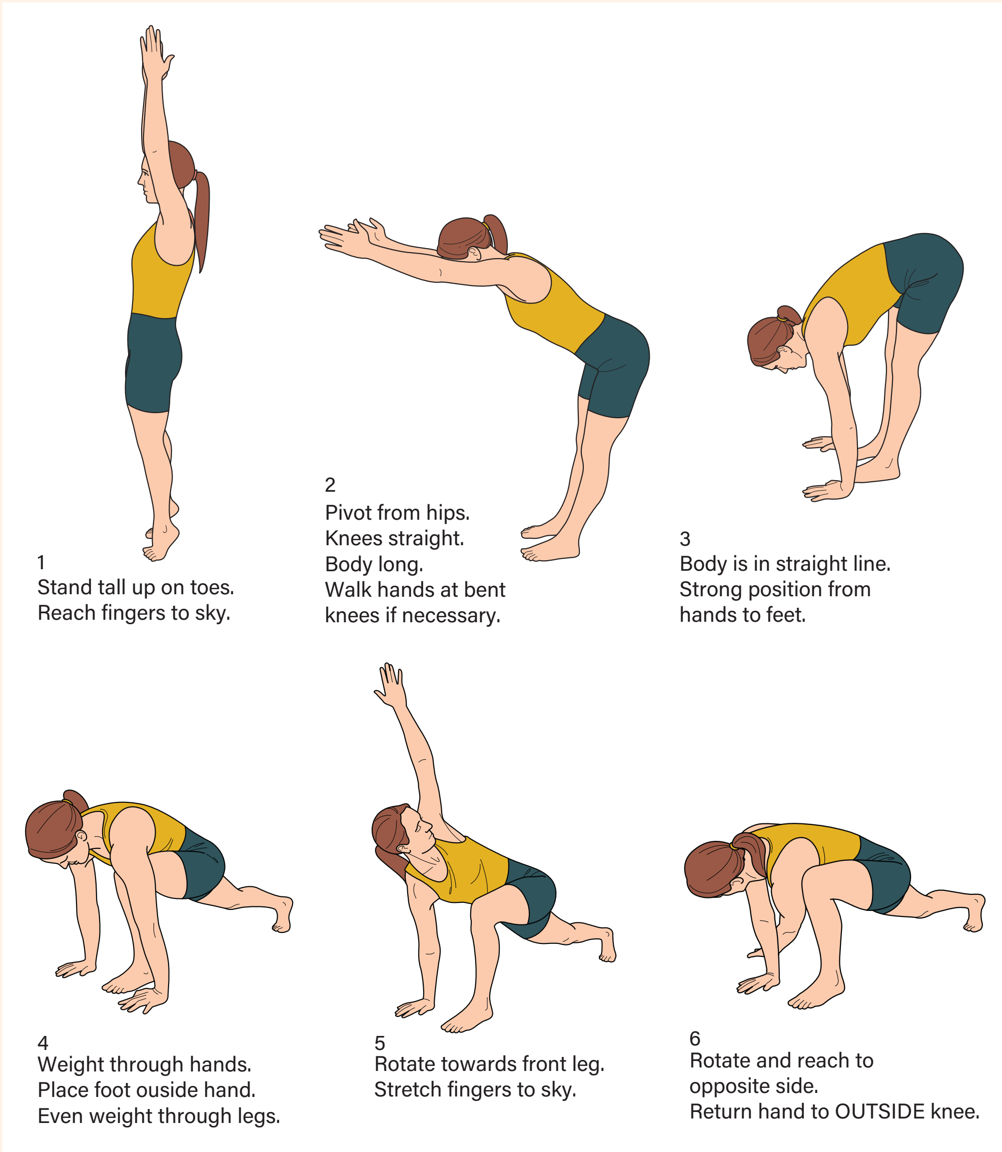
Warm-up

A warm-up is an important part of preparing to move or exercise. The purpose of a warm-up is to physiologically and psychologically prepare the body for exercise. This helps:

- reduce the risk of injury
- increase heart rate
- increase blood flow to working muscles
- increase muscle temperature to increase elasticity
- decreases viscosity of joints
- increase messages from the brain to the muscle
- enhance focus and concentration
- reduce oxygen deficit.

TABLE 12.6 The three phases of a warm-up

General	Dynamic stretching	Movement specific
Full body movement, such as jogging or riding, at a moderate intensity for five minutes	Moving joints continuously through range of motion	Activities that mimic the physiological requirements of the activity



Avpics/Alamy Stock Photo

FIGURE 12.27 A dynamic stretching sequence forms part of an effective warm-up.

Weblink
The world's greatest stretch

SIGNPOST

Following the movements demonstrated in the steps below, work your way through what many have called 'the world's greatest stretch.'

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REAL WORLD APPLICATIONS

RAMP warm-up

The best type and style of warm-up before exercise has long been debated. Some people even debate its importance! Increasingly, the RAMP-style warm-up is being adopted by athletes and sports clubs. RAMP stands for:

- Raise – physiological responses such as heart rate, blood flow to working muscles and muscle temperature
- Activate – get the right muscles working
- Mobilise – use the specific actions and movements required for the upcoming session
- Potentiate – gradually increase the intensity of the activity to match the session requirements.

Figure 12.28 shows what the RAMP warm-up might look like for running.

RAMP warm-up

RAISE	Fast walk or jog
ACTIVATE	Walking lunges Arabesques
MOBILISE	Leg swings Lunge twists
POTENTIATE	High knees Striding

FIGURE 12.28 RAMP warm-up prior to a running session

Protocols

protocols
Rules that explain the correct procedure to be followed when undertaking functional or fitness assessment

Protocols refer to the rules or methodology that should be used when undertaking an FMA. Each tool within an FMA will have specific rules that must be adhered to, to ensure the process reflects best practice. There are some more general protocols which must be considered when conducting each assessment. They are:

- validity
- accuracy
- reliability.

Validity

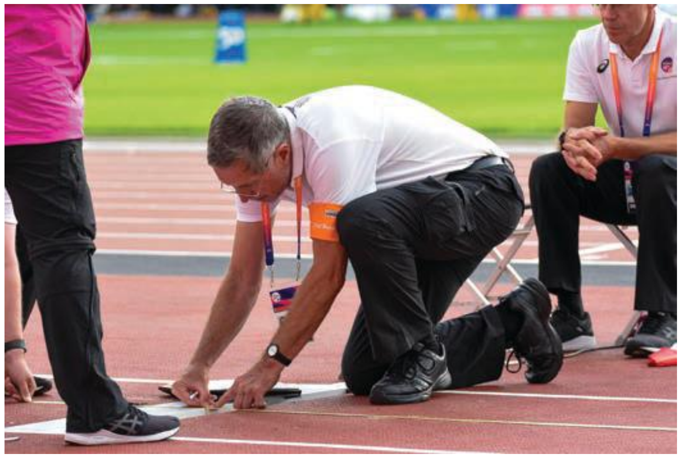
validity
The degree to which an assessment measures what it intends to measure

A valid assessment tool is one that measures what it is supposed to measure. Therefore, it is important that you are able to link each tool with a health-related fitness component where appropriate. Conducting a Cooper 12-minute run is a valid assessment for aerobic power, as it predicts how much oxygen you can take in, transfer and utilise in one minute. However, it is not a valid assessment for muscular strength, the peak force muscles can produce in one contraction. Recalling the definitions of fitness components will support your understanding of this concept.

Accuracy

accuracy
When an assessment is performed free from error

An **accurate** test is one that is performed without error. An error may occur if measurements are incorrect, if equipment is faulty or hasn't been set up correctly, or if the facilitator is unsure of the protocols of assessment. For example, if you are using the 20-metre shuttle run, which requires an individual to run over 20 metres, you need to use a measuring tape to measure the 20-metre distance. Simply stepping out what you believe to be 20 metres will mean the measurement is inaccurate. It can be difficult to avoid human error when using subjective assessment tools, as criteria can be open to personal interpretation. To minimise error, you should be very familiar with the assessment criteria, watch examples of excellent and poor technique, and discuss examples with a partner or as a class.



David Madison/Getty Images Sport/Getty Images

FIGURE 12.29 Using a measuring tape during assessment increases the likelihood of a tool being accurate.

Reliability

Assessment results can be impacted by environmental conditions such as temperature and floor surface as well as the status of the participant, including the amount of sleep they have had or their nutritional and hydration status. **Reliability** ensures the assessment will produce similar results each time it is conducted. It means that, as much as possible, variables that may impact results are controlled and replicated each time the assessment is undertaken. The only variable that should change is the fitness level of the participant. To increase reliability, the following factors should be considered each time an assessment is undertaken:

reliability
The assessment can be repeated with consistent results

- Assessment tools should be administered in the same order.
- The same warm-up should be conducted.
- The test should be administered in the same way.
- Assessment should occur at the same time of day.
- The environmental conditions should be controlled, e.g. the same temperature.
- The nutritional and hydration status of the participant should be similar.
- The participant should be free from injury and illness.
- The same clothing and footwear should be worn.

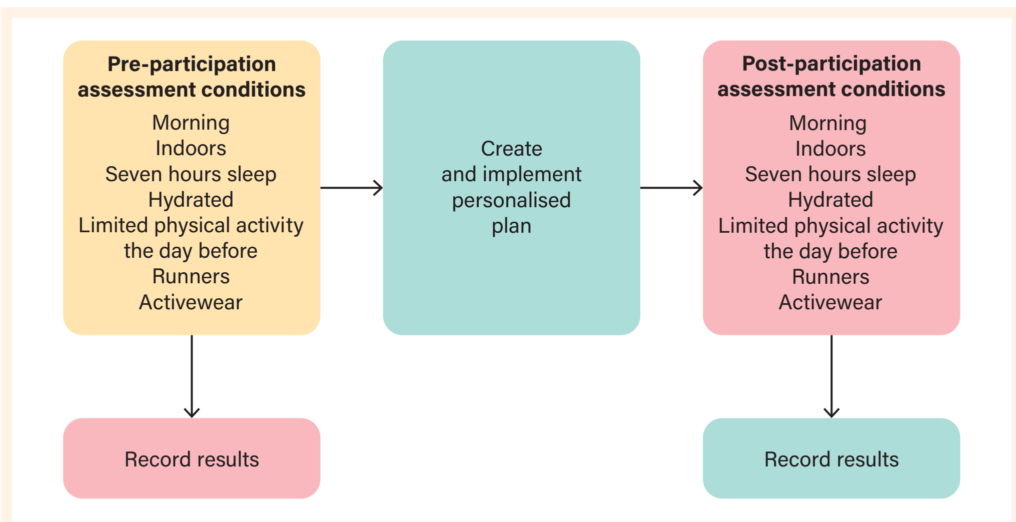


FIGURE 12.30 Ensuring assessment conditions are the same supports reliability of testing.

LEARNING HACK

When considering the concept of reliability, think:
REliability: test-**RE**test.

DID YOU KNOW?

Assessment tools should be administered in order from least fatiguing to most fatiguing, with plenty of rest between efforts if the test involves a high-intensity effort. When a participant is fatigued, their technique and form will be compromised, which will not give you an accurate indication of their ability.

Assessment tools

Now that you have explored the purpose of an FMA and understand how to conduct an assessment, you will need to choose your tools. Be sure to use the evaluation cards to investigate each tool thoroughly prior to your selection, and be familiar with the criteria for a successful performance. For movements in the first five areas, you will observe the movement and give a score of 0–3. You might also like to record the number of successful reps the participant can perform – that is, until fatigue or loss of correct technique. In the assessment for aerobic power, you will give a result that you can compare to normative data and use as a baseline to monitor improvement. Use the FMA assessment card in Figure 12.65 to record your final results.

When observing your client, you should walk around while they move to ensure you see the technique from many angles.

TABLE 12.7 Performance descriptions for scoring your FMA

Score	Performance description
0	The participant experiences pain in any part of the movement. They must stop the movement and be referred to a healthcare professional.
1	The participant is unable to complete the movement or has limited correct technique points.
2	The participant completes the movement with some of the correct technique points.
3	The participant completes the movement with all of the correct technique points.

TABLE 12.8 Assessment tools

Assessment area	Tools
1 Squat/lunge	Squat Lunge
2 Push	Push-up Bench dips
3 Pull	Modified pull-up Resistance band row
4 Brace	Side hold Prone hold
5 Range of motion	Active straight leg raise Shoulder mobility
6 Aerobic power	1.6-kilometre Rockport walk Cooper 12-minute run 20-metre shuttle run

Squat/lunge assessments

Squat assessment

The squat, or versions of the squat, is a very common exercise included in resistance training, as it targets multiple muscles in the lower leg.

Squatting is a natural pattern needed for everyday activities including sitting down and standing up, lowering to pick up something off the ground, producing power to lift a heavy object, and absorbing power when landing.

Method

The squat assessment should be performed on a flat, hard surface. The participant should imagine they are sitting down on a chair. The participant should complete five squats during your observation time.

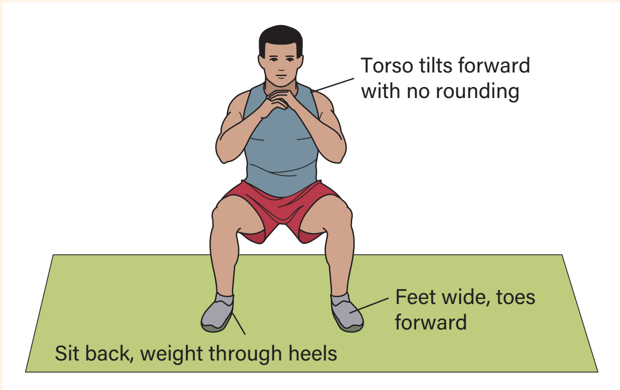


FIGURE 12.31 Correct technique when performing the squat

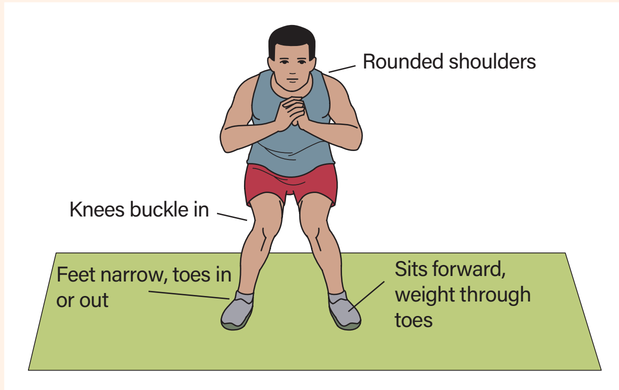


FIGURE 12.32 Common errors when performing the squat

Lunge assessment

The lunge is a popular exercise for the lower body, building strength in gluteal, hamstring and hip flexor muscles as well as requiring flexibility of the hips and hamstrings.

Method

The lunge assessment should be performed on a flat, hard surface. The participant should step forward in front of their body with one foot, complete the lunge, then return to their original position before repeating the movement. The participant should complete five lunges on each leg during your observation time.

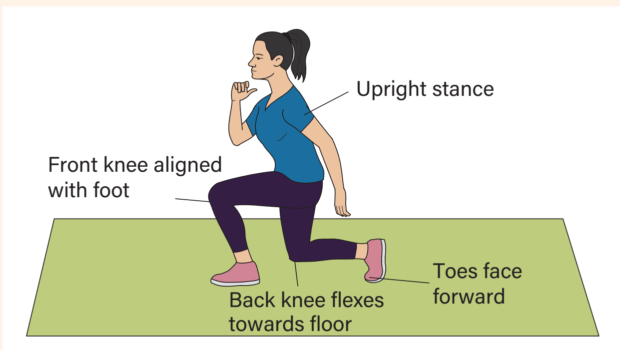


FIGURE 12.33 Correct technique when performing the lunge

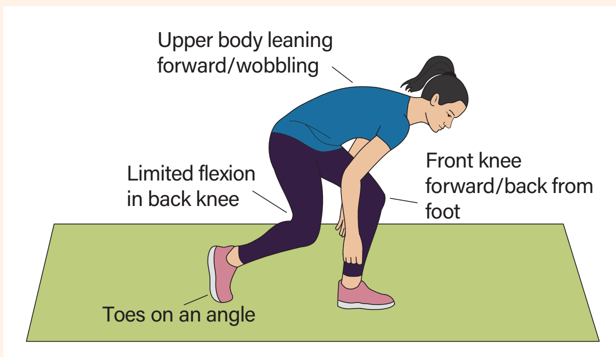


FIGURE 12.34 Common errors when performing the lunge

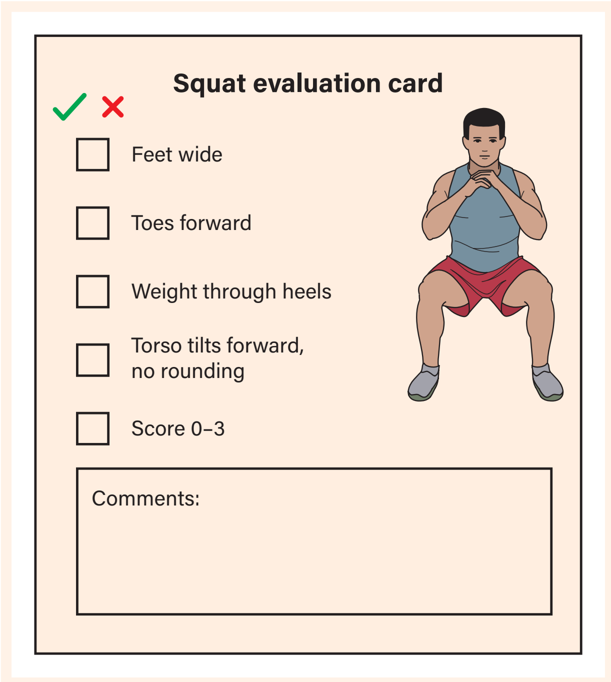


FIGURE 12.35 Squat evaluation card

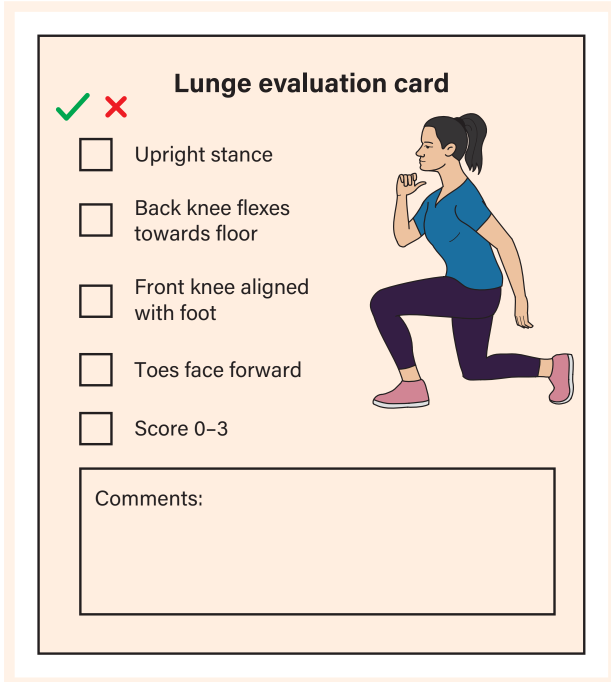


FIGURE 12.36 Lunge evaluation card

Resources
Evaluation card: Squat
Evaluation card: Lunge

TABLE 12.9 Exercises to develop the capacity to squat and lunge

	Squat	Lunge
Exercises	Assisted squat Deep squat Leg extension Yoga chair sit	Lunge walk Ankle dorsiflexion stretch Spiderman lunge Side lunge (suitable for pregnancy)

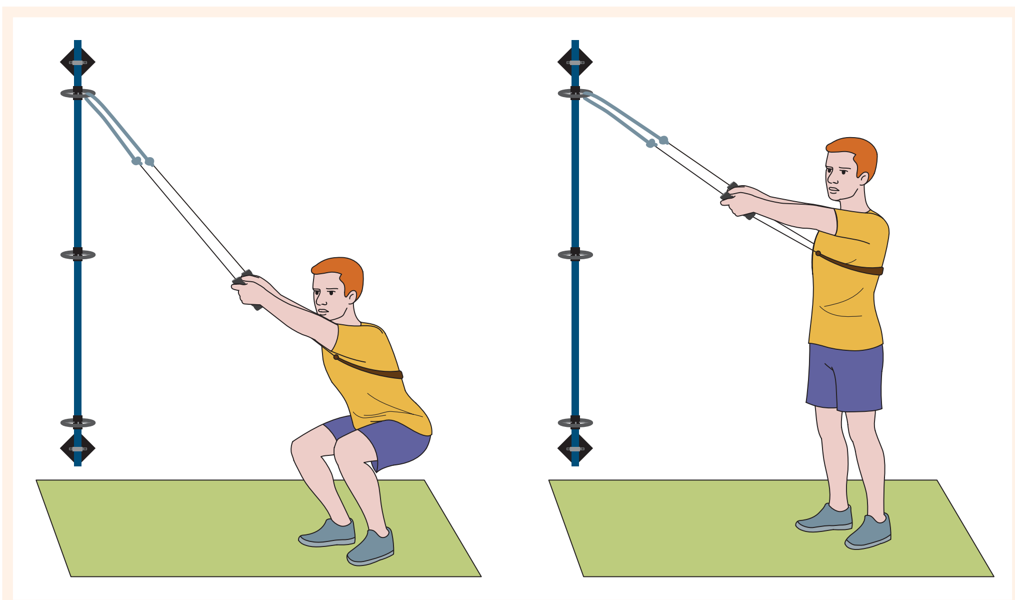


FIGURE 12.37 The assisted squat is a great exercise for someone looking to build their capacity in the squat.

COLLABORATIVE TASK
Prac activity

Inter-rater reliability when assessing the squat

AIM

To explore reliability between observers

EQUIPMENT

- Evaluation cards and Reflective folio
- Clips of squats collected in class or online

METHOD

1. Each observer has copies of the evaluation card.
2. Watch a clip of someone performing a squat.
3. Use the evaluation card to mark against the evaluation points.
4. Record the score of the squat.
5. Compare results in pairs, then as a class.
6. Review several different squats and repeat the process.

DISCUSSION

Use the results and your observations to discuss the following and record your responses in your folio:

1. Were there any differences in evaluation points and scores?
2. If so, why might this be the case?
3. How could you minimise the differences?
4. How can you enhance **inter-rater reliability**?

inter-rater reliability
The extent to which the observers agree in their assessments

Push assessments

Push-up assessment

The push-up is an upper body exercise which can be manipulated to target muscular strength or muscular endurance. It is a popular exercise as it also targets core muscles, supports good posture and replicates functional movements such as opening doors. For this assessment, you should mark to your technique criteria and count the number of successful repetitions before technique is compromised.

Method

The push-up assessment should be performed on a flat, hard surface. The participant should start in a tabletop position with arms wide, then step back with their legs. They bend their elbows to 90 degrees, then press through the hands to push up. The participant should complete as many push-ups as they can before technique is compromised.

Modification: This assessment can be performed from the knees if required.

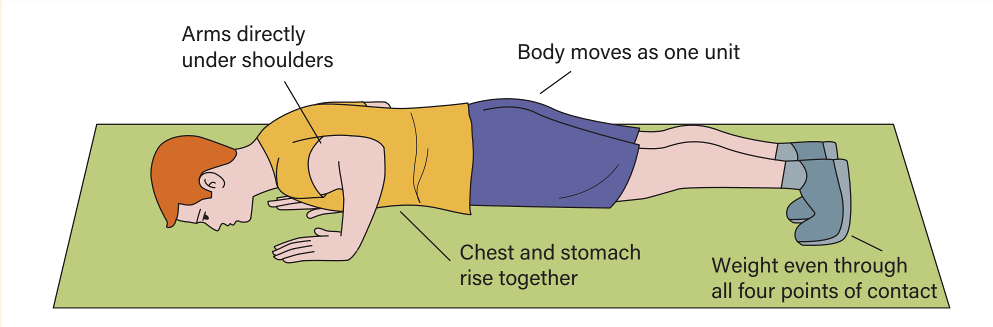


FIGURE 12.38 Correct technique when performing the push-up

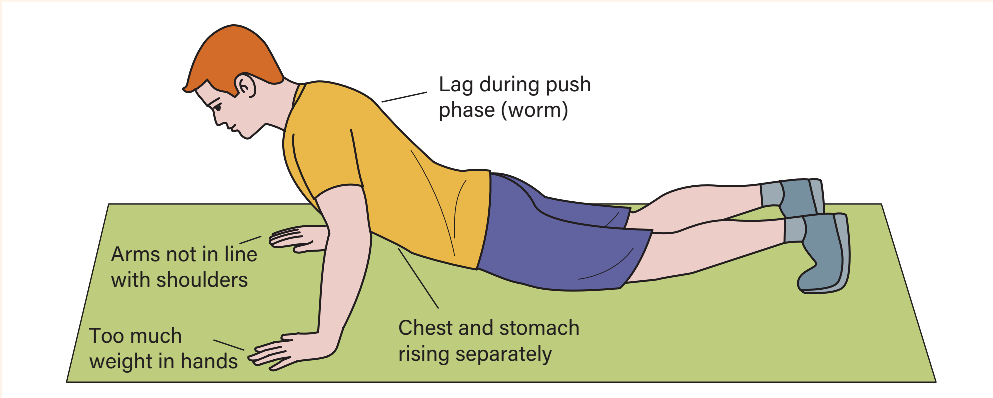


FIGURE 12.39 Common errors when performing the push-up

Bench dips assessment

Bench dips have been included as an option as they are a common exercise for the upper body, are simple to modify to make easier or harder, and use core muscles, targeting multiple joints and muscles. For this assessment, you should mark to your technique criteria and count the number of successful repetitions before technique is compromised.

Method

The bench dip assessment should be performed on a flat, hard surface with a bench. Legs should be extended straight in front. The participant should bend their elbows and slowly lower themselves to the ground, then push up with their arms.

Modification: This assessment can be performed with knees bent if required.

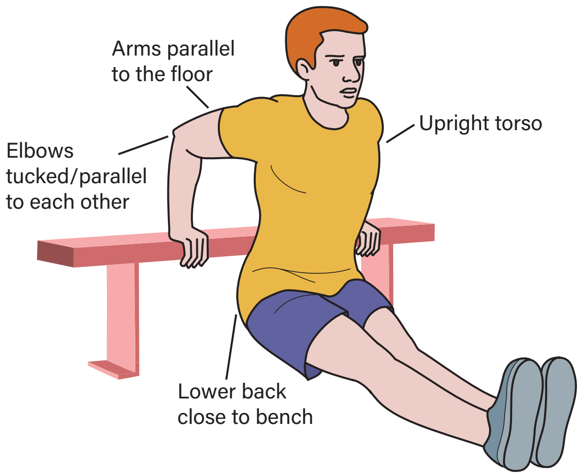


FIGURE 12.40 Correct technique when performing the bench dip

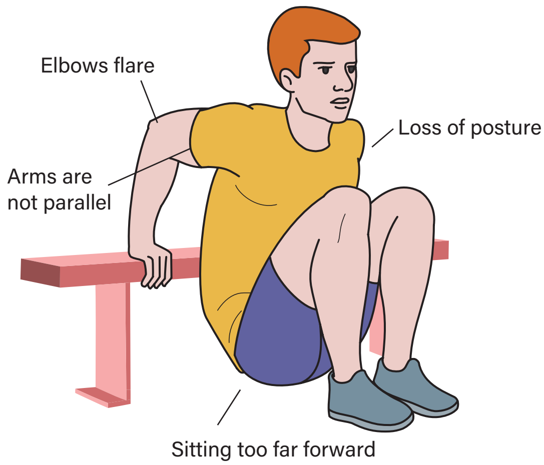
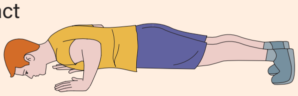


FIGURE 12.41 Common errors when performing the bench dip

Push-up evaluation card

✓ ✗

- ☐ Arms directly under shoulders
- ☐ Chest and stomach rise together
- ☐ Body moves as one unit
- ☐ Weight even through all four points of contact
- ☐ Score 0–3



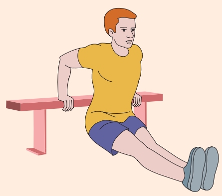
Comments:

FIGURE 12.42 Push-up evaluation card

Bench dips evaluation card

✓ ✗

- ☐ Arms parallel to floor
- ☐ Upright torso
- ☐ Arms tucked/ parallel to each other
- ☐ Back close to bench
- ☐ Score 0–3



Comments:

FIGURE 12.43 Bench dips evaluation card

TABLE 12.10 Exercises to develop the capacity to push

	Push-up	Bench dip
Exercises	Trunk rotation Prone hold Side plank/side plank knee Push-up shoulder tap	Dips Cable push down

Resources
Evaluation card: Push-up
Evaluation card: Bench dips

Pull assessments

Modified pull-up assessment

The modified pull-up assesses muscular strength of the upper body. It is accessible for most population groups, as whole-body weight does not need to be pulled up. For this assessment, you should mark to your technique criteria and count the number of successful repetitions completed before technique is compromised.

Method

The participant lies on their back, shoulders in line with a horizontal bar. Set up the bar at the appropriate height, just above the reach of the participant. An elastic or resistance band is placed 20 centimetres below the bar. This participant must touch their chin to this band to complete a rep.

Modification: This assessment can be performed with feet underneath bent knees if required.

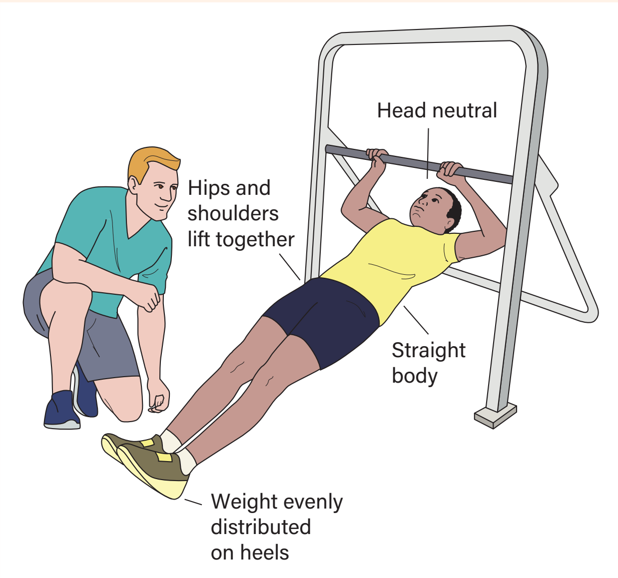


FIGURE 12.44 Correct technique when performing the modified pull-up

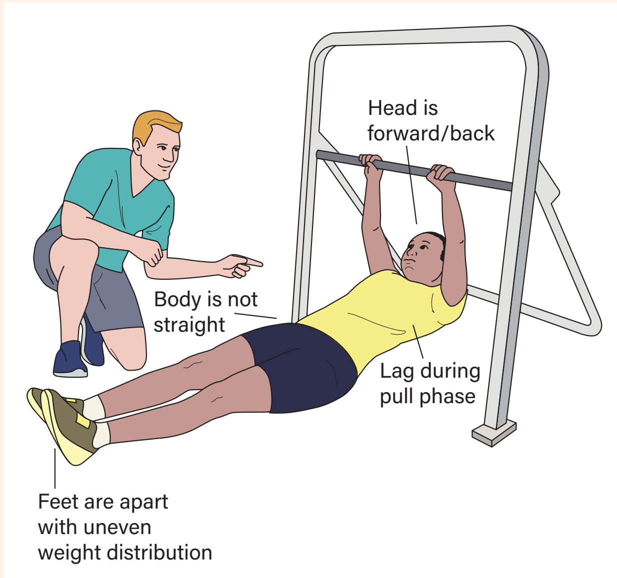


FIGURE 12.45 Common errors when performing the modified pull-up

Resistance band row

This assessment also targets the upper body but will use a lighter resistance, so is more likely to assess local muscular endurance. For this assessment, you should mark to your technique criteria and count the number of successful repetitions before technique is compromised.

Method

Ensure you have selected the appropriate resistance band which allows the participant to perform at least several successful repetitions.

The participant sits in an upright position with straight knees, or a slight bend if they do not have enough flexibility in their hamstring. Using a resistance band around the feet, pull the hands towards the chest, maintaining a tall and stable torso.

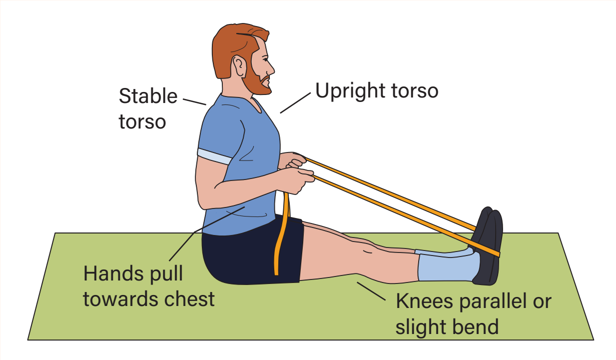


FIGURE 12.46 Correct technique when performing the resistance band row

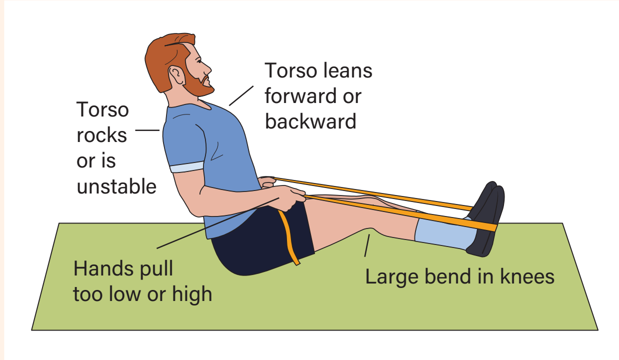
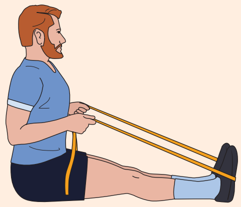


FIGURE 12.47 Common errors when performing the resistance band row

Resistance band row evaluation card

✓ ✗

- ☐ Upright torso
- ☐ Stable torso
- ☐ Knees parallel or slightly bent
- ☐ Hands pull towards chest
- ☐ Score 0–3



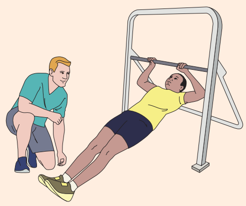
Comments:

FIGURE 12.48 Resistance band evaluation card

Modified pull-up evaluation card

✓ ✗

- ☐ Head neutral
- ☐ Straight body
- ☐ Hips and shoulders lift together
- ☐ Weight evenly distributed on heels
- ☐ Score 0–3



Comments:

FIGURE 12.49 Modified pull-up evaluation card

TABLE 12.11 Exercises to develop the capacity to pull

	Modified pull-up	Resistance band row
Exercises	Assisted band pull up Barbell bench row Seated row	Seated row Bent over row Band arm single row

Brace assessment

Side hold

The side hold is an assessment that requires balance and activation of the abdominal muscles as well as the oblique muscles, which are not targeted in traditional sit-ups and crunches. As an exercise, it can support good posture as well as build strength in the shoulder joint.

For this assessment, you should mark to your technique criteria and record the time the position can be held before technique is compromised.

Resources
Evaluation card: Resistance band row
Evaluation card: Modified pull-up

Method

The participant lies on their side with a straight body. They then push onto their elbow, place their hand on their hip and hold the correct position for as long as they can.

Modification: Participants can perform the movement on their knees if required.

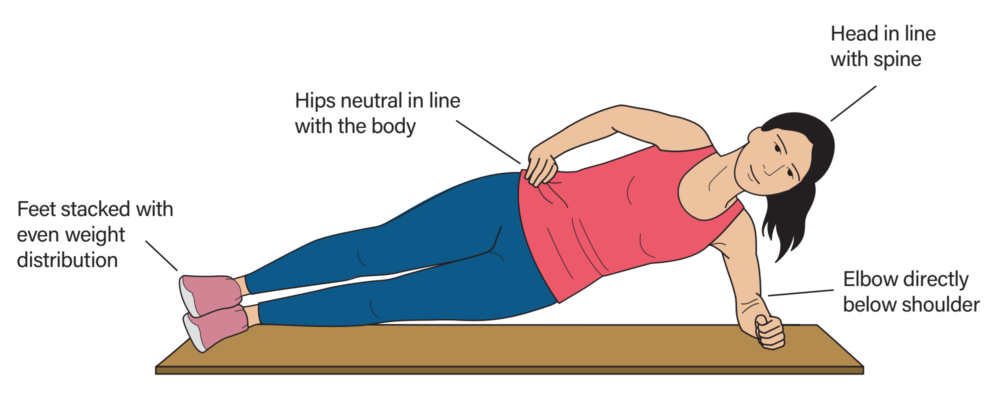


FIGURE 12.50 Correct technique when performing the side hold

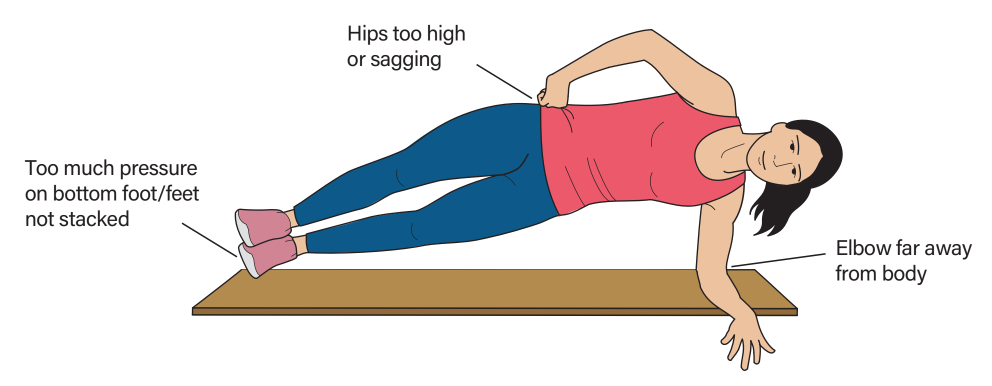


FIGURE 12.51 Common errors when performing the side hold

Prone hold

The prone hold/plank is an assessment that requires core strength and muscular endurance to hold the position for as long as possible. The prone hold requires the shoulders and back to be in a neutral position, which is important to maintain posture and can help alleviate back hunching, which is increasingly problematic in jobs that require extended periods of sitting, or when we use devices such as phones or tablets.

For this assessment, you should mark to your technique criteria and record the time the position can be held before technique is compromised.

Method

The participant should lie prone, then push up onto their elbows and hold the correct position for as long as they can.

Modification: Participants can perform the movement on their knees if required.

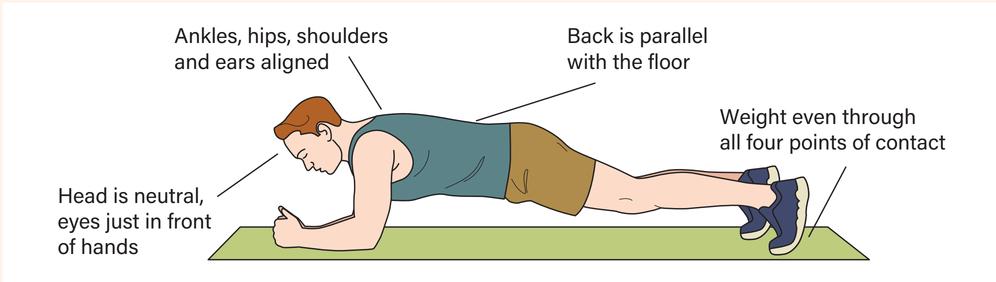


FIGURE 12.52 Correct technique when performing the prone hold

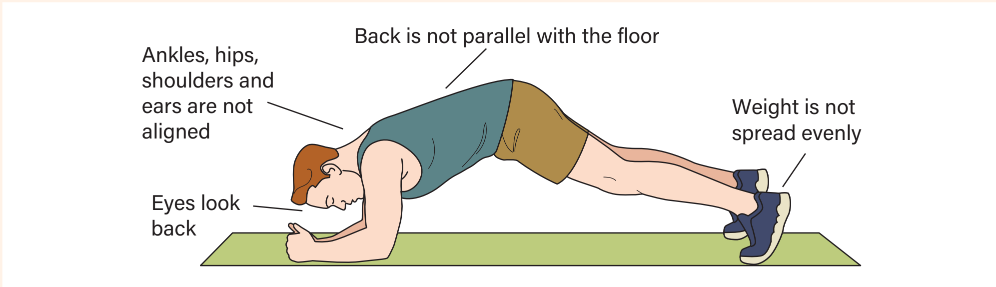


FIGURE 12.53 Common errors when performing the prone hold

Resources
Evaluation card: Side hold
Evaluation card: Prone hold

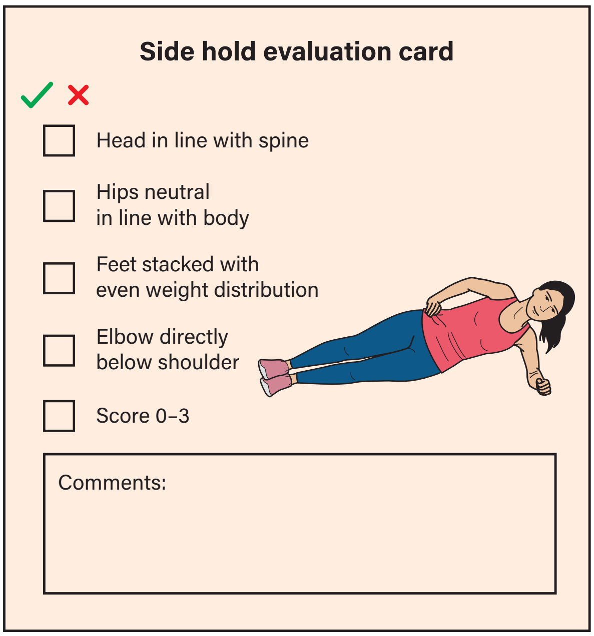


FIGURE 12.54 Side hold evaluation card

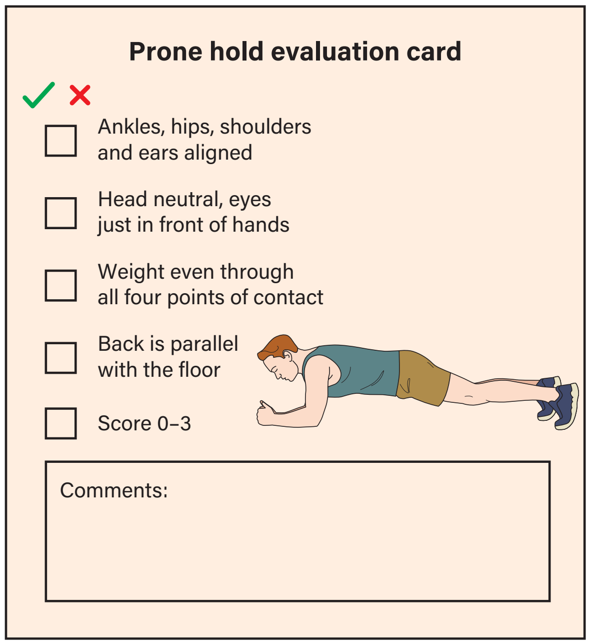


FIGURE 12.55 Prone hold evaluation card

TABLE 12.12 Exercises to develop the capacity to brace

	Side hold	Prone hold
Exercises	Kneeling side plank Side plank dips Toe tap crunches	Mountain climbers Prone shoulder step-up Cobra pose

Range of motion assessments

Active straight leg raise assessment

This is an assessment of flexibility of the hip joint which requires core stability to perform correctly. Mobility in the hip joint is important for many functional activities including walking, bending to pick something up off the floor and climbing stairs.

Method

The participant lies supine, arms by their sides with straight legs approximately 20 centimetres apart. Use a long ruler or similar tool and place it vertically mid-thigh. The participant raises one leg to the highest point possible, stopping if they reach 90 degrees. Swap legs and repeat on the other side.

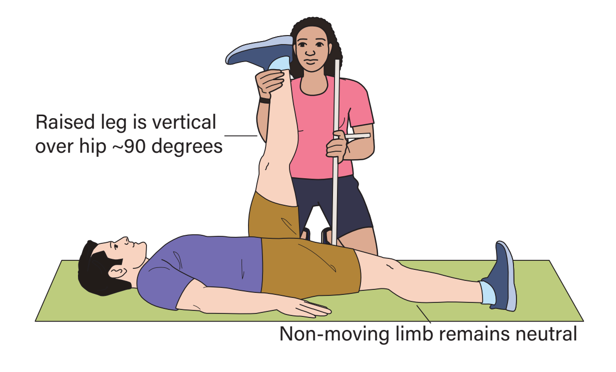


FIGURE 12.56 A score of three on the active leg raise

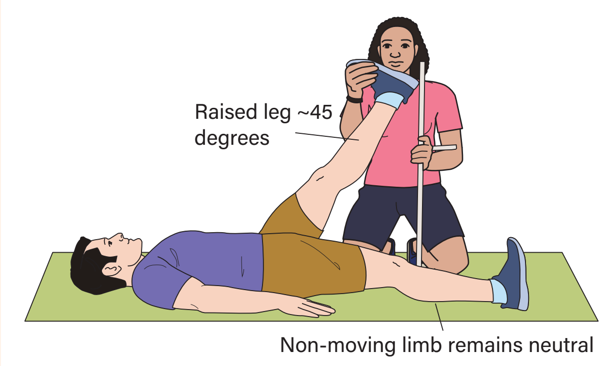


FIGURE 12.57 A score of two on the active leg raise

FIGURE 12.58 A score of one on the active leg raise

Resource
Evaluation card: Active leg raise

Active leg raise evaluation card

	Score				
	0	1	2	3	Comments:
Left					
Right					

FIGURE 12.59 Active leg raise evaluation card

Shoulder mobility assessment

This is an assessment of flexibility of the shoulder joint. Mobility in the shoulder joint is important for many functional activities including reaching and lifting, as well as recreational sporting pursuits like swimming and bike riding.

Resource
Evaluation card: Shoulder mobility

Method

The length of the participant's hand is measured. Then, forming two fists, they move one arm over the back of the head and the other up the spine. Their hands should remain as fists and the distance between the two closest knuckles should be measured.

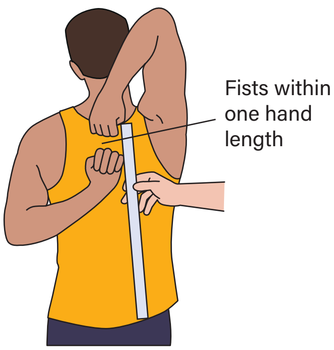


FIGURE 12.60 A score of three on the shoulder mobility assessment

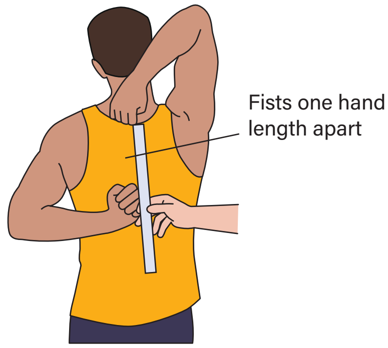


FIGURE 12.61 A score of two on the shoulder mobility assessment

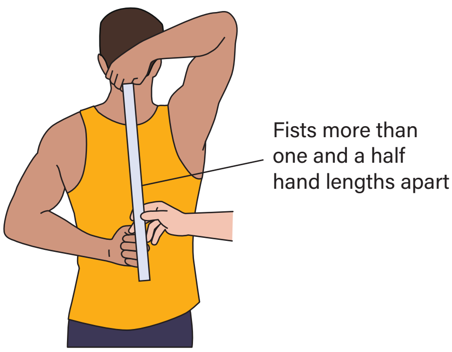


FIGURE 12.62 A score of one on the shoulder mobility assessment

Shoulder mobility evaluation card

	Score				
	0	1	2	3	Comments:
Left					
Right					

FIGURE 12.63 Shoulder mobility evaluation card

Aerobic power

The following assessments have been chosen for their accessibility, ease of performance and to provide diversity for the various ability levels of the clients that students completing Units 1 and 2 will be designing a personalised plan for. You may also explore these assessment tools in Unit 4, as fitness tests for athletes. If the three tools provided do not meet the needs of your client, there are plenty of other options available. Discuss the best option with your teacher.

1.6 kilometre Rockport walk

This assessment is suitable for people of all ages who have been sedentary or have a low fitness status. It would also be suitable for someone with joint issues who may not be able to run. The aim of the assessment is to walk as fast as possible for 1.6 kilometres. While you can calculate a predicted maximal oxygen uptake for this assessment, a more straightforward technique would be to calculate the total time taken to complete the walk. If you wish to explore the predicted maximal oxygen uptake, use the calculator in the MindTap resources.

Weblink
Rockport walk test

SIGNPOST

To calculate predicated maximal oxygen uptake and explore links to sample programs scaffolded for diversity in aerobic fitness, visit the Rockport walk test page on the ExRx.net website.

Cooper 12-minute run

This test requires the participant to run for 12 minutes. An advantage of this assessment is that the participant must continue to move for 12 minutes. If the participant is unable to run for the full time, encourage them to briefly walk, then run again. This assessment is useful to measure the distance they have covered in the 12 minutes, which you can to then compare to an assessment after they have undertaken their activity plan.

Method

Use a track or field that allows you to measure out 400 metres accurately. Place cones to mark out every 20 metres. The participant runs continuously for 12 minutes and the total distance is recorded.

20-metre shuttle run

This test is also known as the beep test, or the multistage fitness test. It has been widely embraced over the past 40 years and is maximal in nature, which means it is run to exhaustion. It is a suitable test for those who are very active and can physiologically cope with a maximal effort.

Method

Measure 20 metres on a flat surface and use an audio recording of the assessment. The participant will start out jogging the 20 metres, commencing each 20 metres at the sound of a beep. The beeps get progressively closer together, increasing the pace and therefore the intensity of work. When the participant is unable to meet the 20 metre line twice in a row, they must stop the assessment.

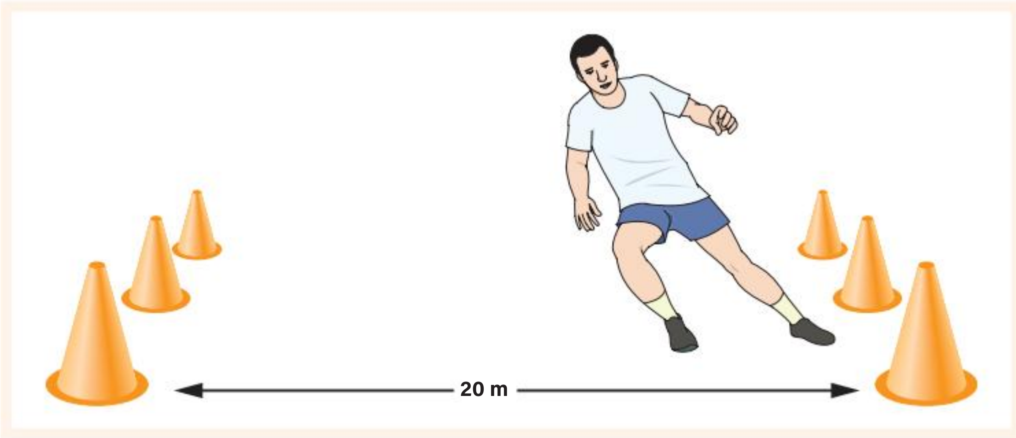


FIGURE 12.64 Set-up for the 20-metre shuttle test

Source: Kate Fuller, National Sport Science Quality Assurance (NSSQA) Program, Australian Institute of Sport

Resource
Evaluation card: Overall

Name	Current physical activity
Age	Pre-screen notes
Gender	Goals of activity plan

Area	Name of assessment	Score (0–3)	Reps/Time	Comments
Squat/lunge				
Pull				
Push				
Brace				
Range of motion				
Aerobic power				

FIGURE 12.65 FMA assessment card

COLLABORATIVE TASK
Prac activity

Peer FMA

AIM

To practise administrating an FMA

EQUIPMENT

- PDF evaluation cards printed or on a device
- Equipment for the selected tool

METHOD

1. Select trial participants from the class or complete as a group of three.
2. Complete pre-participation screening.
3. Select several assessment tools.
4. Review the protocols.
5. Document how you will ensure your assessment is accurate and reliable.
6. Conduct the assessment: one person completes the movement while the others score separately.
7. Compare scores.

DISCUSSION

Use the experience and results to discuss the following:

- How did you ensure accuracy and reliability?
- Which assessment was easiest to conduct? Why?
- Which assessment was most challenging to conduct? Why?
- Would any of the assessments be inappropriate to use for an older client? Why or why not?
- Did you have a different score for any of the assessments? **Discuss** subjectivity challenges with the FMA.

WORKED EXAMPLE

PHYSIOLOGICAL, PSYCHOLOGICAL AND SOCIOCULTURAL CONSIDERATIONS

Question 1

Kelsa is an active adult who walks her dog regularly, participates in circuit class and plays tennis. She wants to increase her flexibility to increase her range of motion to make her tennis shots more powerful and effective.

Her coach selects the active straight leg raise as a way to assess her range of motion prior to designing a personalised program. Evaluate the active straight leg raise from a physiological, sociocultural and psychological perspective.

Suggested response

Signpost the perspectives to guarantee they are aligning the comment correctly

Always try and link psychological perspectives to motivation

From a **sociocultural** perspective the test is cheap and easy to perform, making it appropriate from a **socioeconomic** perspective. Kelsa is active and **motivated** by a participation goal, meaning the straight leg raise is appropriate from a **psychological** perspective. From a physiological perspective, Kelsa is an active adult who would be **capable of performing the test**. However, while the tool measures range of motion, it **isn't specific to the joint** she wishes to target. The **shoulder mobility test** would be more specific and better choice for Kelsa.

Think carefully about the appropriateness of the test. Does it match the goals of the client – is it specific? If not, suggest another more approriate test.

Socio-economic status is easily linked to equipment and access, making it a good choice for these answers

CASE STUDY

THE DIFFERENCE BETWEEN TRADITIONAL STRENGTH TRAINING AND FUNCTIONAL STRENGTH TRAINING

Strength training, both traditional and functional, is beneficial for building strength and increasing muscle mass, and has health benefits such as supporting weight control due to increased metabolism and bone health.

While traditional strength training focuses on building strength in isolated muscle groups, functional strength training places a greater emphasis on multiple joint movement, coordination, and the integration of strength into functional activities. Both approaches have their advantages, and the choice between them may depend on an individual's goals, preferences and specific needs.

Some differences are summed up in Table 12.13.

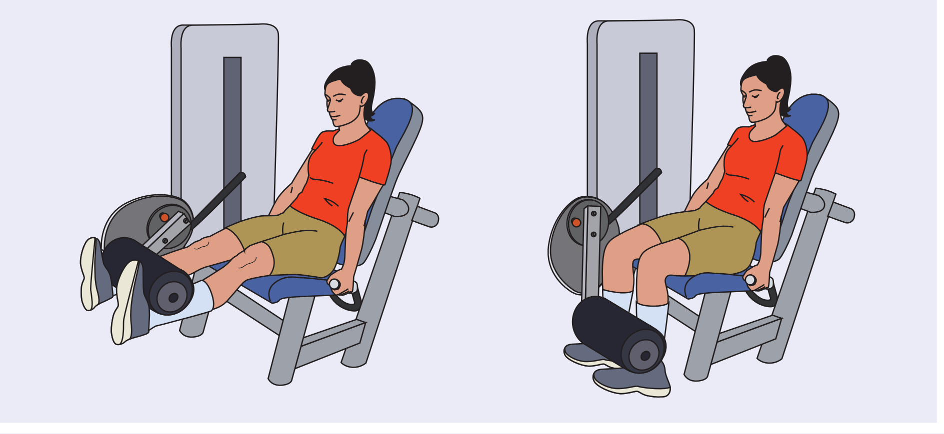
TABLE 12.13 Differences between traditional and functional strength training

	Traditional strength training	Functional training
Specificity	Focuses on building strength in a specific muscle	Prioritises building strength and stability in a more holistic approach
Balancing muscle imbalances	As the focus is often one group of muscles, if others are neglected an imbalance can occur	Tries to correct muscle imbalances by improving overall functional movement patterns
Exercise selection	Often focuses on isolated muscle exercises such as bicep curls	Mimics real-life movement like dead lifts that use multiple muscle groups simultaneously

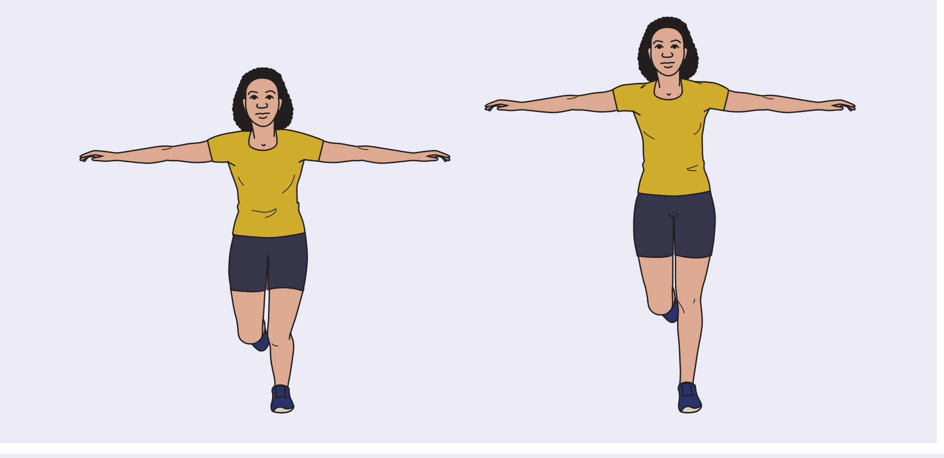
To summarise, while traditional strength training focuses on building strength in isolated muscle groups, functional strength training places a greater emphasis on overall movement patterns, coordination and the integration of strength into functional activities.

QUESTIONS

1 **Identify** one difference between traditional and functional strength training.
2 **State** two health benefits of any type of strength training.
3 If age-related loss of muscle mass reduces produces a decline in muscular strength, **predict** an adaptation that would occur as a result of undertaking any type of strength training, and **explain** how this would improve muscular strength.
4 **Explain** why functional strength training builds more coordination than traditional strength training.
5 Use your understanding of traditional and functional stretch training to **classify** each of the exercises below, justifying your selection.



Exercise 1



Exercise 2

REAL WORLD APPLICATIONS

a_space

a_space is a company that is passionate about community play and fitness. They have been commissioned by local municipalities in Australia to create fitness and health stations in local parks and on walking trails. The stations focus on functional movement such as shoulder mobility and abdominal strength, as seen in the pictures of two of their stations in Figure 12.66.

The concept centres around having a diverse range of options, providing spaces for adults to participate in activities that they may not have access to in their everyday life.

Each station has instructions as well as a QR code for more specific technique tips. They are placed in easy to access areas around the local community.

a_space Australia Pty Ltd

FIGURE 12.66 Stations such as the leg raise and shoulder mobility target important health-related fitness components of flexibility and muscular strength.

LOOKING BACK

Social-ecological model

Chapter 11

The implementation of exercise stations in local communities is targeting the physical environmental level of the social-ecological model, which we looked at in Chapter 11. The diagrams and technique advice educates the participant at the individual level. While no one factor changes behaviour, the physical environment level should be targeted first to provide an accessible space for participants to use.

SIGNPOST

Visit the a_space website to look at the stations a_space have created in Elwood, in Yalukit William Country in the City of Port Phillip and in Altona at Cherry Lake.

Weblink
a_space

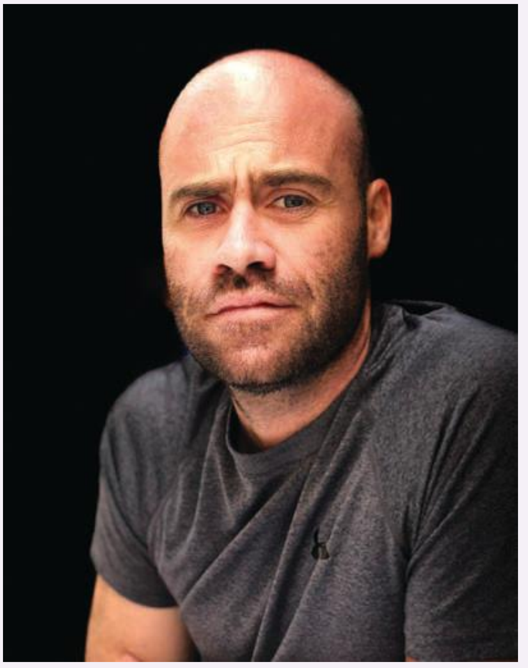
REAL WORLD APPLICATIONS

Ask an expert – Interview with Matt Harris, Osteopath at Everything's Connected Progressive Osteopathy

What is your role as an osteopath?

Osteopaths are primary healthcare practitioners, with most osteopaths working in the private practice sector. We work with a range of different patient populations. My practice has a strong bias towards elite athletic performance, injury management, and the ageing geriatric population. While the populations are variable, the management principles across the populations remain the same.

In geriatrics, we focus on improving activities of daily living, while with the athletic population we focus on sports skill acquisition.



Matt Harris

FIGURE 12.67 Osteopath Matt Harris

Do you have a focus on functional movement in your practice?

Our entire practice is focused around improving functional movement and what that may mean to our patients. In our elderly population, this might mean examining standing from a chair or walking across the room. In our elite athletes, this could be dodging from an opponent or kicking a ball. Whether the patient is in pain from injury or uninjured and wants to improve performance, understanding how the body functions within the related task is essential to good practice.

How we move in the world has a direct reflection on how we perceive the world and vice versa.

Why is this so important for you as a healthcare professional?

There is good evidence in the literature to suggest that patients do not attend osteopathic clinics when they have pain, but instead, when the pain inhibits their function.

To understand a patient, it is important to understand their goals and needs and how their movement system is supporting or acting against them.

We aim to help them find efficient, hopefully, pain-free ways to achieve this.

What are some long-term physical consequences of inefficient movement patterns?

Movement is essential for mind, body and soul. When movement becomes affected, it inhibits how we can interact with the world. If we take the case example of an elderly patient with severe knee osteoarthritis. Walking can become extremely difficult, severely impacting how they interact in the world. If the knee hurts to take a step it's unlikely that we will travel outside or far from home. Confidence becomes affected, the patient sees less of their friends and family and enjoyment of life becomes inhibited. As movement becomes impaired, physiological processes become impaired. Without movement, we begin to see metabolic derangement, which has impacts across all of our organ systems. We see such changes as reduced respiratory function, cardiac decline, sarcopenia and depressive mental states to name but a few consequences.

What are some of the factors affecting functional movement (e.g. age, injury)?

Functional movement can become inhibited by a wide range of consequences. Some of these include injury, age and genetics.

Our lifestyle factors play a big role in our ability to move successfully in the world. The choices we make around nutrition affect our energy levels and our body's ability to heal and perform.

>

Sleep impacts our ability to heal, exposing us to a greater risk of injury when placing our bodies under strain.

Stress under all of its guises, social, financial and physical can all alter the way our body functions and performs. Just think about how anxiety has either helped or hindered your sporting performance when you are playing that 'big' game.

What are some common functional movements that your clients find challenging?
Within the geriatric patient base, many elements of life that we take for granted can become extremely difficult. Getting in and out of chairs, on and off the toilet, and simply making our way across the room without falling over can all be consequences of a poorly ageing movement system.

The elite athlete can achieve things with their body that I can only dream about. Their ability to put together complex movements to avoid players and make the shot as the buzzer goes off is sometimes nothing short of miraculous. Especially when you consider the complexity of the movement that is occurring in an environment of chaos.

What sort of exercises do you use in your treatment to develop functional movement?
Within my practice, we assess the task that the patient/athlete is finding difficult or wants to improve. We watch how the movement is performed and examine for such things as coordinative control, speed, balance, mobility, and power of the athlete.

We then map these individuals' physical capacities to the needs of the specified task. For example, the position that they play on the soccer pitch, the level of soccer they play, and the demands of the time of season.

Our treatment and exercises are individualised to the particular needs of the client or athlete. By understanding function, we can apply specific exercises that are tailored to the individual.

Other than exercise, how can someone improve their quality of life from a physiological perspective?
Lifestyle factors are the most overlooked interventions within the general population. Understanding the benefits of good sleep, regular movement, and a nutritious whole-food diet seems to be lost. Patients often want fancy supplements or the next cool exercise when in reality, they just need to eat better, sleep better, and move well and often.

12.3 CHECK-IN QUESTIONS

1 **Identify** the health-related fitness component targeted in the shoulder mobility assessment.
2 **Explain** the importance of undertaking a warm-up prior to an assessment.
3 **Identify** two factors to consider when ensuring reliability of the assessment process.
4 **Discuss** the advantages of digitally recording a movement as part of the observation phase of a qualitative analysis.
5 Select an assessment tool for an older adult who is sedentary and wants to improve their ability to reach for items on a high shelf. **Justify** your selection from a physiological perspective.
6 Select an assessment tool for a peer at your school who is active and wants to improve their aerobic power when running. **Justify** your selection from a physiological, psychological and sociocultural perspective.
7 A student decides to use the following tools in their FMA. Use your understanding of these tests to place them in the order in which they should be conducted, and **justify** your selection:
   - **a** shoulder mobility
   - **b** Cooper 12-minute run
   - **c** squat
   - **d** side plank hold.

Assessment
12.3 Check-in questions

Command terms

identify
Recognise and name and/or select an event, feature, ingredient, element, speaker and/or part from a list or extended narrative or argument, or within a diagram, structure, artwork or experiment

justify
Show, prove or defend, with reasoning and evidence, an argument, decision and/or point of view using given data and/or other information

CHAPTER SUMMARY

Resource
Self-assessment checklist

Video
Masterclass: Chapter 12

12.1 Physical fitness and health-related fitness components

- Physical fitness is made up of many components and refers to one's ability to get through activities of daily living efficiently and effectively.
- Aerobic power is the rate of energy production from the aerobic energy system.
- Muscular strength is the peak force a muscle or group of muscles can produce in one contraction.
- Muscular endurance is the ability to sustain repeated contractions in the face of fatigue.
- Flexibility refers to the range of motion around a joint.
- The major factors affecting fitness components include: genetics, sex, age, training status and muscle fibre type.

12.2 Functional Movement Assessment

- Functional Movement Assessment (FMA) is a movement screen undertaken prior to participating in a personalised plan which aims to evaluate an individual's functional movement patterns, skills, stability and can measure health-related fitness components.
- Pre-participation health screening is the systematic application of a test or enquiry to identify individuals with any risk of a specific disorder that warrants further investigation.
- A number of considerations need to be made when selecting the most appropriate assessment tool. These include physiological, psychological and sociocultural considerations.
- Physiological considerations include: are they able, and does the assessment match the muscle groups and actions of their goals?
- Psychological considerations include motivation and are linked to physiological considerations.
- Sociocultural considerations include socio-economic status and cultural sensitivities.
- Informed consent is a process designed to minimise the risk of assessment for the participant and the facilitator.

12.3 Conducting a Functional Movement Assessment

- A qualitative analysis involves non-numeric evaluation of technique of skills or movements.
- There are four stages to a qualitative analysis: preparation, observation, evaluation and error correction.
- The purpose of a warm-up is to physiologically and psychologically prepare the body for exercise.
- Validity is the degree to which as assessment measures what it intends to measure.
- Accuracy ensures an assessment is as free from error as possible.
- To increase accuracy, a facilitator should use measuring devices, follow the protocols and be familiar with the assessment process.
- Reliability of a test means that a test could be repeated by a different assessor and similar results would be obtained.
- Factors affecting reliability include: environmental conditions, nutritional and hydration status, sleep, warm-up, assessment order and test administration.

CHAPTER REVIEW

1 Functional age is defined as:
   A optimal physiology for the years they have been alive.
   B how long a person has been exercising on a regular basis.
   C the number of years a person has been alive.
   D how well a person functions in daily life, including in their job.

2 a **Define** muscular strength.
   b **Explain** how age affects muscular strength.
   c **Discuss** how the age-related change in muscular strength may impact functional independence.

3 **Explain** two purposes of an FMA.

4 The side hold is an example of assessment in which area?
   A Lunge
   B Brace
   C Range of motion
   D Aerobic power

5 Use a brainstorm template to rapid fire all the information you can remember about one of your assessment tools. A blank template you can use for each tool can be found on Nelson MindTap. Add this to your Reflective folio.

6 a Informed consent is important prior to undertaking an FMA. **Describe** informed consent.
   b **Explain** three things that are important during the informed consent process.
   c **Explain** how informed consent might be different for a school-aged student, compared to an adult.

7 Using an example, **explain** the difference between reliability and accuracy.

8 **Discuss** the implications of performing an assessment tool before a program in cold weather outside, then after a program in hot weather inside.

9 **Discuss** the importance of following the correct methodology when administering a test.

10 Develop an appropriate warm-up prior to undertaking the squat/lunge, justifying each of the three stages you have prescribed.

11 **Identify** the health-related fitness components that would be important for a farmer and explain your selection, using specific examples of daily occupational tasks a farmer may perform.

12 For two of the assessment tools you undertook, **describe** how you ensured they were accurate and reliable.

13 **Explain** why screening tools should be used prior to undertaking a personalised program.

Assessment
Chapter 12 Review

Command term

explain
Give a detailed account of why and/or how with reference to causes, effects, continuity, change, reasons or mechanisms; make the relationships between things evident

Template
Brainstorm

CHAPTER 13

DESIGNING A PERSONALISED PHYSICAL ACTIVITY PLAN

UNIT 2 – AREA OF STUDY 1

sushytska/Adobe Stock

FIGURE 13.01 Physical activity plans can be personalised to suit anyone's interests.

Quizzes

Chapter 13 Pulse check

13.1 Check-in questions

13.2 Check-in questions

Chapter 13 Review

Videos

Masterclass: Chapter 13

13.2 In focus: Substituting more active alternatives in everyday life

Resources

13.1 Template: Process of change questionnaire

13.1 Template: Daily personal activity record

13.2 Template: Weekly training schedule

13.2 Template: Training session (gym)

Chapter 13 Self-assessment checklist

Nelson MindTap

To access resources above, visit **cengage.com.au/nelsonmindtap**

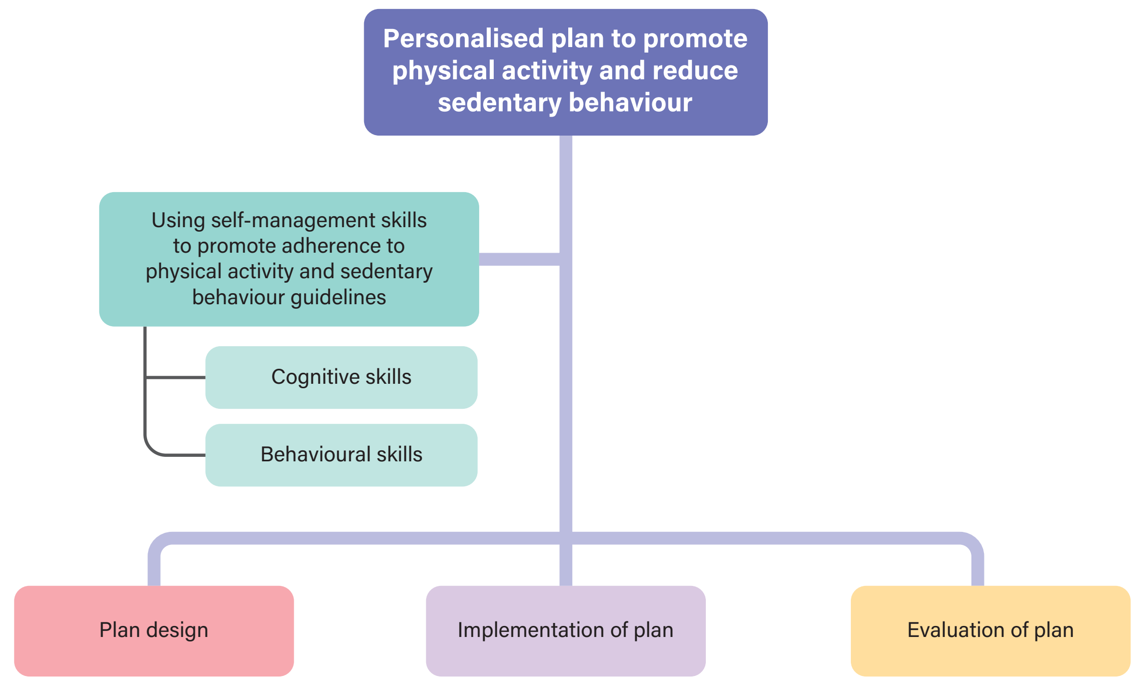
KEY KNOWLEDGE

- considerations of a personalised plan, including self-management skills, used to promote physical activity and reduce sedentary behaviour

KEY SKILLS

- using self-management skills, design a sustainable personalised plan that promotes adherence to physical activity and sedentary behaviour guidelines
- implement strategies from a personalised plan to gather primary data about strengths and limitations of the program design

Source: VCAA VCE Physical Education Study Design (2025–29)



Video
Masterclass: Chapter 13

LOOKING BACK
Functional Movement Assessment (FMA)
Chapter 12

As discussed in Chapter 12, prior to participation in a personalised plan the person should have completed a Functional Movement Assessment (FMA), which aims to evaluate an individual's functional movement patterns, skills and stability. An FMA can indirectly measure health-related fitness components and establish a baseline that can be used to prescribe activities within a personalised physical activity program.

In this chapter we will cover things we need to consider when promoting physical activity at an individual level, and the importance of and different types of cognitive and behavioural self-management skills. We will also explore the design, implementation and evaluation of individualised plans to promote physical activity and reduce sedentary behaviour. We will examine conducting a needs analysis, training principles, training programs and how we might determine whether a program has been effective.

Assessment
Chapter 13 Pulse check

PULSE CHECK

Take the pulse check quiz to check your prior knowledge and understanding of the concepts covered in this chapter.

1 **List** three behavioural strategies you could use to increase your likelihood of adherence to the physical activity and sedentary behaviour guidelines.
2 **Identify** two methods you could use to assess your fitness.
3 **Describe** what is meant by 'interval training.'
4 Brainstorm a more active alternative to being driven to school or to the local shops.
5 **Explain** an example of how you could remind yourself to be active.

13.1 CONSIDERATIONS OF A PERSONALISED PHYSICAL ACTIVITY PLAN

In this module you will learn about:
- considerations of a personalised plan, including self-management skills, used to promote physical activity and reduce sedentary behaviour

and learn to:
- complete a needs analysis to inform the development of a personalised physical activity plan.

cognitive
Involves attitudes, thinking and awareness

behavioural
The abilities you have, involves what you do

Reducing physical inactivity involves changes to both individual behaviour and the environment, but most physical activity research tends to focus on changing individual behaviour. Many health professionals, health educators, medical practitioners and psychologists also use approaches that encourage the individual to change their behaviour. Individual approaches focus on biological, **cognitive** and **behavioural** factors. As we consider the design, implementation and evaluation of individualised physical activity programs, we will explore a range self-management skills that utilise cognitive and behavioural strategies to promote adherence to physical activity guidelines (see Table 13.1). Often these strategies are prescribed or recommended by the professionals mentioned above during a one-on-one counselling session.

TABLE 13.1 Self-management skills can be classified as cognitive or behavioural.

Cognitive strategies	Behavioural strategies
Increasing knowledge Encourage the individual to read and think about physical activity.	**Finding alternatives** Encourage the individual to participate in physical activity when they are tired, stressed or unlikely to want to be physically active.
Being aware of risks Ensure the individual understands that being inactive is very unhealthy.	**Enlisting social support** Encourage the individual to find a family member, friend or co-worker who is willing and able to provide support for being active.
Caring about consequences to others Encourage the person to recognise how their inactivity affects their family, friends and co-workers.	**Rewarding yourself** Encourage the individual to praise and reward themselves for being physically active.
Comprehending benefits Assist the individual to understand the personal benefits of being physically active.	**Committing yourself** Encourage the individual to make promises, plans and commitments to be active, and then write these down.
Increasing healthy opportunities Help the individual to increase their awareness of opportunities to be physically active.	**Reminding yourself** Teach the individual how to set up reminders to be active, such as keeping walking or running shoes in the car and at the office, ready to be used at any time.

Source: Adapted with permission from Marcus, B.H. & Forsyth, L.H. (2009). *Motivating People to be Physically Active,* 2nd edn. Champaign, IL: Human Kinetics, p. 18.

LEARNING HACK

Ensure you understand the difference between a cognitive and behavioural self-management skill. One involves what you think and one relates to what you do. Think of cogs turning as a cue to the brain thinking to remember what cognitive means.

Counselling

Counselling is a widely used individual approach to physical activity promotion. Advice about being physically active can be provided by a personal trainer, general practitioner (GP), osteopath, physiotherapist, physical activity adviser, physical education teacher, fitness instructor or psychologist. Counselling has proven to be a very effective method of promoting physical activity at an individual level. Advice about physical activity may be delivered via:

- health-professional counselling
- telephone or email/online counselling
- automated telephone- or online-delivered advice (via text messages, email etc.).

Amnaj Khetsamtip/Shutterstock.com

FIGURE 13.02 Why is a GP in an ideal position to counsel people about the benefits of physical activity?

The most successful counselling intervention programs tailor or match their materials and information to the individual's level of physical activity. This is sometimes referred to as 'stage-matched' materials. Research has shown that tailoring the processes of change to the individual's activity level results in a greater success rate.

In general, people who are not meeting the physical activity guidelines require mostly cognitive processes, with some behavioural processes, while people who regularly meet the guidelines typically use mostly behavioural processes and some cognitive processes. In a stage-matched intervention, individuals who are not meeting the guidelines might benefit from cognitive strategies such as increasing awareness and knowledge of the benefits of physical activity. The focus for individuals who are meeting the guidelines might include behavioural strategies such as developing a reminder system and using rewards for being physically active (see Table 13.1).

COLLABORATIVE TASK
Activity

Processes of change questionnaire

Processes of change questionnaire					
Physical activity or exercise includes activities such as walking briskly, jogging, cycling, swimming or any other activity in which the exertion is at least as intense as these activities. The following experiences can affect the exercise habits of some people. Think of any similar experiences you may currently have or have had during the past month. Then rate how frequently the event occurs. Please circle the number that best describes your answer for each experience. How frequently does this occur? 1 = never 2 = seldom 3 = occasionally 4 = often 5 = repeatedly					
1 Instead of remaining inactive I engage in some physical activity.	1	2	3	4	5
2 I tell myself I am able to be physically active if I want to.	1	2	3	4	5
3 I put things around my home to remind me to be physically active.	1	2	3	4	5
4 I tell myself if I try hard enough I can be physically active.	1	2	3	4	5

Source: Marcus & Forsyth, 2009

1 Complete the questionnaire developed by Marcus and Forsyth (2009), the first four questions of which are shown here. Circle the appropriate number for each of the 40 items. You can find a digital copy on Nelson MindTap.
2 Table 13.2 shows which items relate to each process of change. To find your average score for each process, add the four numbers you circled for those items and divide by four. (For example, for 'increasing knowledge', add the numbers you circled for items 5, 8, 17 and 28. Divide the total by 4.) Do not score an individual process if fewer than three items were answered.
3 Compare your scores with those in Table 13.3, which shows the average scores by activity level for the questionnaire.

Template
Process of change questionnaire

QUESTIONS

1 In which three processes of change did you score highest?
2 In which three processes of change did you score lowest?
3 **Describe** the strategies you could use to improve three of your processes of change.

TABLE 13.2 Grouping related items on the processes of change questionnaire

Process	Items
Increasing knowledge	5, 8, 17, 28
Being aware of risks	11, 12, 13, 14
Caring about consequences to others	30, 33, 34, 37
Comprehending benefits	15, 31, 35, 38
Increasing healthy opportunities	10, 22, 32, 36
Substituting alternatives	1, 21, 39, 40
Enlisting social support	16, 19, 24, 25
Rewarding yourself	7, 18, 20, 23
Committing yourself	2, 4, 6, 27
Reminding yourself	3, 9, 26, 29

Source: Marcus & Forsyth, 2009, p. 59

TABLE 13.3 Average score by physical activity level for the processes of change questionnaire

Process	Inactive	Low active	High active
Increasing knowledge	1.88	2.76	2.99
Being aware of risks	1.92	2.26	2.46
Caring about consequences to others	1.82	2.46	2.47
Comprehending benefits	2.14	3.22	3.28
Increasing healthy opportunities	2.14	2.75	2.79
Substituting alternatives	1.71	2.72	3.55
Enlisting social support	1.78	2.42	2.64
Rewarding yourself	1.52	2.54	3.01
Committing yourself	2.08	3.17	3.68
Reminding yourself	1.42	2.02	2.20

Source: Marcus & Forsyth, 2009

Identifying opportunities to be active

Before you can identify times during the day when you could be more active, you need to be aware of how often you move. You may be surprised at the amount of time you spend sitting each day, such as when travelling to school, in class and after school. (See the sample daily personal activity record or diary on p. 464.) Modern technology has minimised the need to move, meaning people today sit for hours longer than previous generations.

It is also important to identify alternatives for certain situations. For example, if it is raining, walking around a shopping centre or large indoor market would be a good alternative to outdoor exercise. If it is too windy to go bike riding, you could use an exercise bike instead.

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FIGURE 13.03 Physical education teachers and coaches can assist young people to identify opportunities to be physically active.

DID YOU KNOW?

If you walked up and down every aisle of a large Bunnings store, you would accumulate over 2 kilometres on your wearable device!

Template
Daily personal activity record

TABLE 13.4 Sample daily physical activity record (diary)

Date: 4 July	Weekday weekend day (circle)		
Time (duration and frequency)	Activity (type)	Physically active	
		Yes	No
7 a.m.–9 a.m.	Showered, got dressed	5 mins.	
	Walked to bus stop	8 mins	
	Travelled by bus to school		13 mins
	Walked to class	2 mins	
9 a.m.–12 p.m.	Sat in English class		100 mins
	Walked to canteen	2 mins	
	Sat and talked with friends at recess		20 mins
	Sat in biology class		50 mins
12 p.m.–4 p.m.	Sat with friends on oval		45 mins
	Walked to class	3 mins	
	Sat in maths class		50 mins
	Travelled home by bus		12 min
	Walked down to local shops	15 mins	
4 p.m.–10 p.m.	Watched Netflix		120 mins
	Chores	15 mins	
	Netball game	40 mins	
	Homework		120 mins
	Ate and watched more Netflix		65 mins
	Total time	90 mins	595 mins

Gradual programming

Gradual programming is essentially the same principle as 'progressive overload', one of the training principles you will learn about in Unit 4 of VCE Physical Education. Gradual programming requires a gradual increase in workload, frequency or intensity. For people who have not been regularly active for many years, or who have never been regularly active, a slow, step-by-step approach is desirable. It is unrealistic to expect these people to meet the physical activity guidelines after only a few months of being active or attempting to be active. These individuals must build up their activity gradually. For a beginning exerciser, being exhausted at the end of a session greatly reduces the likelihood that they will continue to be active.

Tailoring

Wholesale exercise programs are constantly marketed as the perfect way for any individual to become more active or increase their fitness. But just as no two people are the same, no two physical activity programs should be the same. Tailoring allows a counsellor (for example, a personal trainer) to prescribe a physical activity plan that meets the individual needs of each person. Individual factors to consider include social support, access to walking trails and other facilities, work hours and settings, whether the person is a morning person, when they eat throughout the day, cultural factors, family structure, fitness levels and climate. It is impossible to write a one-size-fits-all physical activity program based only on the individual's goals.

13.1 CHECK-IN QUESTIONS

1 **List** five professions or occupations that are likely to use counselling to encourage individuals to be more physically active.
2 **State** three methods of delivering physical activity advice, and describe one of them.
3 **Outline** six strategies used in physical activity counselling, and summarise two of them.
4 **Describe** two self-management skills including that use cognitive strategies.
5 Provide specific examples of two behavioural strategies that people could employ to become more active.

Assessment
13.1 Check-in questions

Command term

state
Give a specific name or value or other brief answer without explanation or calculation

13.2 DEVELOPING, IMPLEMENTING AND EVALUATING PERSONAL PHYSICAL ACTIVITY PLANS

In this module you will learn about:
- considerations of a personalised plan, including self-management skills, used to promote physical activity and reduce sedentary behaviour

and learn to:
- complete a needs analysis to inform the development of a personalised physical activity plan.

Developing a plan to promote physical activity and reduce sedentary behaviour

To begin planning your persoal physical activity plan, you will need to consider incorporating a variety of movement opportunities, including:
- maximising incidental physical activity (e.g. walking from one classroom to another when the bell rings)
- household chores and working in the garden
- occupational physical activity (e.g. physical demands of your job or activity during school time)
- active commuting (e.g. walking, skating or riding to work or school)
- leisure-time physical activity (LTPA) – includes recreational physical activity such as lifestyle physical activity and structured sport or exercise for fitness.

As a starting point, you would complete a basic needs analysis by working your way through Table 13.5.

TABLE 13.5 Needs analysis completed when developing your personalised physical activity plan

Component	Description and examples
Set your goals 	What do you hope to achieve from your personal physical activity plan (e.g. enhanced feelings of energy and wellbeing, to improve specific fitness components)? Be sure to include meeting the physical activity and sedentary behaviour guidelines relevant to your age group.
Current physical activity level 	You need to assess your current physical activity habits and sedentary behaviours. You could fill out a survey such as the Children's Leisure Activities Study Survey (CLASS) survey or an online survey to determine your baseline physical activity level. Alternatively, you could wear a pedometer for 2–3 days and record your daily steps. Record your daily totals each day and calculate the average by adding the daily totals together and dividing by the number of days monitored. This will be addressed in more detail later in the chapter, when we talk about implementing your plan.
Establish your priorities 	You need to identify which fitness components and muscle groups you want to develop. If you play a specific sport, your coach or PE teacher may be able to help you determine which fitness components (health-related and/or sport-related) are important for your sport, and even for the position/s you play. Alternatively, you may just have a particular area you want to improve in.
Fitness testing 	Based on the priorities identified, select the relevant fitness tests that could be used to assess the relevant health- and sport-related components of fitness. Ensure you select recognised standardised tests that will allow you to compare your results to normative data. Then you can determine your strengths and identify areas you would like to improve in. There are many fitness test descriptions and normative data available online.
Tailor to your interests 	Write down what your interests are, for example: walking, social netball, yoga. You are much more likely to stick to your program if it is tailored to (a) the things you enjoy, (b) in the places where you like to hang out and with (c) the people you like to spend time with.
Availability of time and resources 	You need to create a program that works in with other commitments in your life, such as school, work, social events, family expectations and daily chores. The program needs to be based on what resources you have access to. For example, what equipment you have at home, such as a bicycle, or what facilities you have access to within your local community, such as parks, facilities and trails.
Appropriate training methods 	Are these appropriate for you? Can you access the appropriate facilities? For example, do you need to be able to access a weights room? What training methods will be used, and what is the justification for their selection? We briefly touch on training methods when we talk about implementing your personalised program.

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LOOKING BACK

Functional Movement Assessment (FMA)

Chapter 12

As discussed in Chapter 12, a Functional Movement Assessment should be completed prior to participation in a personalised plan. An FMA aims to evaluate an individual's functional movement patterns, skills and stability. It can indirectly measure health-related fitness components and establish a baseline, which can be used to prescribe activities within a personalised program.

REAL WORLD APPLICATIONS

Stairway to lifetime fitness

While attending school, students are generally required to participate in a range of physical activity opportunities like sport and physical education classes, along with other active organised activities. Many people may even actively commute to and from school several days per week. Once students finish compulsory physical education and sport or school altogether, it will be totally up to them to organise regular physical activity opportunities. If people do not participate in regular physical activity, many of the associated health benefits (as discussed in Chapter 7) gained while they were active at school will quickly disappear. Moving from the time students spend in physical education right through to lifetime fitness requires a transition from a level of dependence to independence. Figure 13.04 shows how students should assume progressively more responsibility for their own activity, fitness and wellness, as illustrated by the Stairway to lifetime fitness (Corbin & Lindsey, 2007).

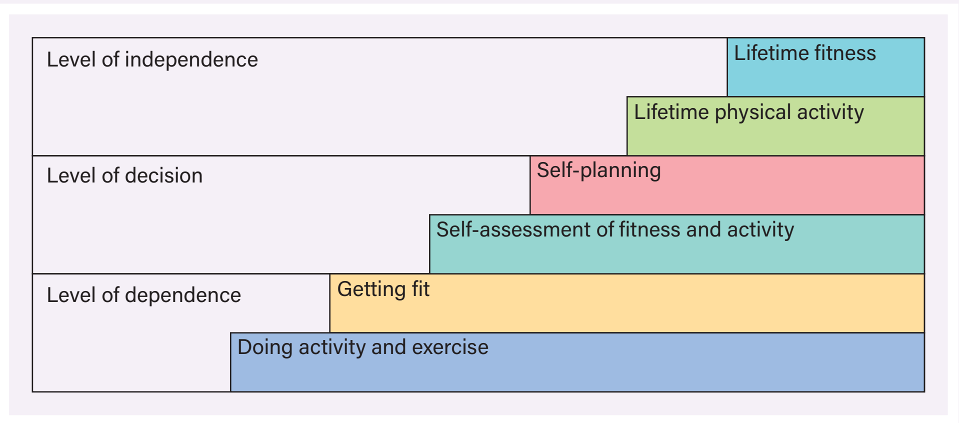

FIGURE 13.04 Stairway to lifetime fitness

Source: Corbin, C. & Lindsey. R. (2007). *Fitness for Life Updated 5th Edn*. Champaign, IL: Human Kinetics.

Implementing a plan to promote physical activity and reduce sedentary behaviour

Implementing training principles

There are 10 key principles to consider in any physical activity program, particularly in relation to developing and maintaining our fitness levels. These 10 principles are: specificity, intensity, duration, frequency, overload (progressive), detraining (reversibility), maintenance, individuality, diminishing returns and variety. You will learn about training principles in greater detail in Unit 4.


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FIGURE 13.05 A basketball player needs to train for explosive power in order to jump high to shoot and rebound.

Specificity

If a physical activity program is to be maintained it must be tailored specifically to the needs and interests of the person, as outlined within the needs analysis completed in Table 13.5. If you play sport you can specifically tailor your program based on the demands of your sport or, even more specifically, the position you play. You can focus on the energy demands, fitness components and muscles used. For example, an AFL player who plays an 'on ball' position would have very different demands on their body than a full-back player. You should tailor your training to work the relevant energy systems, fitness components and muscles used based on the skills you need to perform.

Intensity

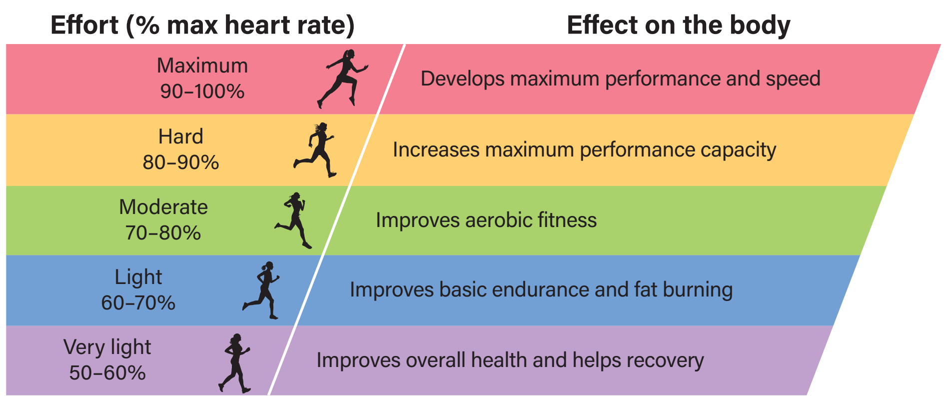
Intensity refers to how hard your heart, lungs and muscles are working during physical activity. If we want to train certain fitness components or muscle groups for particular activities, we need to train at the required intensity. Most of the health-related fitness benefits associated with being physically active occur when we are working at least at moderate intensity. Moderate-intensity physical activity usually consists of sustained rhythmic movements. If you are working at a moderate intensity:

- you should be able to carry out a conversation comfortably
- you are working at 50–70 per cent of your maximum heart rate
- you are expending 3–6 times the energy that you would while at rest.

Moderate-intensity physical activities include brisk walking, cycling, raking leaves, mopping the floor, sweeping, lifting weights, doing aerobics, golfing and paddling in a pool.

DID YOU KNOW?

The saying 'No pain, no gain' is an exercise myth – while exercise can be difficult, it should never hurt. If you exercise at an intensity beyond discomfort and actually feel pain, you are significantly increasing your chance of becoming injured.



Runnergirlspodcast

FIGURE 13.06 Training at different intensities has different effects on your body.

LOOKING BACK

Determining intensity

Chapter 7

In Chapter 7 we explored methods of determining intensity, including perceived exertion, measuring your heart rate, and ability to talk comfortably (Talk Test). A common way to determine the intensity we are working at while training is to refer to target training zones during aerobic activity. You will notice that working at different intensities (Figure 13.06) has different effects on the body.

DID YOU KNOW?

Moderate-intensity training and physical activity is far more attractive to most people than vigorous-intensity physical activity. Studies consistently show that vigorous intensity can be a deterrent to many people being active. This is why most physical activity guidelines internationally for adults encourage 'at least moderate-intensity' physical activity, rather than long durations of vigorous-intensity physical activity.

Duration

As discussed in Chapter 7, duration refers to how long we do something. For example:

- how long a training program goes for (e.g. 12 weeks pre-season)
- the minimum time you would need to train to achieve a health or fitness benefit (e.g. at least six weeks)
- how long an actual training session would have to go to achieve a health or fitness benefit (e.g. at least 20 minutes to achieve aerobic adaptations)
- how long a bout of exercise is within a training session (e.g. a 10-minute bout of vigorous-intensity running).

Progressive overload

Ultimately, the aim of your training program should be to achieve long-term health and fitness benefits that can be maintained. The human body is very adaptable and tries to constantly adjust to whatever activities we perform. The principle of overload is the most basic of all, and means doing 'more than normal'. When we introduce a new activity requiring a higher intensity, different

plateau
To reach a level or period where no change is observed

fitness component or muscle group, it creates a stress response. In response to this stress, the body adapts and accustoms itself to the new demands, and then the adaption **plateaus**. To gain further improvements we need to progressively overload our body with additional stress. This might be achieved by running for two extra minutes, by using a larger dumbbell or doing an extra session per week. For an adaptation to occur, we need to allow our body to rest and recover. We can also overload our bodies by increasing the number or repetitions or sets completed, by increasing the intensity of an activity or by reducing the rest interval.

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FIGURE 13.07 To overload you can increase either the weight, the repetitions or the sets of repetitions, but you should not increase more than one of these variables at a time.

Detraining (reversibility)

Detraining means a rapid return to pre-training levels. It is usually caused by either stopping a training method or by stopping training altogether. You might stop training due to illness, injury or boredom, or due to increased commitments at work or school. When this happens, there is a reversal in the training benefits achieved. The fastest reversal tends to occur to the **VO_2 maximum**, where a decrease of 18 per cent can occur in as little as three months.

VO_2 maximum
The maximum amount of oxygen that can be taken up, transported and utilised per minute

Frequency

Frequency refers to how often we are active. When you want to improve a fitness component it is generally considered necessary to train that component three times per week. As mentioned earlier, it is also important to ensure adequate rest between sessions to allow adaptations to occur. Often, people who do **resistance training** train every second day. Those who do resistance training every day generally alternate the muscle groups they work every second day – this is known as a 'split routine'. For example, you might work your upper body, chest, shoulders and arms one day and your back, legs and abdominal muscles the next. This allows the body to recover and maximises adaptations.

resistance training
To move against a force provided by a person's own body weight, machine or weight such as barbell, dumbbell, kettle ball or medicine ball

Maintenance

You can maintain fitness gains by training twice per week. Some people might play sport several times per week. In these cases, it is important to allow adequate time to recover, while still maintaining fitness. If training stops altogether there can be reversibility; it is important to maintain regular training in order to avoid detraining.

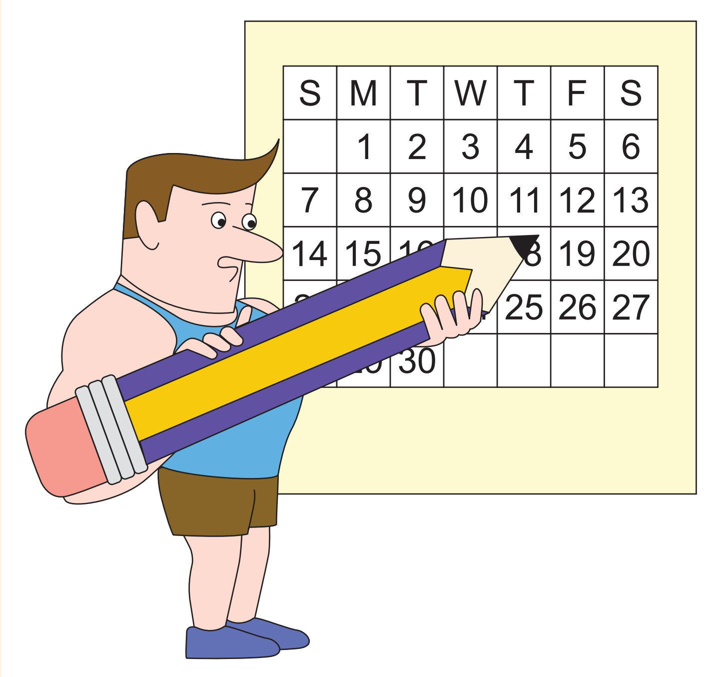


FIGURE 13.08 The frequency of your physical activity sessions can be mapped on a calendar.

Individuality

It is important to keep in mind that each person responds and adapts differently to exercise and to different training methods and workloads. These differences are due to individual factors such as:

- initial fitness levels
- hormones
- genetic factors
- motivation
- nutritional requirements
- recovery.

Diminishing returns

Have you ever wondered if you have an absolute limit to your physical potential? The answer is yes – every person has an absolute maximum potential for improvement for each fitness component, and this is genetically pre-determined. There is a saying, 'If you want to be an Olympic athlete you need to pick your parents carefully.' Environmental influences and training can only take you as far as your genetic potential will allow. A person who is new to training and untrained has a much larger potential to improve compared to an elite athlete who trains daily and is near their maximum potential. As you get closer to your ultimate potential (ceiling), the rate at which you can improve significantly slows down. As shown in Figure 13.09, a person can move in either direction along the continuum.

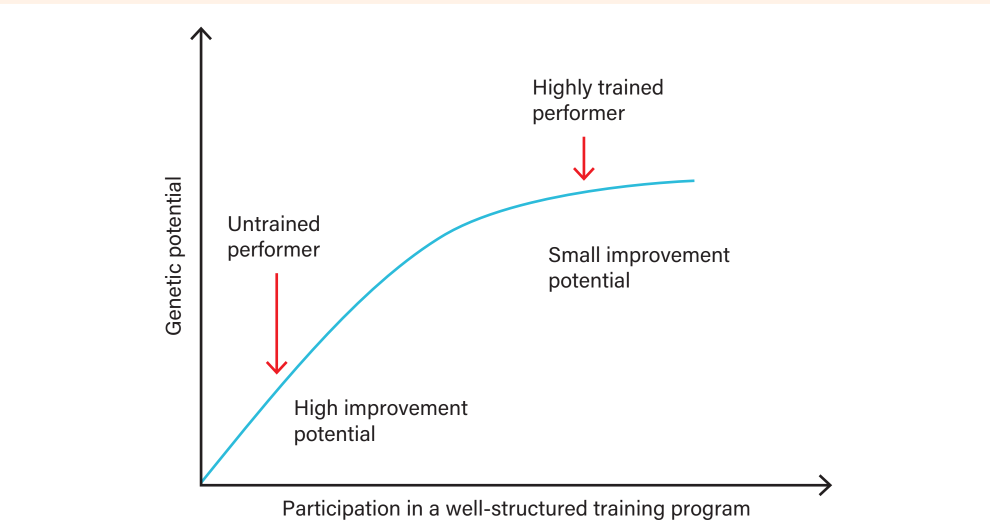


FIGURE 13.09 Diminishing returns continuum

Variety

There is an old saying, 'Variety is the spice of life'. It is also the key to avoid becoming bored with your fitness training and physical activity program. It is important to change things up at times by alternating things like:

- where you work out
- who you are active with
- the types of activities you perform
- using cross-training (for example, for aerobic training you could run, swim, ride a bike or an exercise bike, use a treadmill, rowing machine, elliptical, do an aerobics or zumba class)
- duration and intensity and rest intervals.

Elite athletes need variety, but they also need consistent routines, so must be careful that variety does not compromise the specificity of their training. For example, while elite swimmers will obtain health and fitness benefits from cross-training, if they want to be race ready they need to swim more than any other form of cross-training to ensure they are race fit.

Training methods

As mentioned earlier, the training methods selected for your individualised physical activity plan will be based on factors such as:

- your goals
- your Functional Movement Assessment (see Chapter 12)
- your needs and interests
- the demands, muscle groups used, actions and movements performed and fitness components important to the physical activities or sports you participate in
- what resources you have access to in terms of time, facilities in your home, school, or local community, someone to drive you to places where you can be active such as training session or the park.

Justifying physical activity selection for your program

Table 13.6 will help you understand the different training methods and how you would justify your selection of physical activities included in a personalised program by identifying which training methods are linked to the various health- and sport-related fitness components.

TABLE 13.6 Training methods used to improve health-related and sport-related fitness components that can be incorporated into your personal physical activity plan

Training method	Fitness component	Aerobic power	Local muscular endurance (LME)	Muscular strength	Anaerobic power	Muscular power	Speed	Agility	Flexibility
Continuous		✓	✓						
Fartlek		✓	✓						
Long interval		✓	✓						
Intermediate interval			✓				✓		
Short interval					✓		✓		
Speed					✓		✓		

Training method	Fitness component	Aerobic power	Local muscular endurance (LME)	Muscular strength	Anaerobic power	Muscular power	Speed	Agility	Flexibility
Weights/ resistance				✓	✓	✓			
Circuit			✓	✓	✓	✓	✓	✓	
Plyometrics					✓	✓	✓	✓	
Flexibility									✓
Swiss ball and Pilates			✓	✓					✓

Table 13.7 outlines the main training methods used to improve health-related and sport-related fitness components.

anaerobic power
The ability to deliver energy for physical activity at a high rate, without oxygen for a short period of time

TABLE 13.7 Training methods

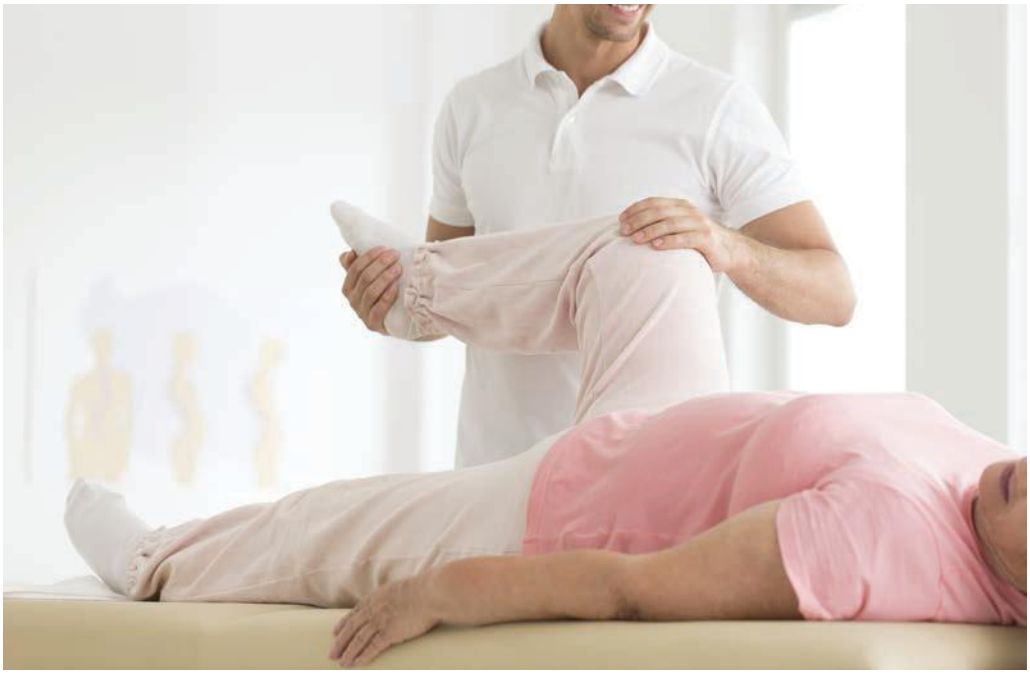
Training method	Description and important considerations
Continuous	This is sometimes referred to as low slow distance (LSD) training and involves work periods conducted in the aerobic training zone of 70–85% of your maximum heart rate with no rest during the session. Usually consists of a minimum of 20 minutes to achieve aerobic benefits. Typical activities are those that use the whole body or large muscle groups – for example, aerobics, swimming, running.
Fartlek	This is a variation of continuous training that combines continuous activity with short bursts of high-intensity effort at regular stages during the training session. Many team sports requiring a solid aerobic base use Fartlek training because it can closely replicate the demands on your energy systems during a game.
Interval training	All interval training involves periods of work followed by periods of rest. Interval training can be classified as either: long interval, intermediate or short interval, depending on the intensity, duration and recommended rest intervals. Interval training is most commonly undertaken with running, however, it can be made more specific by using swimming or cycling and 'training' specific muscle groups in the actions that are going to repeated in the performance/competition. Generally, the higher the intensity and the longer the rest, the more the interval training will work the ATP-PC system.
Speed	This involves training the nervous and muscular systems to work more efficiently together and, in a sense, brings about the most efficient stride frequency and length. Activities might include sprinting with a band connected to a tyre or parachute.
Weights/ resistance	There are three types of weight/resistance training: isokinetic, isometric and isotonic. **Isokinetic training** involves the resistance being adjusted to allow you to exert the maximal force that you can throughout the entire range of movement. This can only be achieved through the use of machines such as Cybex and Nautlilus that you might find in a gym. **Isometric training** involves a contraction in the muscles against the resistance (weight) at a particular joint angle for a period time with no change in muscle length. Gains are only made at the angle performed, so tend to be limited to activities like skiing, gymnastics or weightlifting. **Isotonic training** is the most commonly used form of resistance training and involves the use of 'free weights' (dumbbells or barbells) or pin-loaded machines. Pin-loaded machines only allow a restricted range of movements. Free weights allow you to mimic actions used in game situations. Resistance bands can also be used. Table 13.8 outlines the difference in strength training, power training and muscular endurance training.

Training method	Description and important considerations
Circuit	This involves performing a number of activities at various 'stations' in sequence during a workout. These activities can be tailored to specific components of fitness, systems, muscle actions and distances required for your sport or the position you play. Even work and rest intervals can be designed to mimic the demands of the sport you play during competition. There are three types of circuit training: individual load, fixed load or fixed time. **Individual load** involves taking into account the strengths and weaknesses and different loads you can manage at each station. **Fixed load** and **fixed time** circuits involve you performing a set number of repetitions or work against a resistance for a set time, and doing as many repetitions as you can. Activities might include using your own body weight (push-ups, skipping) or weights.
Plyometrics	Plyometrics involves stretching/lengthening a muscle (eccentric contraction) and then a rapid shortening (concentric contraction) to bring about an explosive action. Examples of plyometric activities include: depth jumping, clap push-ups, bounding/leaping and throwing a medicine ball. Plyometric activities usually involve the person using their own body weight, or jumping from a platform to the ground and up again, or over obstacles. Athletes who need to be explosive, such as basketball, netball, volleyball, soccer or hockey players or high and long jumpers often use this form of training.
Flexibility	Flexibility is critical in achieving maximal ranges of motion and hence contributes to every movement we make. There are three major classifications of stretching: dynamic stretching, static stretching or PNF stretching. **Dynamic stretching** involves either slow, controlled movements or ballistic, explosive movements through a full range of motion. **Static stretching** involves gradually stretching a joint to its maximum range and then holding this position for 10–20 seconds. Static stretching is often used at the end of training sessions to help you relax. **PNF stretching** involves taking a joint to its maximum range and then contracting isometrically (no movement of muscles) against a resistance provided by a partner or band. This is repeated to increase the range until no further increases in range of motion can be attained.

LOOKING FORWARD
Training principles and methods

Unit 4

You will study training principles and training methods in more detail in Unit 4 of VCE Physical Education.



Ground Picture/Shutterstock.com

FIGURE 13.10 PNF stretching is the most effective form of all the stretching methods.

In Table 13.8 we outline three methods of resistance training: strength training, power training and muscular endurance training. Please note, the sets and repetitions listed are just a guide, to give you an idea of the difference between the methods, and will vary depending on the individual.

TABLE 13.8 Weight training for muscular strength, power or endurance

Strength training	Power training	Muscular endurance training
% of 1RM*: 80–95	% of 1RM*: 30–50	% of 1RM*: 40–60
Sets: 3–5	Sets: 3–5	Sets: 2–4
Reps: 2–4	Reps: 3–5	Reps: 15–20
Speed: Slow/medium	Speed: Fast	Speed: Medium/fast
Rest: 3–4 mins	Rest: 3–4 mins	Rest: 1–2 mins

*1RM = the maximum amount of weight one can lift in a single repetition for a given exercise

Maintaining your physical activity and fitness training

When creating a personal physical activity plan you need to be realistic. Start with a simple, personalised plan based on the activities you enjoy – things that you could easily build into your everyday life. By far the most challenging aspect of a personalised plan is to develop something that is sustainable and can become a habitual part of your life.

There is no such thing as 'one size fits all' when creating personal activity plans. Your strategies must be tailored to your own needs, interests

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FIGURE 13.11 Depth jumping is one of the most common forms of plyometric training.

and experiences. Use a range of cognitive strategies, including things that relate to what you think or understand and things that increase your knowledge or awareness. In addition, use a range of realistic behavioural strategies to increase or maintain your activity level. Behavioural strategies are the 'doing' things, like arranging for your friend to go for a walk with you. This is not something you just think about, you also do it.

Cognitive strategies in an individual activity plan

Cognitive strategies include:

- learning more about the importance of being active
- understanding the risks of being inactive and not doing some kind of activity every day
- caring about consequences (how your inactivity can affect yourself, your family and friends)
- understanding the benefits of being active
- being more aware about opportunities to be active.

Although cognitive strategies are an essential first step, they are not enough to change your behaviour on their own. Behavioural strategies, the things that you actually do, are most important. A person must be regularly active in order to improve or maintain their physical activity and fitness.

Behavioural strategies in an individual activity plan

Behavioural strategies are the doing things. Realistic behavioural strategies are essential to an individual physical activity plan. They include:

- substituting alternatives
- enlisting social support
- motivating and rewarding yourself
- committing yourself by setting realistic goals
- reminding yourself.

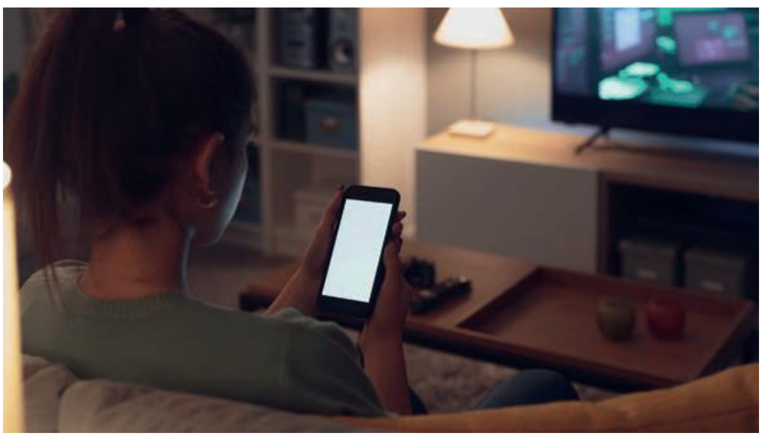
Stokkete/Shutterstock.com

FIGURE 13.12 Excessive screen time can lead to many physical, emotional and psychological problems.

Substituting alternatives

A great place to start is to think about your current physical activity level. By completing a daily activity log, you will become more aware of your sedentary behaviours. Today, technology continually keeps us from having to move and expend energy. Many people sit in a vehicle to travel to and from school or work. They then sit for most of the day, and then sit for many hours at home afterwards, watching screens on their computer, smart phone or tablet.

Have a look at the activities you do in a typical day and then identify up to 10 more active alternatives to some of your light-intensity or sedentary activities. The idea is to find ways to replace your typical behaviour with a more active option, building this into your everyday life until it becomes a lifelong physical activity. Table 13.9 has some suggestions for substitute activities.

Video
In focus: Substituting more active alternatives in everyday life

TABLE 13.9 Substituting more active alternatives in everyday life

Typical sedentary activities	More active alternatives
Park as close to the shops as possible.	Park further away from the shops and walk.
Sit or lie down while watching television.	Exercise while watching TV, or exercise for a few minutes during the advertisements by doing sit-ups, push-ups, squats, lunges, stretching or bicep curls, for example.
Complete household chores slowly, such as picking up laundry or tidying your room.	Dance or move vigorously to music while completing household chores.
Drive to watch the football each week or watch sport on television.	Play a recreational sport each week instead of watching it, or take public transport to watch a game.
Drive to the local shops.	Walk, cycle, scooter or skate to the local shops.
Be driven to school.	Walk, ride or take public transport to and from school at least once per week.
Be driven to a friend's house.	Walk, cycle scooter or skate to a friend's house.
Play a computer game with friends while sitting down.	Play something active with your friends, or an active computer game such as Wii Fit or Wii Sports.
Lie still before getting out of bed or going to sleep.	Stretch in bed before getting out of bed or going to sleep.
Sit while waiting for your toast to cook, the kettle to boil or while talking on the phone.	Exercise while you wait – for example, complete squats, lunges or leg raises.
Sit at your desk while studying.	Stand at your desk – place a box under your keyboard or buy a desk that changes height.
Sit still in the car as a passenger.	Perform some isometric exercises while travelling in a car.
Sit and talk during school recess and lunch.	Walk around while talking during recess and lunch.
Use a trolley to carry shopping bags to the car.	Carry your shopping bags to the car and do some bicep curls using the bags as your weights.

Enlisting social support

You are much more likely to exercise regularly if you have someone to do it with. It doesn't matter who that person is: it could be a family member, a friend or even a dog.

FIGURE 13.13 How to enlist social support

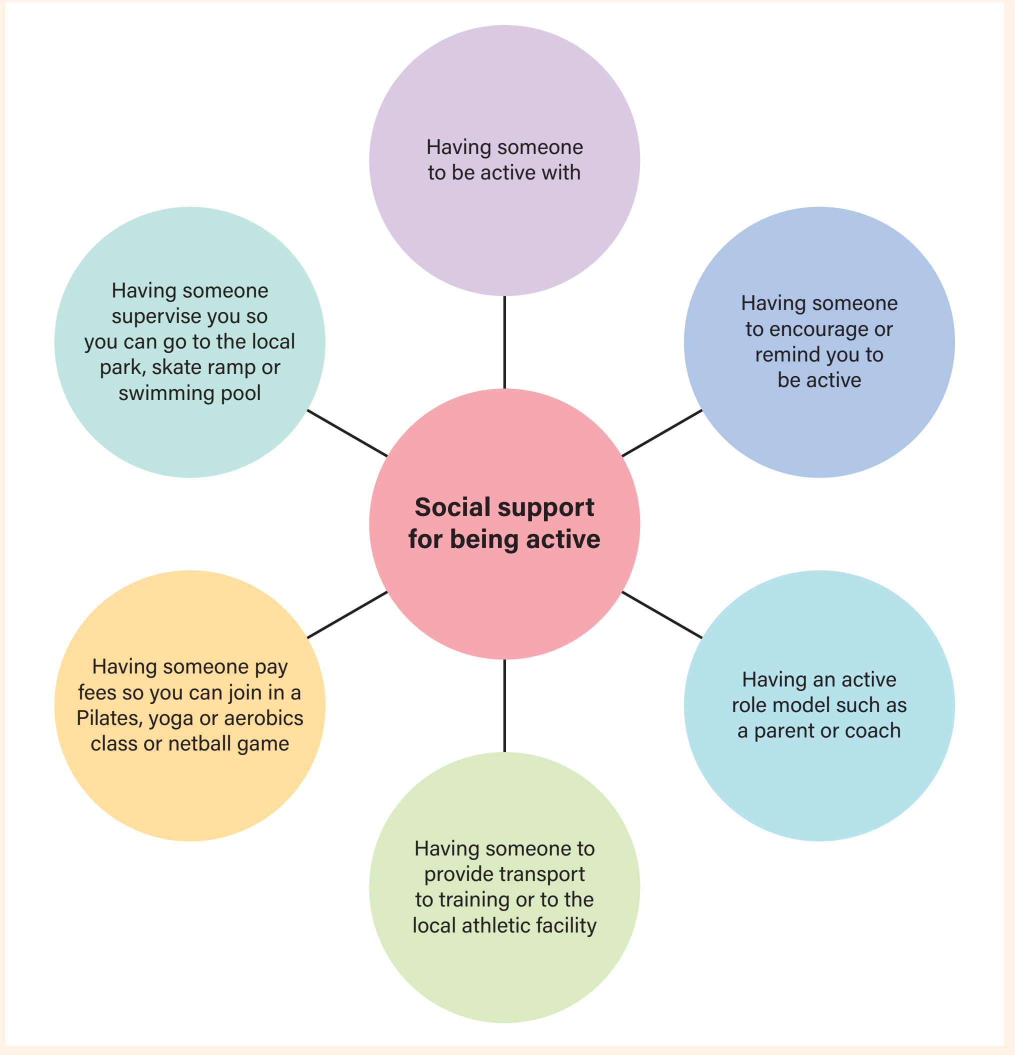

FIGURE 13.14 Social support for being active

Africa Studio/Shutterstock.com

FIGURE 13.15 Social support can take many forms: being active with someone else, providing encouragement, role modelling, providing transportation to an activity or providing supervision.

DID YOU KNOW?

If you want to talk to someone about any health concerns, there are a variety of people you could ask: your family, your friends, a coach, teacher, your doctor, your school nurse, physiotherapist, school counsellor, social worker, chemist or local council staff. The important thing is to communicate with people whenever you have any concerns about your health.

Motivating and rewarding yourself

When creating a personal physical activity plan, it is important to recognise both internal and external factors that motivate [reinforce] you to be active. Understanding what motivates you greatly increases your chances of success and of keeping to a routine over time. As discussed in Chapter 10, one of the most powerful ways you can track your activity level and access instant feedback to help you stay motivated is through the use of wearables. These can provide you with live data on how much physical activity you've done, how much time you have spent sedentary and even how many steps you've taken for the day.

CASE STUDY FUN RUNS

Sometimes having an event such as a fun run or school bushwalk to train for motivates you to work towards a specific goal such as walking or running 5 or 10 or 25 kilometres. Fun runs are an incredible opportunity to raise money for important organisations. For example, the Carman's Fun Run raises money for the Breast Cancer Network Australia. Fun runs also enable a mass participation event in which individuals can participate in a distance suitable for their personal ability or level of fitness.

Amanda Telford

FIGURE 13.16 Entering a fun run is a wonderful way to work towards a goal.

Making a commitment and recording your goals

The key to success in creating your personal physical activity plan is to make a commitment or set a goal. Being able to set goals is an essential self-management skill. Goal setting is a motivational technique allowing you to set clear targets, priorities and expectations. Table 13.10 describes the guidelines for effective goal setting using the SMART approach.

Your smart watch has a range of functions to assist you to set goals, track your activity and remind you to be active. It can even give you daily goals based on the daily activity accumulated. Telling someone or sharing your goals via social media, for example, is even more powerful in helping you stick to them.

TABLE 13.10 Developing effective goals using the SMART approach

SMARTER	Description	Example goal: cycling to and from school
Specific	Goals need to be specific and as clear as possible	To cycle to and from school at least three days per week for a month
Measurable	You should be able to measure progress	To cycle 10 kilometres to and from school at least three days per week
Accepted	Goals should be accepted by everyone involved	It is okay with your parents/guardian to cycle to school, and okay with your school to leave your bike there during the day
Realistic	Goals should extend you but be achievable	The path includes a hill; it is okay to get off the bike and walk it up the hill
Time-based	Goals should include a specific end date	Until the end of term 1

LEARNING HACK

SMART is an acronym to help you remember that effective goals are: **S**pecific, **M**easurable, **A**ccepted, **R**ealistic and **T**ime-based.

LOOKING FORWARD

SMART goals

Unit 3 – Chapter 2

You will learn more about goal setting using the SMART approach in Chapter 2 of *Nelson Physical Education VCE Units 3&4*.

WORKED EXAMPLE

UNDERSTANDING SELF-MANAGEMENT SKILLS

Jenny, aged 60, is a busy teacher who works long hours, as she is in charge of the Senior school at a large school. Most days she has meetings after school and doesn't have enough energy left at the end of the day to be active. Jenny understands the importance of being active. She used to go to the gym five days a week when she was younger, but just can't seem to find the time in her day to be active these days. Jenny lives 1500 metres from the school and drives each day, as she likes to be at work at least 90 minutes before school starts. On weekends Jenny likes to read and catch up with her family and friends.

1 Identify two windows of opportunity for Jenny to be active during her week that would be suitable to her lifestyle, and justify your response.
2 Discuss which self-management skills would be most useful for Jenny to help her be more active during a typical week.

>

Suggested responses:

1 *A common mistake here would be to suggest after school or evening physical activities. Instead, target before school – a brisk walk to school, for example – when her energy levels are likely to still be high, and also weekends.*

2 *The pitfall here is to assume because Jenny is currently not regularly active she would need to focus on cognitive strategies. Given her background, she obviously understands the importance of being active and is aware of the benefits and risks. Instead, the use of behavioural strategies such as finding alternatives (e.g. walk instead of drive to work two days per week) or enlisting social support (e.g. going for a walk with a friend on weekends) would be more effective for Jenny.*

REAL WORLD APPLICATIONS

Goal setting

To work out what motivates you to be active, examine five ideas or goals relating to your personal health, physical activity, fitness and sedentary behaviour that you would like to achieve. Determine the internal and external reinforcers you could use to help you achieve your goals. Fill in a table like the one shown here.

Task or goal	Internal reinforcer	External reinforcer
Example: I will walk to school three day this week	I will have more energy at school and won't feel as tired	My parents will let me go to a friend's house on the weekend if I reach my goal

QUESTIONS

1 **Discuss** the strengths and limitations of your ideas.

2 **Outline** three cognitive strategies and three behavioural strategies you currently use or could use to help you be active.

3 **Define** each component of SMART goals.

CASE STUDY INDIVIDUAL PLAN

Engaging in regular physical activity requires highly developed self-management skills such as being able to:

- record your goals and commit yourself by putting together a weekly plan or schedule (Figure 13.17) and training session outlines (Figure 13.18). Templates are available on Nelson MindTap.
- enlist social support and be active with someone
- use reminder systems so you don't forget to be active
- reward yourself at different intervals.

Template
Weekly training schedule

>

	6–9 a.m. (before school)	9–3 p.m. (school hours)	3–10 p.m. (after school)
Name: Madison (aged 16 years)			
Personal goal: To meet the 24-hour movement guidelines for children and young people (5–17 years)			
Monday	Walk to school 10 mins		Tennis squad training 90 mins
Tuesday		Physical education class 100 mins	
Wednesday	Walk to school 10 mins		Afterschool interschool sport (volleyball) 90 mins
Thursday	Boxing stations 20 mins		Walk the dog 45 mins
Friday		Physical education class 50 mins	Home-based fitness circuit 45 mins
Saturday	Push-ups × 30 Sit-ups 3 sets × 25 reps	Bike ride 90 mins	
Sunday			Walking the dog 70 mins

FIGURE 13.17 Example weekly training schedule

Figure 13.18 provides you with an example of a training session based in a gym. Notice the components include a warm-up, weight (resistance) training exercises and a cool-down. Also notice that the program alternates which muscle group is being worked.

Template
Training session (gym)

Date: 20/06/2028	Location: YMCA gym	Time: 9–10.30 a.m.
Warm-up Walk on treadmill 5 mins Exercise bike 15 mins Rowing machine 5 mins Stretching 5 mins		
Weight-training exercises	**Repetitions**	**Sets**
Lat pulldown	12–15	2–3
Leg press	15–20	2
Crunches	20–25	3
Bench press	5–10	2–3
Leg curls	12–15	2–3
Bicep curls	5–10	2–3
Lunges	10 each side	2
Triceps extensions	12–15	2–3
Sit-ups	20–25	1–2
Bent-over row	10–15	2–3
Cool-down Exercise bike (slow) 5 mins Stretching 10 mins		

FIGURE 13.18 Example template for training session (gym session)

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FIGURE 13.19 Research consistently shows that dog owners walk more than non-dog owners.

QUESTIONS

1 Did Madison meet the 24-hour movement guidelines for children and young people (5–17 years)? **Justify** your answer. (Ignore the screen-time component for the purpose of this exercise.)
2 **Identify** which sessions would most likely enhance each of the health-related components of fitness.
3 Create a blank table using the same format and complete a weekly training schedule for yourself.
4 **Evaluate** any changes you might need to make to meet the guidelines.

Remind yourself

Another essential component of creating a personal physical activity plan is setting up an effective reminder system. Here are some simple tips you can use to remind yourself to be active and to complete your physical activity plan:

- Keep physical activity clothing and shoes in your parent's/caregiver's car.
- Set automated reminders in your phone or computer, or write them in your calendar or diary.
- Place prompt signs around your house, such as on your fridge, on your desk or in your parents' car, saying things like 'Have you done your physical activity today?'
- Email a reminder to yourself.
- Keep a spare pair of runners at the front door as a reminder to be active.

COLLABORATIVE TASK
Prac activity

Using non-specialised or recycled equipment to improve health and skill-related fitness

You don't necessarily need to own specialised gym equipment such as treadmills or barbells and machines to improve your fitness. In this section we will look at a range of non-specialised equipment that you could find at home or at the local playground to develop your health- and sport-related fitness. The home is one of the important settings you can be active in, along with school, work and the community. A pair of dumbbells can cost anywhere between $20 and $120. However, instead of using dumbbells you could fill a pair of 2-litre milk or cordial bottles with sand or water. You could use a variety of household items to make up your own fitness circuit, or in games you could play with your family and friends.

The aim of this practical activity is to come up with a range of ideas for activities that you could engage in at home to improve your health and fitness. Your school will either provide or expect you to bring one or several of the items shown in Table 13.11. You will notice the items have been classified as either household items, recycled items or inexpensive sporting items. These are just some examples – use your imagination and you will be able to come up with lots more.

In pairs or small groups, your teacher may allocate some class time for you to come up with as many physical activities as possible that could be incorporated into either a fitness circuit or backyard game. You need to come up with at least two activities for the fitness circuit and two games. Your teacher will ask each group, either at the end of the lesson or during the next lesson, to present your ideas to the rest of the class.

TABLE 13.11 Examples of non-specialised fitness and play equipment

Household items	Recycled items	Inexpensive sporting items
Blankets	Tyres	Frisbee
Tarps	Boxes	Tennis balls
Brooms	Milk crates	Pool noodles
Broom handles	Chaff bags	Skipping ropes
Buckets	Rope	Play balls
Small steps	Milk/cordial bottles	Hacky sack
Hay bales	Sand	Hoops

COLLABORATIVE TASK
Prac activity

Getting active at your local park

Either as an in-class or homework activity, go to a local park which has a range of the following: playground equipment such as monkey bars, slides, other climbing equipment or swings and seating. You are to design a fitness circuit that could consist of either of the following formats:

- fixed time at each station (for example, one minute on the monkey bars doing chin-ups, swinging across the ladder or hanging)

>

- fixed load – a continuous circuit where you complete a set number of repetitions at each station before moving on to the next station (for example, complete 20 step-ups on the park bench).

Your circuit needs to incorporate the playground equipment and other natural (for example, grassy hill, logs or trees) and human-made features at the park. Your circuit could include activities such as those displayed in Table 13.12.

TABLE 13.12 Fitness ideas you could use at your local park and playground

Crunches	Hanging	Step-ups
Push-ups	Swinging across monkey bars	Sliding down slide
Chin-ups	Sprints	Swinging on swing
Squats	Sit-ups	Hill runs
Lunges	Jumping over lines	Plank
Dips	Stretches	Swinging on a rope

When you design your circuit make sure you take into consideration the following:

- Write down the name of each activity to be completed at each station. Take a photo of the equipment/location to be used and, if possible, include a photo of someone performing the activity safely. You may need to do some research online to look up the key tips for completing that exercise safely.
- Ensure you build in a warm-up before completing your circuit.
- Outline the time (fixed time format) or repetitions (fixed load format) you would complete at each station of your circuit.
- The order of the circuit needs to alternate the muscle groups used to allow adequate rest. For example, avoid doing two upper body exercises in a row, like push-ups followed by chin-ups.
- You could make a poster of your circuit which shows the order of activities photographically, the location of each station and the key safety tips.

QUESTIONS

1 Create a table that outlines which health-related and sport-related components of fitness are developed for each of the activities within your circuit.

2 **Explain** how you could modify the circuit if you had someone who wasn't very fit to ensure they could still participate at their own level of fitness safely.

3 **Describe** the benefits other than improved fitness to completing a fitness circuit at home or at your local park.

Miljan Zivkovic/Shutterstock.com

FIGURE 13.20 You are only limited by your imagination when designing your own circuit.

REFLECTIVE FOLIO

Reflect on whether you think the circuit you designed would be feasible to include in your weekly, fortnightly or monthly routine, and discuss the strengths and limitations of the design.

Evaluating a personal physical activity and fitness plan

In this section of Chapter 13 we consider how we can evaluate our personal physical activity and fitness levels. There are five basic steps in evaluating your personal physical activity and fitness plan:

1 setting your goals
2 establishing your baseline physical activity and fitness levels
3 identifying strengths and areas of improvement
4 monitoring your progress
5 considering the strengths and limitations of your program design.

Step 1: Setting your goals

You learnt about how to design effective goals earlier in this chapter where we used the acronym 'SMART'. Goals need to be **S**pecific, **M**easurable, **A**cceptable, **R**ealistic and **T**ime phased. Your goals might relate to meeting the physical activity guidelines for your age or improving particular fitness components for the sports you play. Once you set your goals you will be able to monitor your progress towards reaching those goals.

Step 2: Establishing your baseline physical activity and fitness levels

The only way we can determine whether we have improved, maintained or gone backwards in terms of our physical activity and fitness levels is to monitor our progress towards our set goals. Earlier in this chapter we looked at self-management skills such as goal setting and self-monitoring, rewarding ourselves and reminding ourselves to be active. These are all important self-management skills you need to develop that will help you monitor your progress. Before commencing a new physical activity or fitness program we need to establish a starting point. This is known as the 'baseline' level of your physical activity and fitness. We can collect data before, during and after programs on any of the following factors:

- basal heart rate – generally measured when the person is at rest and relaxed and hasn't exercised or exerted themselves recently
- blood pressure – the pressure exerted by circulating blood upon the walls of blood vessels
- hours of sleep per night
- fitness test results for a battery of tests relating to the various health- and sports-related fitness components (refer to Table 13.6)
- daily steps per day
- time spent in light-, moderate- or vigorous-intensity physical activity
- types of physical activities and sedentary behaviour you engage in each day
- training sessions
- whether you meet the national guidelines for your age relating to physical activity and sedentary behaviour.

Once you assess one or several of these factors, you then analyse your results by comparing them to what is recommended in relation to physical activity, blood pressure, hours of sleep etc.

Weblink

Physical activity and exercise guidelines for all Australians

SIGNPOST

Search online for recommendations for some of the factors mentioned above, such as national physical activity, exercise and sedentary behaviour guidelines for different age groups on the Australian Government's Department of Health and Aged Care website.

Step 3: Identifying your strengths and areas for improvement

Once you have collected preliminary data on a range of key variables you can make a selection of appropriate activities to work on the areas you need to improve in or areas you want to focus on. Your teacher will be able to assist you with this, or a personal trainer or possibly your coach, if you have one.

Step 4: Monitoring your progress

There are lots of ways to assess our physical activity and fitness levels to monitor our progress towards our set goals. As discussed in Chapter 12, the most effective strategy is to consistently use the same technique to measure your activity level or fitness. For example, it is not useful to conduct a baseline (pre-program) measurement of your physical activity using only a self-report recall survey and then over the following 12 weeks use only a pedometer to record your activity. You cannot compare the two measures across the different time points to determine improvement, because they measure different outcomes. It is okay to use a combination of measures, but to in order determine whether you have improved you must use identical measures or fitness tests. Table 13.13 (on p. 488) displays example measures you could use to monitor your progress.

Based on the monitoring of your progress you may need to adjust what you are doing to achieve your set goals. You may need to adjust the intensity, duration, frequency or even the type of activities/exercises being performed in order to make your program more effective. You may even decide to adjust your set goals, either once you achieve them or to make them more achievable or more challenging. Ultimately, the main goal should be to be as active and fit as you can be. Remember, even doing something small regularly is better than doing nothing or only doing something once a week.


martin-dm/Getty Images

FIGURE 13.21 Digital devices can provide individuals with immediate feedback about their physical activity intensity, location, speed, heart rate, energy expenditure, steps and total distance covered.

COLLABORATIVE TASK
Lab activity

Assessing your progress

1 Conduct online research to complete Table 13.13, which outlines what factors each of the measures can be used to assess.

2 Search for some examples of fitness test protocols and norms to **compare** your results to.

3 **Discuss** which of the measures in Table 13.14 are accessible to you to use.

TABLE 13.13 Measures of physical activity, sedentary behaviour and fitness

Measure	Format (e.g. electronic)	What does this measure assess?
Diaries and logs	Paper or electronic such as online or apps	
Survey	Paper or electronic such as online or apps	
Pedometers*	Digital	
Accelerometers*	Digital recording personal devices	
Heart rate monitors*	Digital recording personal devices	
Fitness tests	Apps	
Global positioning systems (GPS)*	Digital recording personal devices	

* these are functions of wearable devices

TABLE 13.14 Example fitness tests for the components of fitness

Tests to assess health-related components of fitness	Tests used to assess sport-related components of fitness
Aerobic capacity VO_2 maximum treadmill/ergometer test Cooper's 12-minute run Harvard step test 20-metre shuttle run (Beep) test Critical swim speed test 1.6-kilometre jog test Yo-yo intermittent recovery test	**Balance** Stork balance stand test Standing balance test
Anaerobic capacity Phosphate recovery test Running-based anaerobic sprint test (RAST) Wingate anaerobic cycle test (30 seconds)	**Reaction time** Ruler-drop reaction test Online reaction tests
Body composition Body mass index (BMI) Waist circumference Skinfold sums % body fat	**Co-ordination** Alternate-hand wall toss test Soft-drink can test
Muscular strength Handgrip dynamometer 1RM bench press; 1RM leg press 7-level abdominal test	**Agility** Illinois agility test SEMO agility test
Muscular endurance Timed sit-ups, timed push-ups Pull-ups and modified pull-ups Flexed arm hang Partial curl-ups	**Speed** Sprint standing start tests 15, 40 and 50 metre Running 40-metre sprint test
Flexibility Modified sit and reach Shoulder and wrist elevation test Trunk and neck extension Ankle extension test Shoulder rotation test Ankle (dorsi) flexion test	**Muscular power** Standing long jump Vertical jump test Basketball throw

Jacob Lund/Shutterstock.com

FIGURE 13.22 Although VO_2 max tests are accurate, they are hard to access.

Step 5: Considering the strengths and limitations of your program design

When evaluating the design of your individual physical activity program, it is important to identify the strengths and limitations of your program. Consider the following:

- What works well that you will keep in your program?
- What are the limitations of your program?
- Are you consistently meeting the physical activity and sedentary behaviour guidelines for your age group? How do you know whether you are meeting these?
- What improvements could you make to enhance your likelihood of adhering to the physical activity and sedentary behaviour guidelines for your age group?

13.2 CHECK-IN QUESTIONS

1 **List** three types of fitness training methods you could incorporate into your individual physical activity plan.
2 **Identify** three self-management skills that use behavioural strategies.
3 **Outline** what the SMART acronym stands for and provide an example of a SMART goal in relation to goal setting.
4 **Discuss** why having variety in your individual physical activity plan is important.
5 **Describe** two ways you could enlist social support in your individual physical activity plan.
6 **Compare** an internal reinforcer to an external reinforcer and provide an example of each.
7 **Explain** why progressively and gradually building up the activity in your plan is essential.
8 **Justify** why you should evaluate the strengths and weaknesses of your individual physical activity plan.

Assessment
13.2 Check-in questions

Command terms

list
Provide a series of related words, names, numbers or items that are arranged consecutively

justify
Show, prove or defend, with reasoning and evidence, an argument, decision and/or point of view using given data and/or other information

CHAPTER SUMMARY

Resource
Self-assessment checklist

Video
Masterclass: Chapter 13

13.1 Considerations of a personalised physical activity plan

- Many health professionals, health educators, medical practitioners and psychologists also use approaches that encourage the individual to change their behaviour. Individual approaches focus on biological, cognitive and behavioural factors which can be developed using self-management skills.
- Self-management skills that use cognitive strategies involve increasing knowledge, awareness of risks, caring about the consequences to others, comprehending the benefits of being active and increasing your awareness of healthy opportunities.
- Behavioural strategies are the doing things. Realistic behavioural strategies are essential to an individual physical activity plan. They include: substituting alternatives, enlisting social support, motivating and rewarding yourself, committing yourself by setting realistic goals, and reminding yourself.
- An important part of designing a sustainable physical activity plan is to ensure you incorporate a variety of opportunities to be active throughout your day and typical week.

13.2 Developing, implementing and evaluating personal physical activity plans

- A needs analysis will inform the design of your physical activity plan.
- When you stop being active, the benefits of your program are reversed.
- If you want to improve your health- and sport-related fitness, the training methods incorporated into your individual physical activity plan should be based on the demands of your life and sports.
- Ensuring you develop goals using the SMART approach is important to the success of your program.
- You don't always need highly structured sessions or expensive equipment to be active. You can repurpose household or recycled items to make a circuit, game or exercise.
- Evaluating the strengths and weaknesses of your individual physical activity program enables you to make changes to improve its sustainability and maximises your chance of adherence to the activity guidelines for your age.

CHAPTER REVIEW

1 Consider the five self-management skills classified as cognitive and **identify** which of these would be important for someone in your family who may not be meeting the activity guidelines for their age group.

2 **Identify** three behavioural strategies you regularly use as a self-management skill to be active.

3 **Discuss** why using cognitive strategies in addition to behavioural strategies is more important for someone who is not regularly active than for someone who adheres to the guidelines for their age group.

4 **Describe** the 'Stairway to lifetime fitness' concept in relation to level of independence.

5 **Justify** why a person who is new to training and is untrained has a much larger potential to improve compared to an elite athlete who trains daily and is near their maximum potential.

6 **Evaluate** how effectively you utilise social support strategies to encourage you to be regularly active. Identify which of the examples provided in this chapter you already use regularly, and make a judgement about the strengths and limitations of each. For example, 'I asked my parents to take me to the local recreation centre to go for a swim and so I can hang out with my friends during summer.'

7 **Explain** how you would evaluate whether your individual physical activity program is effective or needs changes. Think about whether you are meeting the guidelines for your age group.

Assessment
Chapter 13 Review

Command term

evaluate
Ascertain the value or amount of; make a judgment using the information supplied, criteria and/or own knowledge and understanding to consider a logical argument and/or supporting evidence for and against different points, arguments, concepts, processes, opinions or other information

UNIT 2 REVIEW

INTEGRATED EXTENDED RESPONSE QUESTIONS

These questions have been developed to allow you to draw on the knowledge and skills that you have developed across both Areas of Study in Unit 2. The responses require you to incorporate the concepts found in each Area of Study, draw on practical examples and integrate theoretical and practical concepts.

Question 1 (12 marks)

Billy, aged 23 years, is an electrician. He starts work most days at 7 a.m. and finishes at 3 p.m. After work from Monday to Thursday he goes to the gym with his workmate Harry, where he does 30 minutes of cardio and alternates weight training for his upper body one day with legs and abdominals the next. Billy has a smart watch and notices he does well over 10 000 steps a day and about 60 minutes of moderate physical activity on gym days. On weekends Billy plays lacrosse on Saturdays (including a 30-minute warm-up and a 60-minute game).

a State the relevant physical activity and sedentary behaviour guidelines for Billy. (2 marks)

b List the domains of physical activity mentioned in this case study. (2 marks)

c Justify whether Billy meets the physical activity guidelines for his age group. (2 marks)

d Describe how Billy could measure his physical activity to determine whether he meets the physical activity guidelines for his age group. (3 marks)

e Discuss two enablers to Billy being active, and explain how each potentially influences his physical activity behaviour. (3 marks)

Question 2 (8 marks)

As part of a staff wellbeing program at ACU called 'Flourish@ACU', the following intervention strategies were implemented to encourage both academic and professional staff to be active:

- installation of a table tennis table
- discounted gym memberships
- signage encouraging stair use
- electronic stand-up desks
- professional learning about breaking up sitting time, back care, using reward systems, finding alternatives and enlisting social support
- walking meetings
- installation of a Pitjau ring, carpet bowls, plastic ten pin bowls and a pickleball set
- a walking club once per week
- team entry into the Great Ocean Walk (over 110 kilometres)
- bicycle racks.

Critique the physical activity strategies within the Flourish@ACU program. Your response should include reference to:

- social-ecological model levels
- evaluation of physical activity levels
- self-management skills
- health benefits.

Question 3 (8 marks)

Steph is 17 years old and currently in Year 11. At lunchtime she sits and chats to her friends, and after school she's in her bedroom, either doing homework or on social media. Steph used to play team sports but lost interest during Year 9 because it became too competitive, and her friends dropped out. Steph got a part-time job at the local bakery, where she works on Saturdays. Her Sundays are mostly taken up by homework or chilling out watching YouTube. Steph is not studying VCE Physical Education, and the school does not offer sport or recreational activities. Although Steph lives 1.2 kilometres from her school, she gets a lift with her neighbour. Steph generally uses social media three to four hours per day, and lately she has been feeling very tired. When she's not feeling tired her interests include dancing, social netball, Pilates, yoga and walking.

Design an individual physical activity plan for Steph that is realistic for someone who hasn't been active for over 18 months. Your response should include reference to:

- enablers and barriers to physical activity
- prevalence of inactivity
- Functional Movement Assessment
- considerations of a plan to promote physical activity.

Question 4 (10 marks)

Blue Lake primary school had an issue with many students sitting during break times. Students were sitting in indoor areas watching YouTube clips, reading, talking or playing passive games. The school only had a couple of basketball rings, which were generally used by Year 6 students. The playground equipment was mostly immovable and very old, and students generally used it to sit on rather than for active play. The principal recruited a brand-new PE teacher who made a range of changes, including:

- installation of line markings
- equipment borrowing system
- rules to ensure different year levels could access different play areas on different days
- Year 5 and 6 students coaching younger students in a range of sports
- introduction of a new sensory playground with lots of movable parts, materials and equipment
- new pickleball courts
- increasing the timetabling of physical education and sport to meet the mandated time
- removing all seating and locking indoor areas during break times
- creating a new yard duty area within the gym to be included within staff workloads
- provision of skipping ropes.

a State the physical activity guidelines for primary school age children. (2 marks)

b Describe a measure the physical education teacher could use to collect data in order to evaluate whether there was a change in physical activity behaviour, and explain when this data would need to be collected. (2 marks)

c Discuss two barriers to the students being active. (2 marks)

d List two health benefits associated with skipping rope. (2 marks)

e Use the following table to outline which strategies were used based on a social-ecological approach, and to critique the program. (2 marks)

Social-ecological model level	Example strategies
Social environment	
Physical environment	
Policy	

GLOSSARY

80%1RM
RM stands for repetition maximum and refers to the maximum amount that can be lifted once. If someone is lifting a weight at 80%1RM and their RM is 10 kilograms, they will be lifting 8 kilograms

abduction
Movement that moves a limb away from the midline of the body

accuracy
When an assessment is performed free from error

acquired ageing
Characteristics commonly associated with ageing that appear at an earlier than normal age

actin
Thin protein filament found in the sarcomere

active transport
Any form of human-powered transportation to get to and from work, school or specific destinations

acute injury
An injury that occurs suddenly, without warning

adaptations
The long-term changes as a result of stress placed on our body that increase the capacity of targeted fitness components

adduction
Movement that moves a limb towards the midline of the body

agonist
The muscle primarily responsible for movement

altitude training
Training undertaken at an altitude significantly higher than sea level

alveolar/capillary interface
The blood–air barrier or air–blood barrier (alveolar–capillary barrier or membrane) situated in the gas-exchanging region of the lungs

anabolic
Promoting metabolic activity concerned with the building of complex molecules

anaerobic
Any function or biological process that occurs in the absence of oxygen

anaerobic glycolysis
The breaking down of glycogen with insufficient oxygen to produce ATP

anaerobic power
The ability to deliver energy for physical activity at a high rate, without oxygen for a short period of time

anatomical position
Position of the body when a person is standing erect with feet facing forward, arms hanging beside the body and palms facing forward

androgenic
Related to the development of male characteristics

antagonist
The muscle that relaxes as the agonist contracts

arteries
Carry oxygen-rich blood away from the heart to the body

articulating
Location where two or more bones meet to form a joint

atherosclerosis
A condition resulting from the arteries becoming narrow due to a build-up of plaque on the artery walls

atrophy
Decrease in the size of a muscle

autoimmune
Autoimmune disease occurs when a person's immune system mistakenly attacks their own body

balance
The ability to control equilibrium while stationary or moving

barriers
Obstacles that block or impede access to physical activity – for example, feeling tired or feeling too self-conscious

batch testing
Laboratory testing of a batch of produce to determine that the batch is free of prohibited substances

behavioural
The abilities you have, involves what you do

beta-blockers
A type of medication that slows down cellular activity including heart rate

bias
A source of untruthful data

blood doping
The misuse of techniques to manipulate components of the blood, which are then introduced into the body

bout
A period of time, usually the duration of an intense exercise session or activity; for example, a distance runner may sprint for a 5-minute bout at a high intensity

built environment
Buildings and other infrastructure built by human beings, including indoor and outdoor places for living, working and playing, and transportation systems

bursitis
Inflammation of the bursae

by-product
A substance that is produced as a result of a chemical reaction

capillaries
Very small blood vessels that allow for the exchange of gases (oxygen and carbon dioxide), water, nutrients and waste products to and from the blood

cardiac output
Cardiac output = Stroke volume × Heart rate

cartilage
Flexible connective tissue that supports and protects bones

central nervous system (CNS)
Made up of the brain and the spinal cord

chronic disease
Long-lasting conditions with persistent effects

chronic injury
Long-term, overuse injury

circumduction
Circular motion of the arm, thigh, hand, thumb or finger that is produced by the sequential combination of flexion, abduction, extension and adduction

cognitive
Involving attitudes, thinking and awareness

concentric action
Muscle shortens as tension develops; joint movement occurs

conducting zone
Parts of the respiratory system responsible for bringing air into the lungs

context
The circumstances that form the setting for an event, statement or idea

contractility
The contractile function of the ventricles, in particular the left ventricle, which pumps blood to all parts of the body (except the lungs)

correlate
A mutual or complementary relationship between two or more factors, such as a cause and an effect, or a test result and an estimated rating

corticosteroid
Synthetic cortisol-like compound used to treat cortisol (hormone)-related disorder

culturally inclusive
Addresses and supports the needs of people from diverse cultures, and values their unique contribution. It involves ongoing awareness raising, where negotiations and compromise may be necessary

culture
The beliefs, behaviours, objects and other characteristics common to the members of a particular group or society. Through culture, people and groups define themselves, conform to society's shared values and contribute to society

deacclimatisation
The loss of adaptations following altitude training

degenerative
Progressive deterioration and loss of function in the organs or tissues

dementia
A disorder that affects the brain; symptoms include memory loss and the loss of the ability to solve problems, do simple daily activities such as get dressed and control emotions

dependent variable
Derives its value from changes to an independent variable – that is, heart rate will change in response to changes in intensity

diaphragm
A dome-shaped muscular partition that is located at the base of the thoracic cavity. It is composed of skeletal muscle and is attached to the lower ribs, spine and sternum

diastole
The period when the heart relaxes and the both atriums fill with blood from the lungs and other body parts

direct injuries
Injuries caused by an external force to the body

doping
The use of prohibited substances or methods to unfairly improve sporting performance or mask presence in the body to gain an advantage over competitors

dorsiflexion
Movement at the ankle that brings the top of the foot towards the shin

dynamic flexibility
Moving continuously through the range of motion

eccentric action
Muscle lengthens as tension develops; joint movement occurs

enablers
Factors that support and facilitate implementation, increase access to resources and encourage or support a person to participate in a sport or physical activity

endomysium
Connective tissue that encases an individual muscle fibre

epimysium
Connective tissue that encases the whole muscle

ergogenic aid
A method or substance used for the purpose of enhancing performance

erythropoietin (EPO)
A polypeptide hormone naturally produced in the kidneys or produced synthetically

eversion
Movement where the sole of the foot is turned away from the midline of the body

excess post-exercise oxygen consumption (EPOC)
The period during recovery from exercise when oxygen consumption remains above resting levels

exercise
Activity that is planned, structured and repetitive to improve or maintain health and/or fitness (including training)

expiration
The phase of ventilation during which air is expelled from the lungs, caused by relaxation of the respiratory muscles

extension
Movement that increases the angle of a joint (straightens the joint)

extrinsic factors
Related to the characteristics of the task and the environment, including intensity and frequency of the task, playing surface and equipment

Fartlek training
An aerobic training method that intersperses bursts of speed within steady aerobic work

fascicles
A bundle of muscle fibres

flexibility
Flexibility refers to the range of motion around a joint

flexion
Movement that decreases the angle of a joint (bends the joint)

functional movement
Movement that is required for functional day to day activities

Functional Movement Assessment (FMA)
A movement assessment undertaken prior to participating in a personalised plan which aims to evaluate an individual's functional movement patterns, and can indirectly measure health-related fitness components

gene doping
The non-therapeutic use of genes, genetic elements and/or cells that have the capacity to enhance athletic performance

glycolytic
Glycolytic fibres use anaerobic glycolysis to generate ATP

haematoma
Abnormal collection of clotted blood outside of a blood vessel, usually caused by injury

haemoglobin
A vital protein in red blood cells that carries oxygen and carbon dioxide throughout the body

heart rate
Sometimes referred to as 'pulse'; the number of times your heart beats per minute

homeostasis
A physiological process that keeps the body's internal environment stable and balanced

hyperextension
Excessive extension of joint, beyond the normal range of movement

hyperflexion
Excessive flexion of joint, beyond the normal range of movement

hyperthermia
An elevated core temperature which is greater than 38.5°C

hypertrophy
An increase in the size of the muscle

hypothermia
Low body temperature; a condition that occurs when body temperature drops below 35°C

hypothesise
Suggest or put forward a point of view, idea, argument, diagram and/or plan based on given data or stimulus material for consideration or action

incidence
The number of new cases of a disease diagnosed per year

incidental activity
Any activity that builds up in small amounts during the day, such as housework and walking for transport

independent variable
Can be changed to measure the impact of a dependent variable – that is, the impact intensity has on heart rate

indirect injuries
Injuries caused by a sudden change in the demands of the activity

infer
To conclude from evidence and reasoning

inference
An interpretation or observation made using our senses

inferior
Describes a position below or lower than another part of the body

informed consent
A process designed to minimise the risk of assessment for the participant and the facilitator

innervate
To supply (a body part) with nerves

insertion
The point where the muscle attaches to the bone that is pulled by the action of the muscle

inspiration
The phase of ventilation in which air enters the lungs, initiated by contraction of the respiratory muscles

intercostal muscles
The 11 sets of muscles located between each rib that help form and move the chest wall

internal respiration
Gaseous exchange that occurs at the muscles and tissues of the body

inter-rater reliability
The extent to which the observers agree in their assessments

intervention
Making a change that might include a single strategy or a range of strategies as part of a more comprehensive physical activity program or initiative

intrinsic factors
Related to the individual's ability to cope with the forces imposed on the body, including alignment of the musculoskeletal system, fitness level and previous history of injury

inversion
Movement where the sole of the foot is turned towards the midline of the body

isoinertial
Muscle action where the resistance is constant throughout the movement

isometric
Muscle action where there is no change in muscle length and no joint movement occurs

leisure-time physical activity
Activity over and above that which occurs within the workplace or at school

lever
A simple machine consisting of a rigid rod that is capable of rotating around an axis

ligament
Connective tissues that connect bone to bone

linear relationship
Occurs when two variables have a direct connection – for example, if the value of *x* is changed, *y* must also change in the same proportion

maximum heart rate
Is age related and may be calculated by using the formula 220 minus age; for example, a 30-year-old's MHR would be 220 – 30 = 190 bpm

mediators
Mechanisms through which an intervention (strategy) is believed to influence physical activity behaviour

MET
Stands for metabolic equivalent. 1 MET is the amount of energy you expend at rest, and 2 METs is twice the energy expenditure of resting levels

meta-analysis
A quantitative, formal, epidemiological study design used to systematically assess the results of previous research to derive conclusions about that body of research. Typically, but not necessarily, the study is based on randomised, controlled clinical trials. (Haidich, 2010)

metabolic by-products
Metabolic wastes left over from metabolic processes (such as cellular respiration) that cannot be used (they are surplus or toxic), and must be excreted

mitochondria
Small structures found in the cytoplasm of a cell where ATP is produced

moderate-intensity physical activity
Physical activity performed at a level that causes the heart to beat faster and some shortness of breath, while the person can still talk comfortably. An intensity that may last between 30 and 60 minutes

monitoring and surveillance
Monitoring means to measure physical activity, and surveillance of physical activity is a core public health function that is necessary for monitoring population engagement in physical activity, including participation in physical activity initiatives

motor neuron
A nerve cell that conveys nerve impulses from the spinal cord or brain away from the central nervous system and towards the muscle

motor unit
A motor neuron and all of the muscle fibres it stimulates

muscle typology
Muscle fibre type composition

muscular endurance
The ability of a muscle or group of muscles to sustain repeated contractions against a resistance for an extended period of time

muscular strength
The peak force a muscle of group of muscles can produce in one contraction

myofibrils
Bundles of protein filaments (myosin and actin) that run the length of the muscle fibre

myoglobin
A protein that transfers oxygen from the blood to the muscle and stores and carries oxygen from the cell membrane to the mitochondria

myosin
Thick protein filament found in the sarcomere

neuroplasticity
The adaptation of the human brain to changing demands by altering its functional and structural properties. This results in learning and acquiring skills, and thereby enhances an individual's capacity to respond to new demands with behavioural adaptations

neurotransmitter
A substance released by the presynaptic terminal that stimulates the production of an action potential

origin
The point where the muscle attaches to the bone

oxidative
Oxidative fibres use aerobic respiration to generate ATP

oxygen deficit
A situation when the body's oxygen consumption exceeds the intake of oxygen – i.e oxygen demand exceeds oxygen supply

parallel play
A form of play where children play adjacent and independently in the same area, with the same materials, but with minimal engagement with one another. They do not try to influence each other

patterns
Observable, repeated sequences represented by data

pennate
Having a structure like that of a feather; in muscle, it is where the fibres extend obliquely from either side of a central tendon

perfusion
The flow of blood or fluid to tissues and organs, primarily via the circulatory system

perimysium
Connective tissue that encases a bundle of muscle fibres

peripheral nervous system (PNS)
Made up of nerves that carry messages to and from the CNS

permitted
Substances and methods that can be used in training and/or competition according to WADA

perpendicular
At right angles (90 degrees) to another line or surface

physical fitness
The ability to get through daily activity tasks efficiently and effectively

physical infirmity
Physical weakness resulting from changes to body chemistry, low levels of weight-bearing exercise, loss of lean muscle, or reduced physical activity that is caused by either old age or disease

physical literacy
Involves holistic lifelong learning through movement and physical activity. It delivers physical, psychological, social and cognitive health and wellbeing benefits

placebo effect
When a person's physical or mental health appears to improve after taking a placebo or 'dummy' treatment

plantar flexion
Movement at the ankle in which the heel is lifted off the ground and/or the toes are pointed

plaques
Combinations of fat, damaged cells, immune cells, and other 'scar-like' components that can form along the walls of blood vessels

plateau
To reach a level or period where no change is observed

potentiation
Activities that make the warm-up effective or will improve the effectiveness of the performance

prehypertension
Occurs when blood pressure is high, but not high enough to be considered hypertension. Regular monitoring is recommended, and strategies to reduce this should be considered

prevalence
How often a behaviour occurs

prohibited
Substances and methods that cannot be used in training and/or competition according to WADA

pronation
Movement of the forearm that turns the palm towards the body

proprioception
Ability to sense the status of movement, action and location of the musculoskeletal system

proprioceptive neuromuscular facilitation (PNF)
A stretch that involves stretching and contracting the muscle to increase the range of motion

protocols
Rules that explain the correct procedure to be followed when undertaking functional or fitness assessment

pulmonary circulation
The closed circuit of vessels that transports de-oxygenated blood from the heart to the lungs

qualitative data
Data representing information and concepts that are not represented by numbers

quantitative data
Measures of values or counts, expressed as numbers; data about numeric variables

reactivity
When individuals alter their behaviour because they are aware they are being observed

reciprocal causation
The interaction between the individual and the environment

reciprocal inhibition
When muscles on one side of a bone or joint relax to accommodate the contraction of the muscle on the other side of the bone or joint

recreational activity
Activity that diverts, amuses or stimulates the body and mind through enjoyment and relaxation

rehabilitation
A set of interventions designed to optimise functioning and reduce disability in individuals with health conditions in interaction with their environment (WHO, 2024)

reliability
The assessment can be repeated with consistent results

repetitions (reps)
The action of repeating something, e.g. biceps curls × 8–12 reps

resistance training
To move against a force provided by a person's own body weight, machine or weight such as barbell, dumbbell, kettle ball or medicine ball

respiratory rate
The number of breaths taken per minute, sometimes referred to as respiratory frequency

respiratory zone
The site of gaseous exchange, namely the alveolar capillary surface area

response bias
A psychological phenomenon that makes study participants answer in a way that makes them look/feel better

rotation
Movement of a bone around a central axis or around its long axis

rupture
A break or tear of the soft tissue

sagitally
Divides the body or an organ vertically into right and left sides

sanction
A punishment for someone who violates the rules

sarcolemma
Thin cell membrane that covers the muscle fibre

sarcomere
Repeating contractile unit located between two adjacent Z lines within a myofibril

sarcopenia
The loss of skeletal muscle mass and strength as a result of ageing

sarcoplasmic reticulum
Endoplasmic reticulum in muscle cells that stores, releases and retrieves calcium ions

self-efficacy
Confidence in your ability to be active within specific circumstances – for example, even when you have no one to be active with

set
Several exercises intended to be done in a series, e.g. bicep curls 3 sets × 8–12 reps

settings-based approach
A strategy in which promotional strategies are delivered within a defined setting (geographical area or institution)

SMART goals
Specific, Measurable, Achievable, Relevant and Timely

social desirability bias
Occurs when people provide describe what they believe is the desired response rather than their actual behaviour

sociocultural
Of or relating to the interaction of social and cultural elements such as family, peers, community, gender, socio-economic status, cultural beliefs and traditions

socio-economic status (SES)
The position of an individual or group on the socio-economic scale, which is determined by a combination of social and economic factors such as income, amount and kind of education, type and prestige of occupation, place of residence, and – in some societies or parts of society – ethnic origin or religious background

sport
Activity with a primary focus on physical exertion and skill, with elements of competition and social participation, where rules and patterns of behaviour govern the activity (formal and informal)

stabilisers
The muscles that stabilise one part of the body while another is moving

static flexibility
Moving through range of motion then holding a stretch

steady state
A situation where oxygen supply is able to meet oxygen demand

subluxation
Partial dislocation of a joint

submaximal exercise
Physical activity that does not exceed 85 per cent of your maximum heart rate

superior
Describes a position above or higher than another part of the body

supination
Movement of the forearm that turns the palm away from the body

synaptic cleft
Space between the pre-synaptic and the post-synaptic membranes

synergists
Muscles that work together to create movement

systematic review
An overview of primary studies which contains an explicit statement of objectives, materials and methods, and has been conducted according to explicit and reproducible methodology (Gopalakrishnan & Ganeshkumar, 2013)

systemic circulation
The closed circuit of vessels supplying oxygenated blood to and returning deoxygenated blood from the tissues of the body

systems-based approach
Involves applying systems thinking, methods and practice to better understand the promotion of physical activity behaviour and identify challenges and collective actions

systole
The period when the heart's ventricles contract and force blood out of the heart to the lungs and other body parts

tailoring
Ensuring exercise prescription matches the participant's physical capabilities, likes and interests

tendinitis
Inflammation of a tendon

tendon
Soft tissue that connects muscle to bone

theoretical models
A model that allows us to understand a concept, such as participation in physical activity behaviour

thermoreceptors
Specialised sensory receptors, primarily found in the skin, that detect changes in temperature and play a crucial role in our perception of hot and cold sensations

thermoregulation
A process that allows your body to maintain its core internal temperature. All thermoregulation mechanisms help return your body to homeostasis. This is a state of equilibrium

tidal volume (TV)
A measurement of the volume of air inhaled and exhaled per breath

transcutaneous
Penetrating or entering through unbroken skin

transverse axis
An imaginary line running from left to eight and perpendicular to the sagittal plane

transversely
Divides the body or organ horizontally into upper and lower parts

validity
The degree to which an assessment measures what it intends to measure

variables
Factors or elements in studies that are subject to change. Independent variables are changed in the study (think about these as the trigger). Dependent variables are observed in the study (think about these as the effects of changes to the independent variable)

vascular shunt mechanism
The redistribution of blood in response to the demands of physical activity

vasoconstriction
A decrease in the diameter of a blood vessel, resulting in a decrease in blood flow to the area supplied by the blood vessel

vasodilation
An increase in the diameter of the blood vessel, resulting in an increase in blood flow to the area supplied by the blood vessel

veins
Carry blood (low in oxygen) back to the heart

venules
The smallest veins that transport blood from capillaries into larger veins

vigorous-intensity activity
Physical activity performed at a level that causes rapid heartbeat and shortness of breath. An intensity that may last up to 30 minutes and no longer than 10 minutes when exceeding 9 METs

viscosity (in joints)
The 'thickness' of synovial fluid around a joint

VO_2
The amount of oxygen that can be taken up, transported and used by muscles

VO_2 maximum
The maximum amount of oxygen that can be taken in, transported and utilised per minute

yarning
An informal conversation that is culturally friendly and recognised by Aboriginal and Torres Strait Islander peoples as meaning to talk about something or someone or provide and receive information. Yarning circles are designed to allow all students to have their say in a safe space without judgement

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