

BTEC
Level 3

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SPORT | LEVEL 3

Book 1 BTEC National

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Chris Mulligan | Pam Phillippo | Louise Sutton

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Websites

The websites used in this book were correct and up to date at the time of publication. It is essential for tutors to preview each website before using it in class so as to ensure that the URL is still accurate, relevant and appropriate. We suggest that tutors bookmark useful websites and consider enabling learners to access them through the school/college intranet.

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Copies of official specifications for all Edexcel qualifications may be found on the Edexcel website: www.edexcel.com

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Also available

There are many different optional units in your BTEC Level 3 National Sport qualification, which you may use to form specialist pathways or to build a broader programme of learning. This student book covers all the mandatory units for the Edexcel BTEC Level 3 National Extended Diploma in Sport across the two main pathways and some support for the Outdoor Adventure Pathway, but if you want a huge choice of optional units you may be interested in Student Book 2.

Written in the same accessible style with the same useful features to support you through your learning and assessment, *BTEC Level 3 National Sport Student Book 2* (ISBN: 9781846906503) covers the following units:

Unit number	Credit value	Unit name
10	10	Outdoor and adventurous activities
12	10	Current issues in sport
13	10	Leadership in sport
14	10	Exercise, health and lifestyle
15	10	Instructing physical activity and exercise
16	10	Exercise for specific groups
18	10	Sports injuries
19	10	Analysis of sports performance
20	10	Talent identification and development in sport
21	10	Sport and exercise massage
22	10	Rules, regulations and officiating in sport
23	10	Organising sports events
24	10	Physical education and the care of children and young people
25	10	Sport as a business
26	10	Work experience in sport



Available direct from www.pearsonfe.co.uk/BTEC2010 and can be ordered from all good bookshops.

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- p. 188** Forestry non-adjusted aerobic fitness values for females table (ml/kg/min) for males. Adapted, with permission, from B. J. Sharkey, 1984, *Physiology of fitness*, 2nd ed. (Champaign, IL: Human Kinetics), 259
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About the authors

Mark Adams is a Senior Verifier for Sport Levels 1 to 3 and has worked with Edexcel for seven years. He has taught for ten years at schools and colleges across all qualifications. Mark is a consultant with the Premier League education and learning team. He is the series editor for our BTEC Level 3 National Sport and BTEC Level 3 National Sport and Exercise Science resources and has written for our BTEC Level 2 First Sport books.

Ray Barker has worked as sports manager and lecturer in a number of contexts for 30 years for companies and colleges in Scotland, Wales, the USA and France. He has written extensively on Sport topics and has assisted in the development of awards for Edexcel and other exam boards. He currently lectures at the University of Hull and is external examiner at Loughborough College and Cardiff School of Sport.

Adam Gledhill has nine years experience teaching throughout Further and Higher education, has been involved with Edexcel's qualification development for five years and external verification for three years and was a co-author of the previous editions of this book for Heinemann. Alongside teaching, Adam is currently working towards a PhD in Sport Psychology around the area of talent development in football at Loughborough University and provides sport science support to youth athletes in a range of sports.

Chris Lydon is a department manager and senior sports lecturer currently teaching BTEC courses at a Further Education college. In this role he is involved in the professional development of new staff and introduces them to BTEC assessment and verification. He has wide-ranging experience of teaching Further Education and Higher Education programmes and has contributed to a number of BTEC Sport textbooks published by Heinemann.

Chris Mulligan has been teaching BTEC qualifications for the last ten years and has taught across all levels. He has worked for Edexcel for the last five years as an external verifier and has written unit specifications for the new First and National Diplomas in Sport. Chris was also an author of the previous BTEC National Sport student book as well as the BTEC Level 3 National Sport Teaching Resource Pack.

Pam Phillippo has played a key role in the redevelopment of Edexcel BTEC Sport qualifications and is an expert in psychophysiology. Formerly a lecturer in Further Education and Higher Education, and having worked with GB athletes, her specialist fields include fitness testing and training, exercise prescription, and experimental methods.

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About your BTEC Level 3 National Sport book

The sport and active leisure industry is very diverse and covers such aspects as coaching, fitness testing and sports development. Every year the sport and active leisure sector outperforms the rest of the UK economy and with the approach of the London 2012 Olympic and Paralympics Games the opportunities available within this sector are more varied than ever before. BTEC Level 3 National Sport will help you succeed in your future career within the sport and active leisure sector. It's designed to give you plenty of flexibility in selecting optional units so you can meet your interests and career aspirations. The principles of sport that you will learn here underpin many aspects of professional life within the sector and reflect the enormous breadth and depth of the subject – from principles of anatomy and physiology to talent identification and development, organising sports events and fitness testing for sport and exercise.

Your BTEC Level 3 National in Sport is a **vocational** or **work-related** qualification. This doesn't mean that it will give you *all* the skills you need to do a job, but it does mean that you'll have the opportunity to gain specific knowledge, understanding and skills that are relevant to your chosen subject or area of work. The qualification can also be used as an entry point to higher education qualifications and more specialist courses.

What will you be doing?

The qualification is structured into **mandatory units** (M) (ones you must do) and **optional units** (O) (ones you can choose to do). How many units you do and which ones you cover depend upon the type of qualification you are working towards.

- BTEC Level 3 National Certificate in Sport: three mandatory units plus optional units to provide a total of 30 credits
- BTEC Level 3 National Subsidiary Diploma in Sport: three mandatory units plus one mandatory specialist unit plus optional units to provide a total of 60 credits
- BTEC Level 3 National Diploma in Sport (Performance and Excellence – **PE**): nine mandatory units plus optional units to provide a total of 120 credits
- BTEC Level 3 National Diploma in Sport (Development, Coaching and Fitness – **DCF**): eight mandatory units plus optional units to provide a total of 120 credits
- BTEC Level 3 National Diploma in Sport (Outdoor Adventure – **OA**): seven mandatory units plus optional units to provide a total of 120 credits
- BTEC Level 3 National Extended Diploma in Sport (Performance and Excellence – **PE**): nine mandatory units plus optional units to provide a total of 180 credits
- BTEC Level 3 National Extended Diploma in Sport (Development, Coaching and Fitness – **DCF**): eight mandatory units plus optional units to provide a total of 180 credits
- BTEC Level 3 National Extended Diploma in Sport (Outdoor Adventure – **OA**): seven mandatory units plus optional units to provide a total of 180 credits

The table below shows how the units covered by the books in this series cover the different types of BTEC qualifications.

Unit no.	Credit value	Unit name	Cert	Sub Dip	Dip (PE)	Dip (DCF)	Dip (OA)	Ext Dip (PE)	Ext Dip (DCF)	Ext Dip (OA)
1	5	Principles of anatomy and physiology in sport	M	M	M	M	M	M	M	M
2	5	The physiology of fitness	M	M	M	M	M	M	M	M
3	10	Assessing risk in sport	M	M	M	M	M	M	M	M
4	10	Fitness training and programming		O	M	M	M	M	M	M
5	10	Sports coaching		O	O	M		O	M	O
6	10	Sports development		O		M			M	
7	10	Fitness testing for sport and exercise	O	M	M	M		M	M	
8	10	Practical team sports		O+	O	M*		O	M†	
9	10	Practical individual sports		O+		M*			M†	
10	10	Outdoor and adventurous activities		O+		O*			O	
11	10	Sports nutrition		O	M	O		M	O	O
12	10	Current issues in sport		O	O	O	O	O	O	O
13	10	Leadership in sport		O		O	M		O	M
14	10	Exercise, health and lifestyle		O		O			O	O
15	10	Instructing physical activity and exercise		O	O	O		O	O	
16	10	Exercise for specific groups							O	
17	10	Psychology for sports performance		O	M	O		M	O	
18	10	Sports injuries			O	O	O	O	O	O
19	10	Analysis of sports performance			O			O	O	
20	10	Talent identification and development in sport						O	O	
21	10	Sport and exercise massage			O	O		O	O	
22	10	Rules, regulations and officiating In sport			O	O		O	O	
23	10	Organising sports events				O	O	O	O	O
24	10	Physical education and the care of children and young people		O		O	O	O	O	O
25	10	Sport as a business				O	O	O	O	O
26	10	Work experience in sport		O	O	O	O	O	O	O
27	10	Technical and tactical skills in sport		O	M			M		
28	10	The athlete's lifestyle		O	M			M		

* Learners **must select either** Unit 8 or Unit 9 as a mandatory unit.

* Learners **may select**, as an optional unit, whichever of Unit 8 or Unit 9 that was not taken as a mandatory unit, **or** alternatively may select Unit 10.

* Learners **must not** select all three of Unit 8, Unit 9 and Unit 10.

+ Learners may select only **one** from Unit 8, Unit 9 or Unit 10.

† Learners must select **one** of these units (Unit 8 or Unit 9) as a mandatory unit, and may select the other as an optional unit.

Units in green are covered in this book. Units in yellow are covered in *BTEC Level 3 National Sport Student Book 2* (ISBN: 9781846906503)

How to use this book

This book is designed to help you through your BTEC Level 3 National Sport course.

It contains many features that will help you develop and apply your skills and knowledge in work-related situations and assist you in getting the most for your course.

Introduction

These introductions give you a snapshot of what to expect from each unit – and what you should be aiming for by the time you finish it!

Assessment and grading criteria

This table explains what you must do in order to achieve each of the assessment criteria for each unit. For each assessment criterion, shown by the grade button **P1**, **M1**, **D1** there is an assessment activity.

Credit value: 5

1 Principles of anatomy and physiology in sport

Have you ever wondered how your body is able to undertake a range of sport and exercise activities? This unit investigates how the parts of the human body are pieced together, what they are made of and how they work whether you are a rugby player, footballer, sprinter, marathon runner, cyclist or canoeist.

As a sport and exercise scientist, your knowledge of the principles of anatomy and physiology of sport are important. This unit introduces you to the basic structures and functions of four key systems of the human body. You will examine the structure and function of the skeletal and muscular systems and their role in bringing about movement in sport and exercise. You will investigate the structure and functions of the cardiovascular and respiratory systems, and develop an understanding of why the heart works as it does and how it combines with the lungs to allow athletes to cope with the demands of sport and exercise. You will also look at the three different energy systems and the sports in which they are predominantly used.

Learning outcomes

After completing this unit you should:

1. know the structure and function of the skeletal system
2. know the structure and function of the muscular system
3. know the structure and function of the cardiovascular system
4. know the structure and function of the respiratory system
5. know the different types of energy systems.

BTEC BTEC's own resources

Assessment and grading criteria

This table shows you what you must do in order to achieve a pass, merit or distinction grade, and where you can find activities in this book to help you.

To achieve a pass grade the evidence must show that the learner is able to:	To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
P1 describe the structure and function of the skeletal system. Assessment activity 1.1, page 13		
P2 describe the different classifications of joints. Assessment activity 1.1, page 13		
P3 identify the location of the major muscles in the human body. Assessment activity 1.2, page 20		
P4 describe the function of the muscular system and the different fibre types. Assessment activity 1.2, page 20	M4 explain the function of the muscular system and the different fibre types. Assessment activity 1.2, page 20	D4 analyse the function of the muscular system and the different fibre types. Assessment activity 1.2, page 20
P5 describe the structure and function of the cardiovascular system. Assessment activity 1.3, page 25	M5 explain the function of the cardiovascular system. Assessment activity 1.3, page 25	
P6 describe the structure and function of the respiratory system. Assessment activity 1.4, page 30	M6 explain the function of the respiratory system. Assessment activity 1.4, page 30	
P7 describe the three different energy systems and their use in sport and exercise activities. Assessment activity 1.5, page 34	M7 explain the three different energy systems and their use in sport and exercise activities. Assessment activity 1.5, page 34	D7 analyse the three different energy systems and their use in sport and exercise activities. Assessment activity 1.5, page 34

Assessment

Your tutor will set **assignments** throughout your course for you to complete. These may take a variety of forms. The important thing is that you evidence your skills and knowledge to date.

Stuck for ideas? Daunted by your first assignment? These students have all been through it before...

Unit 1 Principles of anatomy and physiology in sport

How you will be assessed

This unit will be internally assessed by a range of assignments that will be designed and graded by your tutor. Your assessment tasks will be designed to allow you to demonstrate your understanding of the unit learning outcomes and relate to what you should be able to do after completing this unit. Your assignments could be in the form of:

- presentations
- practical tasks
- written assignments.



Gemma Stewart, a sports enthusiast

In this unit I learned that there are several systems that interact in a complex way to bring my body into action during sport and exercise. As a keen sports participant it has helped me to appreciate and understand how my body works and I have been able to apply what I have learned to understanding my performance in sport and exercise. I particularly enjoyed exploring the different energy systems and those involved in the different sports I take part in. The practical activities for this unit have given me a better understanding of the muscle groups worked by the exercises in my gym programme.

There is a lot of complex information to learn in understanding the principles of anatomy and physiology in sport.

Over to you

- What aspects of the unit might you find most challenging?
- What preparation could you do to make the learning of these complex systems an easier task?

3

Activities

There are different types of activities for you to do: **Assessment activities** are suggestions for tasks that you might do as part of your assignment and will help you develop your knowledge, skills and understanding. **Grading tips** clearly explain what you need to do in order to achieve a pass, merit or distinction grade.

There are also suggestions for **activities** that will give you a broader grasp of the industry, stretch your understanding and deepen your skills.

Assessment activity 1.1

P2 BTEC

A fitness instructor regularly draws on anatomical knowledge to design and develop fitness programmes for clients.

1. Draw two large tables to describe the structure and function of the axial and appendicular

skeletons. Your descriptions should include the location of all the major bones of the skeleton and their different types. **P1**

2. Describe the different classifications of joints and the range of movement each provides. **P2**

Grading tips

P1 Describe the axial and appendicular skeletons and locate and name all the following major bones: cranium, clavicle, ribs, sternum, humerus, radius, ulna, scapula, ilium, pubis, ischium, carpals, metacarpals, phalanges, femur, patella, tibia, fibula, tarsals, metatarsals, vertebral column, vertebrae – cervical, thoracic, lumbar, sacrum and coccyx.

P2 You must be able to describe all three classifications of joint and the movement available at each, including the movement allowed at each of the synovial joints. Examine each of the three classifications of joints, including all six synovial joints, and explain how and why the range of movement allowed at these joints differs. Use sporting examples to support your explanation.

Activity: Muscles at work

When your body is in action during sport and exercise, your muscles shorten, remain the same length or lengthen.

1. Pick up a dumb-bell (or a bag of sugar or a heavy book). Bend your arm at the elbow to bring your forearm up towards your shoulder in a bicep curl action.
2. Think about what your bicep muscle appears to be doing as you bring the weight closer to your shoulder. Has the muscle shortened, remained the same length or lengthened?

3. Return the dumb-bell to the starting position and consider what has to happen to your muscle to allow this action to take place. Do you think the bicep shortened, remained the same length or lengthened?

4. Curl the arm again, but this time only to a 90° angle. Hold your object in this position for a sustained period of time. What does the bicep muscle appear to be doing now? Do you think it is shortening, remaining the same length or lengthening?

Personal, learning and thinking skills

Throughout your BTEC Level 3 National Sport course, there are lots of opportunities to develop your personal, learning and thinking skills. Look out for these as you progress.

PLTS

Researching the structure and function of the skeletal system and examining the range of movement at joints using a variety of sporting examples will evidence your development as an **independent enquirer**.



Functional skills

It's important that you have good English, Mathematics and ICT skills – you never know when you'll need them, and employers will be looking for evidence that you've got these skills too.

Functional skills

Describing the structure and function of the axial and appendicular skeletons and the different classifications of joints and their range of movement will demonstrate your **English** skills.



Key terms

Technical words and phrases are easy to spot. You can also use the glossary at the back of the book.

Key term

Articulation – the meeting of two or more bones.

WorkSpace

Case studies provide snapshots of real workplace issues, and show how the skills and knowledge you develop during your course can help you in your career.

There are also mini-case studies throughout the book to help you focus on your own projects.

WorkSpace

Frank Bedford

Sports Therapist



As a sports therapist I work with the local football team and play a key role in keeping the players fit. I regularly apply the principles of anatomy and physiology to the prevention and management of injuries. In a typical day I work alongside the physiotherapist and the strength and conditioning team to treat and advise players on a range of football-related injuries. I massage players and provide advice on pre- and rehabilitative exercises to help prevent and manage these injuries. My work may also involve undertaking assessments of readiness to return to training following injury, testing joints for ease and range of movement, strapping and taping and advising on stretching, warming-up and cooling down exercises.

During the match I provide first aid and may be involved in examining and assessing injuries and determining whether a player can continue. After the match I may again be involved in examining and assessing injuries and dealing with minor traumas such as cuts, bruises and blisters. I may need to consider whether injured players need extra treatment and coordinate referrals to other practitioners or liaise with other health professionals in the sports sector or in mainstream medicine. I enjoy being part of a multi-disciplinary support team and get great satisfaction out of helping players to achieve their full potential on the pitch.

Think about it!

- What knowledge and skills have you covered in this unit that would provide you with a good understanding of the role of a sports therapist? Jot down your ideas and discuss them with your peers and tutor.
- What further skills and experience might you need to develop if you were to consider this as a potential career path? Consider arranging an opportunity to shadow a sports therapist in their workplace.
- Investigate a common football injury and explore the role of the sports therapist in its prevention and management.

Just checking

When you see this sort of activity, take stock! These quick activities and questions are there to check your knowledge. You can use them to see how much progress you've made.

Edexcel's assignment tips

At the end of each unit, you'll find hints and tips to help you get the best mark you can, such as the best websites to go to, checklists to help you remember processes and useful reminders to avoid common mistakes.

BTEC's own resources

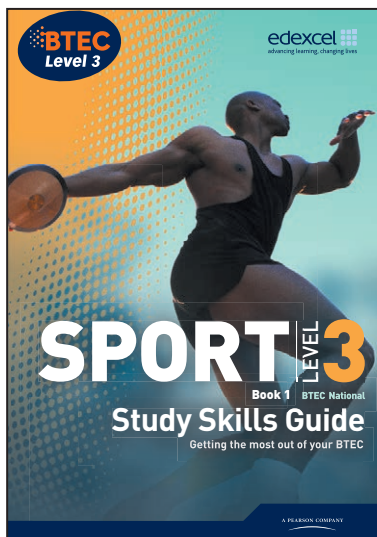
Just checking

1. List five successful sports coaches and describe why each one has been successful.
2. List six roles a sports coach must try to fulfil.
3. List six responsibilities a sports coach should try to fulfil.
4. What common skills are required by a coach to support athletes' development?
5. What are objective and subjective analysis?
6. What is observational analysis and how is it used by coaches to support performance development?
7. Why would technical instruction support performance development and what knowledge would a coach require to provide effective technical instruction?
8. Provide a definition for each of the following:
 - human resources
 - physical resources
 - fiscal resources.
9. What is a risk and what is a hazard?
10. What action can a coach take to reduce the risks and hazards in a coaching session?
11. What methods can a coach use to ensure they obtain appropriate feedback from observers and participants?
12. List the courses that could support the development of a coach in your own sport.
13. What other opportunities could a coach undertake to support their development?

Assignment tips

- Observe a number of sessions run by local coaches and consider the planning and experience required to become an effective coach.
- When planning coaching sessions you will need to have a good understanding of the sport involved. Choose a sport you are confident to coach and have appropriate knowledge about.
- Make the most of opportunities to plan and lead coaching sessions. Enjoy developing new skills.
- Don't be afraid to tell athletes what you think: remember, your job is to improve their performance, not just to observe them making mistakes.
- Remember to consider the methods of feedback you will use to assess the effectiveness of your session; you should get feedback from performers, peers and your assessor.
- Research the coaching courses available in your selected sport, and examine other methods that could be used to develop your skills as a coach.
- Complete a level 1 coaching award to support your development of the required skills and techniques required to coach in your selected sport.
- Ensure that you read the assignment briefs properly. Take your time and ensure you are happy with the task set. If not, ask your tutor for assistance.
- Attempt all parts of the assignments. If you only attempt the pass criteria, this is all you will achieve. Think big and try it all.

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Don't miss out on these resources to help you!

Have you read your **BTEC Level 3 National Study Skills Guide**?

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1

Principles of anatomy and physiology in sport

Have you ever wondered how your body is able to undertake a range of sport and exercise activities? This unit investigates how the parts of the human body are pieced together, what they are made of and how they work whether you are a rugby player, footballer, sprinter, marathon runner, cyclist or canoeist.

As a sport and exercise scientist, your knowledge of the principles of anatomy and physiology of sport are important. This unit introduces you to the basic structures and functions of four key systems of the human body. You will examine the structure and function of the skeletal and muscular systems and their role in bringing about movement in sport and exercise. You will investigate the structure and functions of the cardiovascular and respiratory systems, and develop an understanding of why the heart works as it does and how it combines with the lungs to allow athletes to cope with the demands of sport and exercise. You will also look at the three different energy systems and the sports in which they are predominantly used.

Learning outcomes

After completing this unit you should:

1. know the structure and function of the skeletal system
2. know the structure and function of the muscular system
3. know the structure and function of the cardiovascular system
4. know the structure and function of the respiratory system
5. know the different types of energy systems.

Assessment and grading criteria

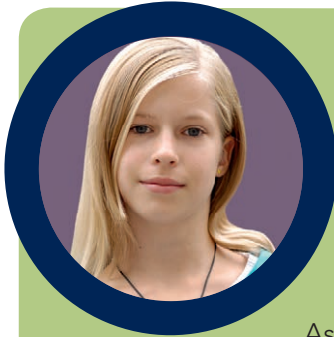
This table shows you what you must do in order to achieve a pass, merit or distinction grade, and where you can find activities in this book to help you.

To achieve a pass grade the evidence must show that the learner is able to:	To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
P1 describe the structure and function of the skeletal system Assessment activity 1.1, page 13		
P2 describe the different classifications of joints Assessment activity 1.1, page 13		
P3 identify the location of the major muscles in the human body Assessment activity 1.2, page 20		
P4 describe the function of the muscular system and the different fibre types Assessment activity 1.2, page 20	M1 explain the function of the muscular system and the different fibre types Assessment activity 1.2, page 20	D1 analyse the function of the muscular system and the different fibre types Assessment activity 1.2, page 20
P5 describe the structure and function of the cardiovascular system Assessment activity 1.3, page 25	M2 explain the function of the cardiovascular system Assessment activity 1.3, page 25	
P6 describe the structure and function of the respiratory system Assessment activity 1.4, page 30	M3 explain the function of the respiratory system Assessment activity 1.4, page 30	
P7 describe the three different energy systems and their use in sport and exercise activities Assessment activity 1.5, page 34	M4 explain the three different energy systems and their use in sport and exercise activities Assessment activity 1.5, page 34	D2 analyse the three different energy systems and their use in sport and exercise activities Assessment activity 1.5, page 34

How you will be assessed

This unit will be internally assessed by a range of assignments that will be designed and graded by your tutor. Your assessment tasks will be designed to allow you to demonstrate your understanding of the unit learning outcomes and relate to what you should be able to do after completing this unit. Your assignments could be in the form of:

- presentations
- practical tasks
- written assignments.



Gemma Stewart, a sports enthusiast

In this unit I learned that there are several systems that interact in a complex way to bring my body into action during sport and exercise.

As a keen sports participant it has helped me to appreciate and understand how my body works and I have been able to apply what I have learned to understanding my performance in sport and exercise. I particularly enjoyed exploring the different energy systems and those involved in the different sports I take part in.

The practical activities for this unit have given me a better understanding of the muscle groups worked by the exercises in my gym programme.

There is a lot of complex information to learn in understanding the principles of anatomy and physiology in sport.

Over to you

- **What aspects of the unit might you find most challenging?**
- **What preparation could you do to make the learning of these complex systems an easier task?**

1. Know the structure and function of the skeletal system



Warm-up

Analysis of sporting movements

In small groups, think of a range of sporting movements, for example, kicking a ball in rugby or football or shooting a goal in netball or basketball.

Identify the bones and muscles involved in these movements.

Discuss your findings to examine a wide range of sporting movements as a whole class.

1.1 Structure of the skeletal system

The skeletal system is made up of bones, cartilage and joints. Without bones, humans would be shapeless heaps of muscle and tissue, unable to get up off the floor. You need to know how the structure and function of the skeletal system contribute to the vast range of motion required to participate in sport.

Your skeleton provides a framework that supports your muscles and skin and protects your internal organs. It is made up of 206 bones, which are divided into two groups: 80 form your axial skeleton – the long axis of your body; the other 126 form your appendicular skeleton – the bones that are attached to this axis.

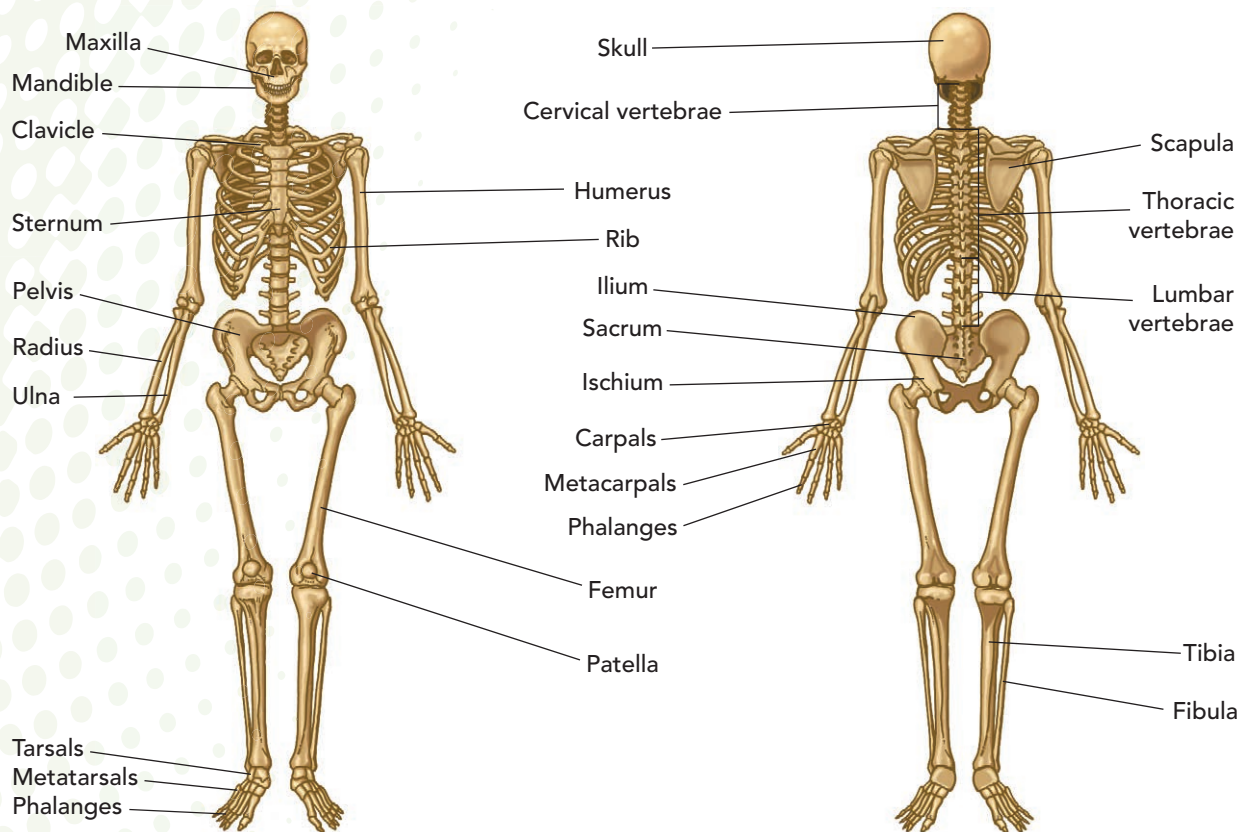


Figure 1.1: Bones of the human skeleton

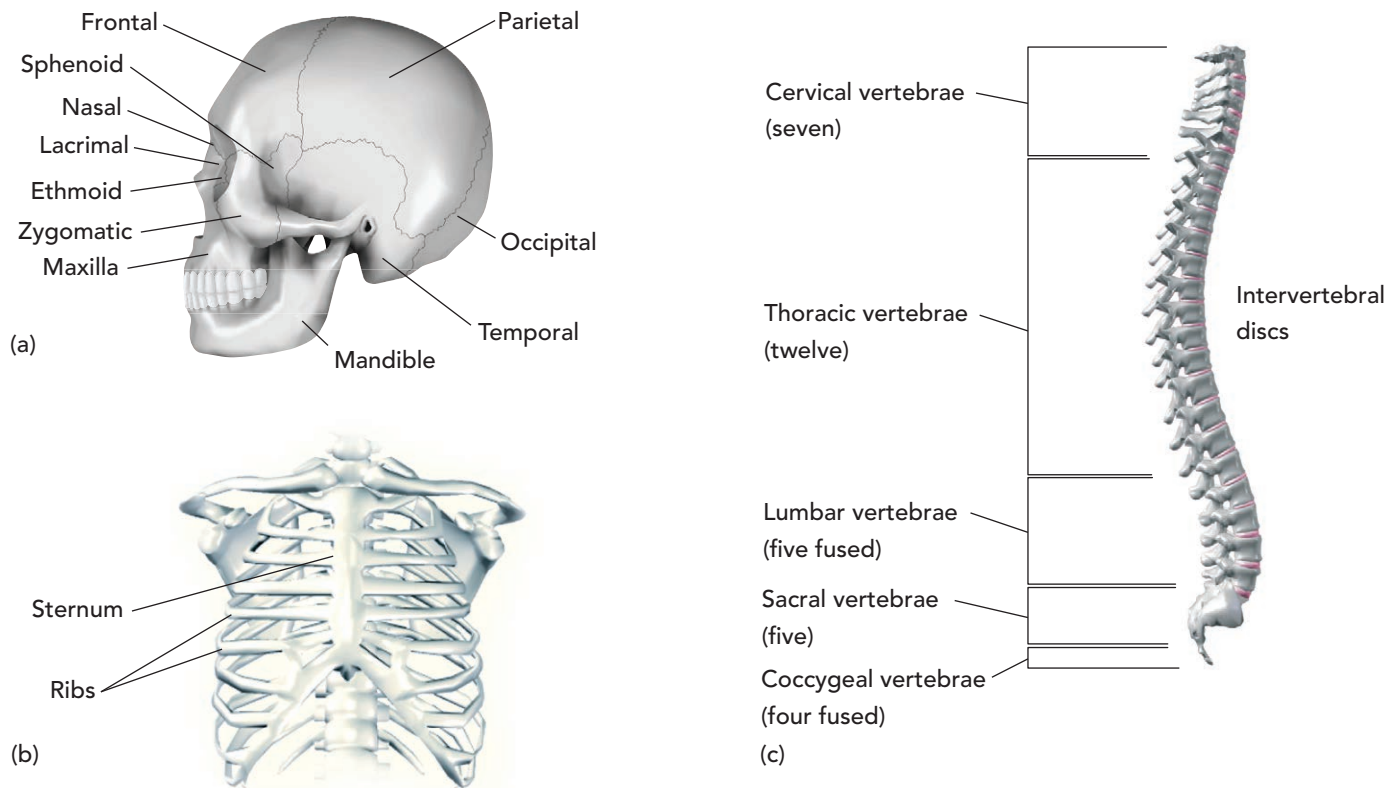


Figure 1.2: The axial skeleton: (a) the skull, (b) the thorax and (c) the vertebral column

Axial skeleton

This forms the main axis or core of your skeletal system and consists of the:

- skull (cranium and facial bones)
- thorax (sternum and ribs)
- vertebral column.

See Figure 1.2 above.

Appendicular skeleton

The appendicular skeleton consists of the following parts (see Figure 1.3 on page 6).

- 60 bones form the upper limbs. Each upper limb is made up of one humerus, one radius, one ulna, eight carpals, five metacarpals and fourteen phalanges.
- 60 bones form the lower limbs. Each lower limb is made up of one femur (thigh bone), one tibia (shin bone), one fibula, one patella (kneecap), seven tarsals, five metatarsals and fourteen phalanges.

These bones are designed for weight-bearing, locomotion and maintaining an upright posture. They need to have a higher degree of strength and stability than the bones of the upper limbs.

- The shoulder girdle consists of four bones – two clavicles and two scapulae – which connect the limbs of the upper body to the thorax.
- The pelvic girdle is made of three bones: the ilium, pubis and ischium. These fuse together with age and are collectively known as the innominate bone. The principal function of the pelvic girdle is to provide a solid base through which to transmit the weight of the upper body. It also provides attachment for the powerful muscles of the lower back and legs, and protects the digestive and reproductive organs.

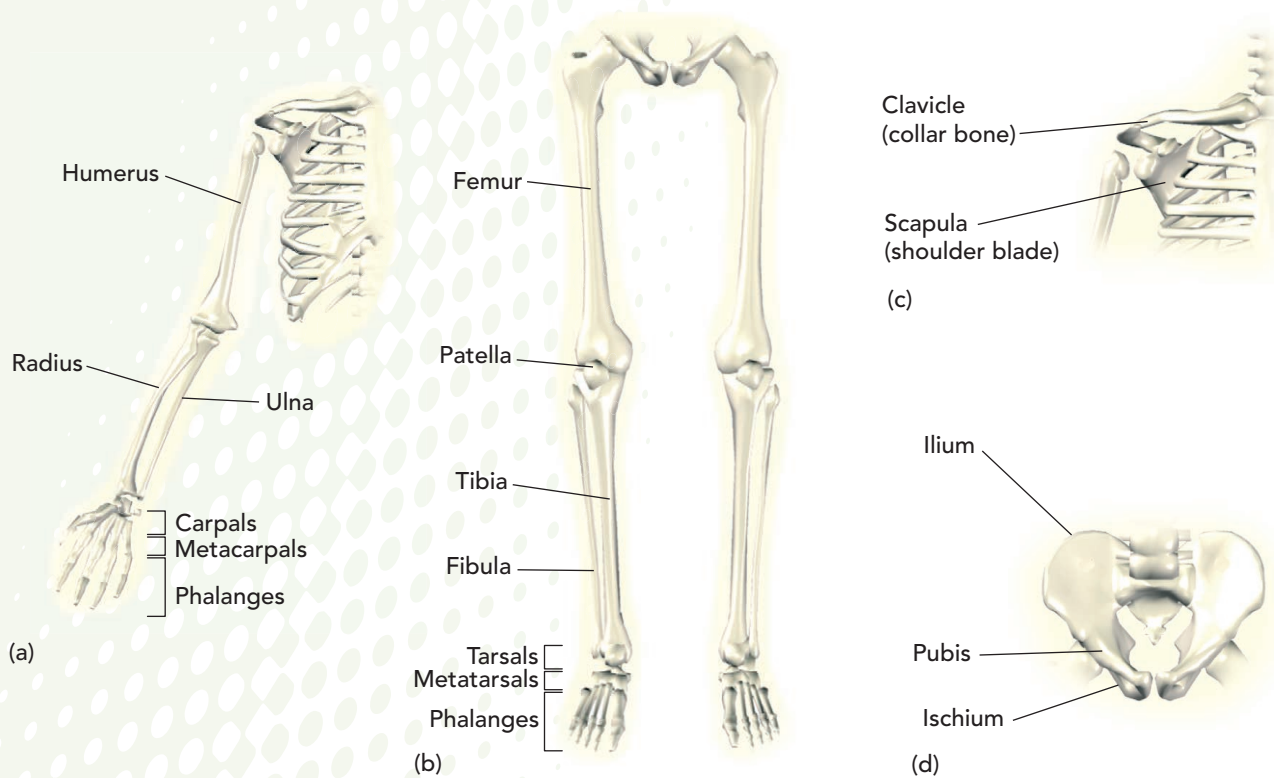


Figure 1.3: The appendicular skeleton: (a) the upper limbs, (b) the lower limbs, (c) the shoulder girdle and (d) the pelvis

Types of major bone

Bones vary in shape and size according to their location and function. They can be classified as follows:

- **Long bones** are found in the limbs. They have a shaft known as the diaphysis and two expanded ends known as the epiphysis (see Figure 1.4).
- **Short bones** are small, light, strong, cube-shaped bones consisting of cancellous bone surrounded by a thin layer of compact bone. The carpals and tarsals of the wrists and ankles are examples of short bones (see Figure 1.5).
- **Flat bones** are thin, flattened and slightly curved, and have a large surface area, examples include the scapulae, sternum and cranium (see Figure 1.6).
- **Sesamoid bones** have a specialised function. They are usually found within a tendon such as the patella in the knee.
- **Irregular bones** have complex shapes that fit none of the categories above. The bones of the spine are a good example (see Figure 1.7).

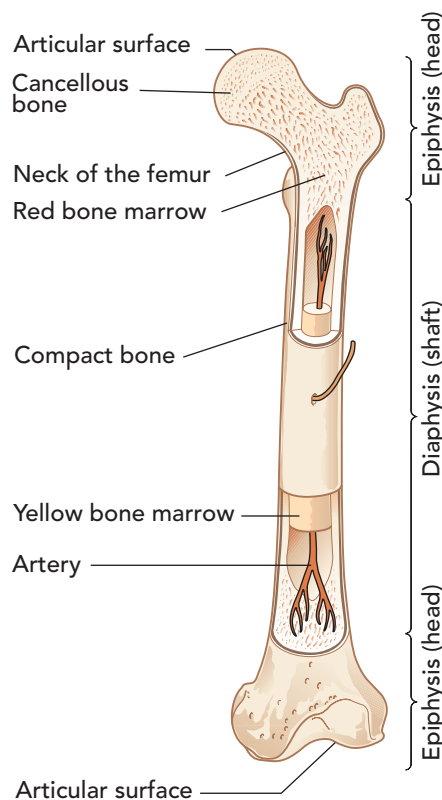


Figure 1.4: Long bones include the bones of the lower limbs, such as the femur, tibia and fibula

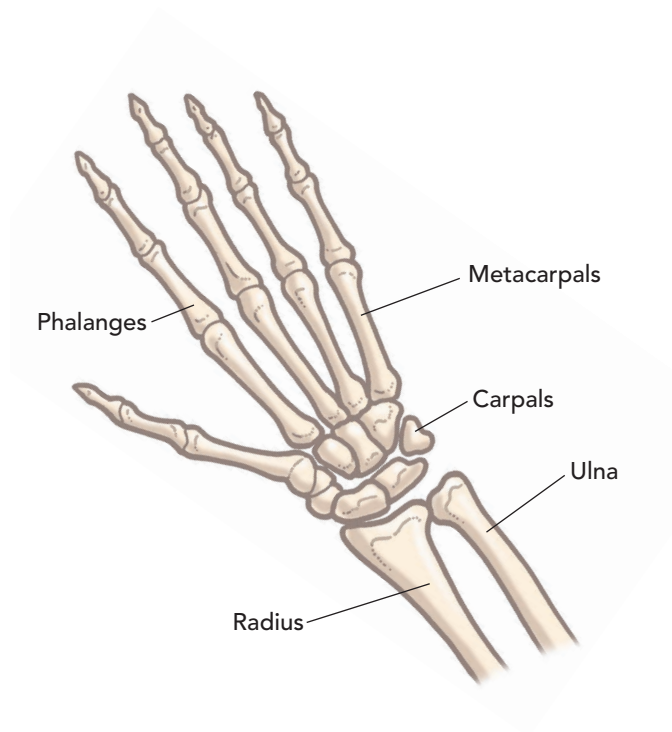


Figure 1.5: The carpals of the hand are examples of short bones

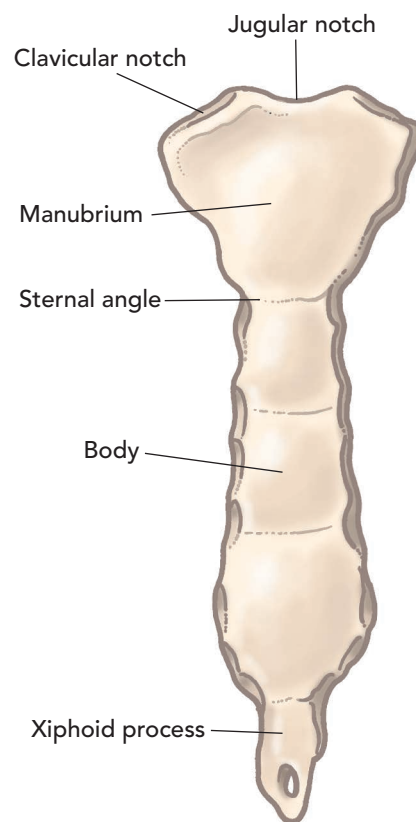


Figure 1.6: The sternum is an example of a flat bone

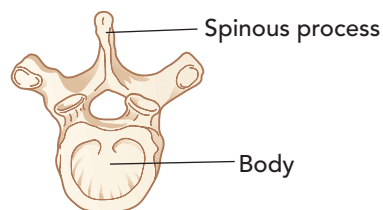


Figure 1.7: The vertebrae of the spine are examples of irregular bones

Location of major bones

Many terms are used to describe the position and location of anatomical structures; some are described in Table 1.1.

Term	Meaning
Anterior	To the front or in front
Posterior	To the rear or behind
Medial	Towards the midline
Lateral	Away from the midline
Proximal	Near to the root or origin
Distal	Away from the root or origin
Superior	Above
Inferior	Below

Table 1.1: Main anatomical terms

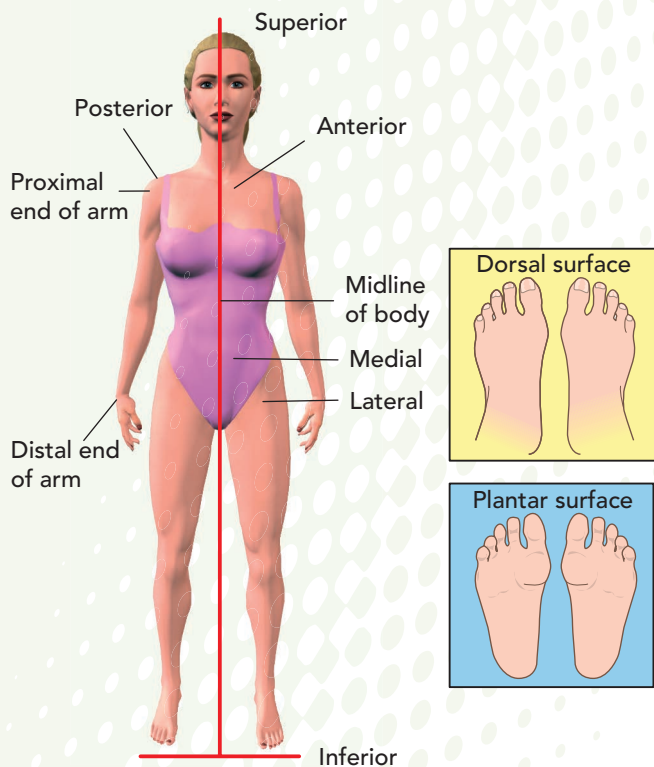


Figure 1.8: Anatomical positions

Cranium – a box-like cavity that contains and protects the brain. It consists of interlinking segments of bone that fuse together during the first few years of life.

Clavicles (collar bones) – the long, slim bones that form the anterior part of the shoulder girdle. This provides a strong and mobile attachment for the arms.

Ribs – long, flat bones. There are twelve pairs in all. The first seven are known as true ribs, as each is joined directly to the sternum. The remaining five pairs are known as false ribs.

Sternum (breast bone) – the elongated, flat bone that runs down the centre of the chest, from the base of the neck to the abdominal wall.

Humerus – the largest bone of the upper limbs. It is a long bone, the head of which articulates with the scapula to form the shoulder joint. The distal end **articulates** with the radius and ulna to form the elbow joint.

Key term

Articulation – the meeting of two or more bones.

Radius and ulna – the ulna is the longer of the two bones of the forearm. The ulna and radius articulate distally with the wrist. The convex shape of the radius allows it to move around the ulna to bring about pronation (turning) of the hand.

Scapulae (shoulder blades) – large, triangular, flat bones that form the posterior part of the shoulder girdle.

Ilium – the bony structure at the base of the spine that provides the sockets for the hip joints and supports the lower abdominal organs. There are three fused irregular pelvic bones collectively known as the innominate bone on each side of the pelvic girdle. The ilium is the upper and largest of these three bones. The upper edge of the ilium is known as the iliac crest.

Pubis (pubic bone) – forms the lower anterior part of the innominate bone.

Ischium – bone situated below the ilium that forms the lower posterior part of the innominate bone.

Carpals – the eight small bones that make up the wrist. They are irregular, small bones arranged in two rows of four. They fit closely together and are kept in place by ligaments.

Metacarpals – five long cylindrical bones in the palm of the hand, one corresponding to each digit. These run from the carpal bones of the wrist to the base of each digit in the hand.

Phalanges – the bones that make up the skeleton of the thumbs, fingers and toes. Most fingers and toes have three phalanges, but the thumbs and big toes have two. The phalanges at the tips of the fingers and toes are known as distal phalanges, whereas those that articulate with the bones of the hands and feet are called proximal phalanges.

Femur – the longest and strongest bone in the body. The head fits into the socket of the pelvis to form the hip joint; the lower end joins the tibia to form the knee joint.

Patella (kneecap) – the large, triangular sesamoid bone found in the quadriceps femoris tendon. It protects the knee joint.

Tibia and fibula – bones that form the long bones of the lower leg. The tibia is the inner and thicker bone, also known as the shin bone. The upper end of the tibia joins the femur to form the knee joint, while the lower end forms part of the ankle joint. The fibula is the outer, thinner bone of the lower leg; it does not reach the knee, but its lower end does form part of the ankle joint.

Tarsals – the foot and heel are formed from seven bones known collectively as the tarsals and often referred to as the midfoot and hindfoot. Along with the tibia and fibula, they form the ankle joint. They are short and irregular. The calcaneus, or heel bone, is the largest tarsal bone. It helps to support the weight of the body and provides attachment for the calf muscles via the Achilles tendon.

Metatarsals – five metatarsals form the dorsal surface of the foot, with 14 phalanges forming the toes. These collectively make up the forefoot. The base of each metatarsal articulates with one or more tarsal bones and the head of one phalange. The forefoot is responsible for bearing a great deal of weight and balances pressure through the balls of the feet. The metatarsals are a common site of fracture in sport.

Vertebral column

The vertebral column, also known as the spine or backbone, extends from the base of the cranium to the pelvis, providing a central axis for the body. It is made up of 33 irregular bones called vertebrae.

The vertebral column accounts for around 40 per cent of a person's overall height. The vertebrae are held together by powerful ligaments. These allow little movement between adjacent vertebrae, but afford a considerable degree of flexibility along the spine as a whole.

The vertebral column has many functions. It protects the spinal cord and supports the ribcage. The larger vertebrae of the lumbar region support a large amount of body weight. The flatter thoracic vertebrae offer attachment for the large muscles of the back and the curves of the spine – four in all. These, along with the intervertebral discs, receive and distribute impact associated with the dynamic functioning of the body in action, reducing shock.

Vertebrae

These increase in size from the top down, and can be classified as follows:

- cervical vertebrae (in the neck)
- thoracic vertebrae (in the chest region)
- lumbar vertebrae (in the small of the back)
- sacral vertebrae (fused vertebrae that form the sacrum)
- coccygeal vertebrae (fused vertebrae that form the coccyx).



The metatarsals are often broken by football players.

Can you think of other sports where common injuries occur?

There are 24 movable vertebrae in all, separated by intervertebral discs. These padded discs act as shock absorbers and give the vertebral column a degree of flexibility. The cervical and lumbar regions of the spine are the most vulnerable to injury as a result of sport and exercise.

Cervical – the vertebrae of the neck. The first two are known as the atlas (C1) and the axis (C2). They form a pivot joint that allows the head and neck to move freely. These are the smallest and most vulnerable vertebrae of the vertebral column.

Thoracic – the vertebrae of the mid-spine, which articulate with the ribs. They lie in the thorax, a dome-shaped structure that protects the heart and lungs.

Lumbar – the largest of the movable vertebrae, situated in the lower back. They support more weight than other vertebrae and provide attachment for many of the muscles of the back. The discs between these vertebrae produce a concave curve in the back.

Sacrum – five sacral vertebrae are fused to form the sacrum, a triangular bone located below the lumbar vertebrae. It forms the back wall of the pelvic girdle, sitting between the two hip bones. The upper part connects with the last lumbar vertebra and the bottom part with the coccyx.

Coccyx – at the bottom of the vertebral column there are four coccygeal vertebrae, which are fused to form the coccyx or tail bone.

1.2 Function of the skeletal system

Your skeleton performs a number of mechanical and physiological functions.

Support – collectively, your bones give your body shape and provide the supporting framework for the soft tissues of your body.

Protection – the bones of your skeleton surround and protect vital tissues and organs in your body. Your skull protects your brain, your heart and lungs are protected by your thorax, your vertebral column protects your delicate spinal cord and your pelvis protects your abdominal and reproductive organs.

Attachment for skeletal muscle – parts of your skeleton provide a surface for your skeletal muscles to attach to, allowing you to move. Tendons attach muscles to bone, which provides leverage. Muscles pulling on bones act as levers and movement occurs at the joints so that you can walk, run, jump, throw etc., but you should remember that the type of joint determines the type of movement possible.

Source of blood cell production – your bones are not completely solid, as this would make your skeleton heavy and difficult to move. Blood vessels feed the centre of your bones and stored within them is bone marrow. The marrow of your long bones is continually producing red and white blood cells. This is an essential function as large numbers of blood cells, particularly red cells, die every minute.

Store of minerals – bone is a reservoir for minerals such as calcium and phosphorus, essential for bone growth and the maintenance of bone health. These minerals are stored and released into the bloodstream as required, facilitating the balance of minerals in your body.

Joints

You have seen that your skeleton is made up of bones that support and protect your body. For movement to occur, the bones must be linked. A joint is formed where two or more bones meet. This is known as an articulation. There are three types of joint, classified according to the degree of movement they allow: fixed, slightly movable and synovial.

Fixed

Fixed joints, also known as fibrous or immovable joints, do not move. They interlock and overlap and are held together by bands of tough, fibrous tissue. An example is between the plates in your cranium.

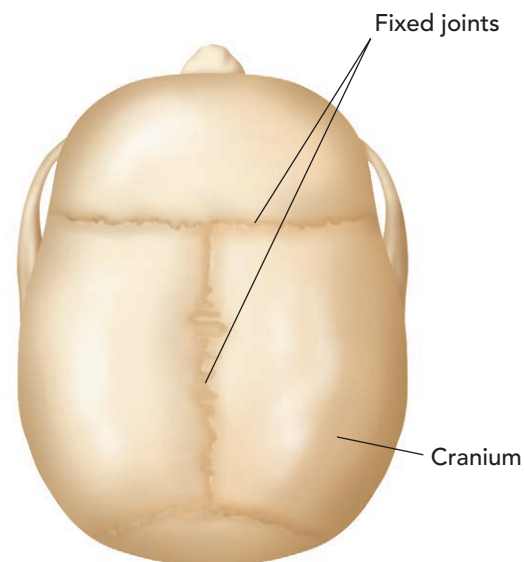


Figure 1.9: Fixed joints in the cranium

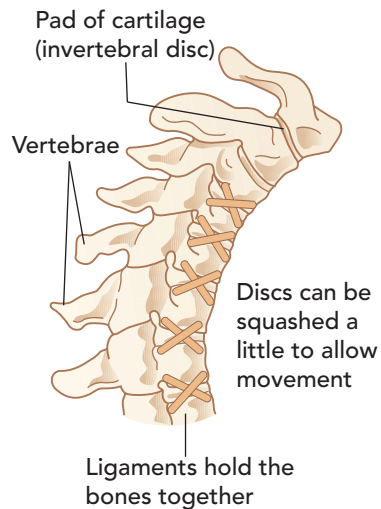


Figure 1.10: A slightly movable joint in the vertebral column

Slightly movable

Slightly movable or cartilaginous joints allow slight movement. The ends of the bone are covered in articular or hyaline cartilage (a smooth, shiny covering that reduces friction) which is separated by pads of white fibrocartilage (a tough cartilage that is capable of absorbing considerable loads). Slight movement at these articulating surfaces is made possible because the pads of cartilage compress, for example between most vertebrae (see Figure 1.10).

Synovial

Also termed freely movable, synovial joints offer the highest level of mobility at a joint. They consist of two or more bones, the ends of which are covered with articular cartilage, which allows the bones to move over each other with minimum friction. They make up most of the joints of your limbs. They are completely surrounded by a fibrous capsule, lined with a synovial membrane, whose purpose is to secrete fluid known as synovial fluid into the joint cavity to lubricate and nourish the joint. The joint capsule is held together by tough bands of connective tissue known as ligaments. This provides the strength to avoid dislocation, while being flexible enough to allow movement.

All synovial joints contain the following features:

- an outer sleeve or joint capsule to help to hold the bones in place and protect the joint

- a synovial membrane: the capsule lining that oozes a viscous liquid called synovial fluid: this lubricates the joint
- a joint cavity: the gap between the articulating bones where synovial fluid pools to lubricate the joint
- articular cartilage on the ends of the bones: to provide a smooth and slippery covering to stop the bones knocking or grinding together
- ligaments to hold the bones together and keep them in place.

Synovial joints can be divided into the following groups, according to the type of movement they allow.

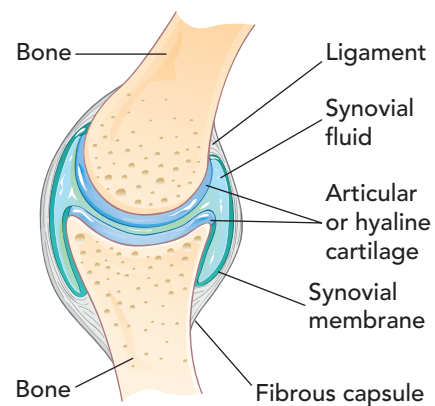


Figure 1.11: A synovial joint in the knee

Hinge

These allow movement in one direction only. Elbow and knee joints are typical examples.

Ball and socket

The round end of one bone fits into a cup-shaped socket in the other bone, allowing movement in all directions. Examples include hip and shoulder joints.

Ellipsoid

Also known as condyloid joints, these are a modified version of a ball and socket joint, in which a bump on one bone sits in the hollow formed by another. Movement is backwards and forwards and from side to side. Ligaments often prevent rotation. An example is the wrist joint.

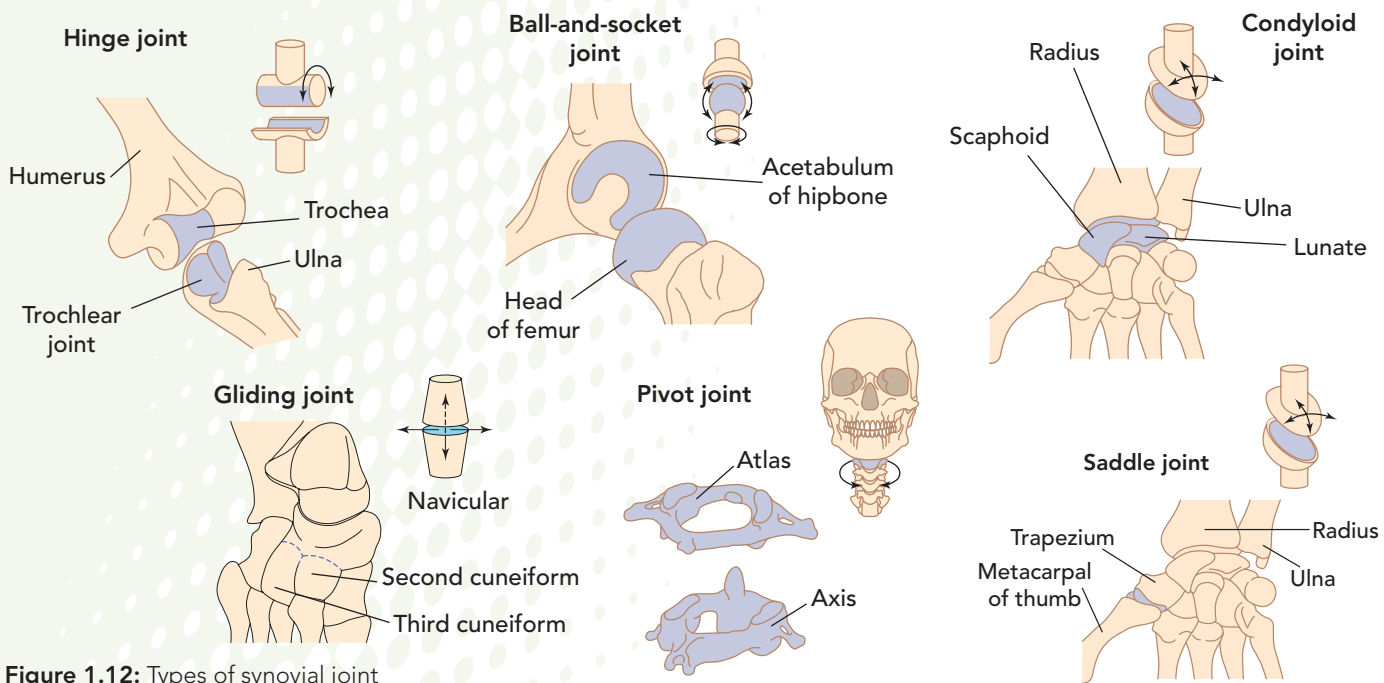


Figure 1.12: Types of synovial joint

Gliding

These joints allow movement over a flat surface in all directions, but this is restricted by ligaments or a bony prominence, for example in the carpals and tarsals of wrists and ankles.

Pivot

A ring of one bone fits over a peg of another, allowing controlled rotational movement, such as the joint of the atlas and axis in the neck.

Saddle

These are similar to ellipsoid joints but the surfaces are concave and convex. Movement occurs backwards and forwards and from side to side, like that at the base of the thumb.

Types of movement

When studying the body in action it is important to understand the range of movements that joints are capable of performing. The degree of movement at joints varies between individuals and depends on many factors, including: the shape and contour of the articulating surfaces, the tension of the supporting connective tissue and muscles that surround the joint, the amount of soft tissue surrounding the joint and the individual's age.

Flexion – bending a limb, reducing the angle at the joint, such as bending your arm in a bicep curl action or preparing to kick a football.

Extension – straightening a limb to increase the angle at the joint, such as straightening your arm to return to your starting position in a bicep curl action or taking a shot in netball.

Abduction – movement away from the body, such as at the hip in a side-step in gymnastics.

Adduction – movement towards the body, such as pulling on the oars while rowing.

Rotation – circular movement of a limb. Rotation occurs at the shoulder joint during a tennis serve.

Pronation – an inward rotation of the forearm so that the palm of the hand is facing backwards and downwards. This occurs at the wrist joint during a table tennis forehand topspin shot.

Supination – an outward rotation of the forearm so that the palm of the hand is facing forwards and upwards. This occurs at the wrist joint during a table tennis backhand topspin shot.

Plantar flexion – a movement that points the toes downwards by straightening the ankle. This occurs when jumping to shoot in basketball.

Dorsiflexion – an upward movement, as in moving the foot to pull the toes towards the knee in walking.

Hyper-extension – involves movement beyond the normal anatomical position in a direction opposite to flexion. This occurs at the spine when a cricketer arches his or her back when approaching the crease to bowl.

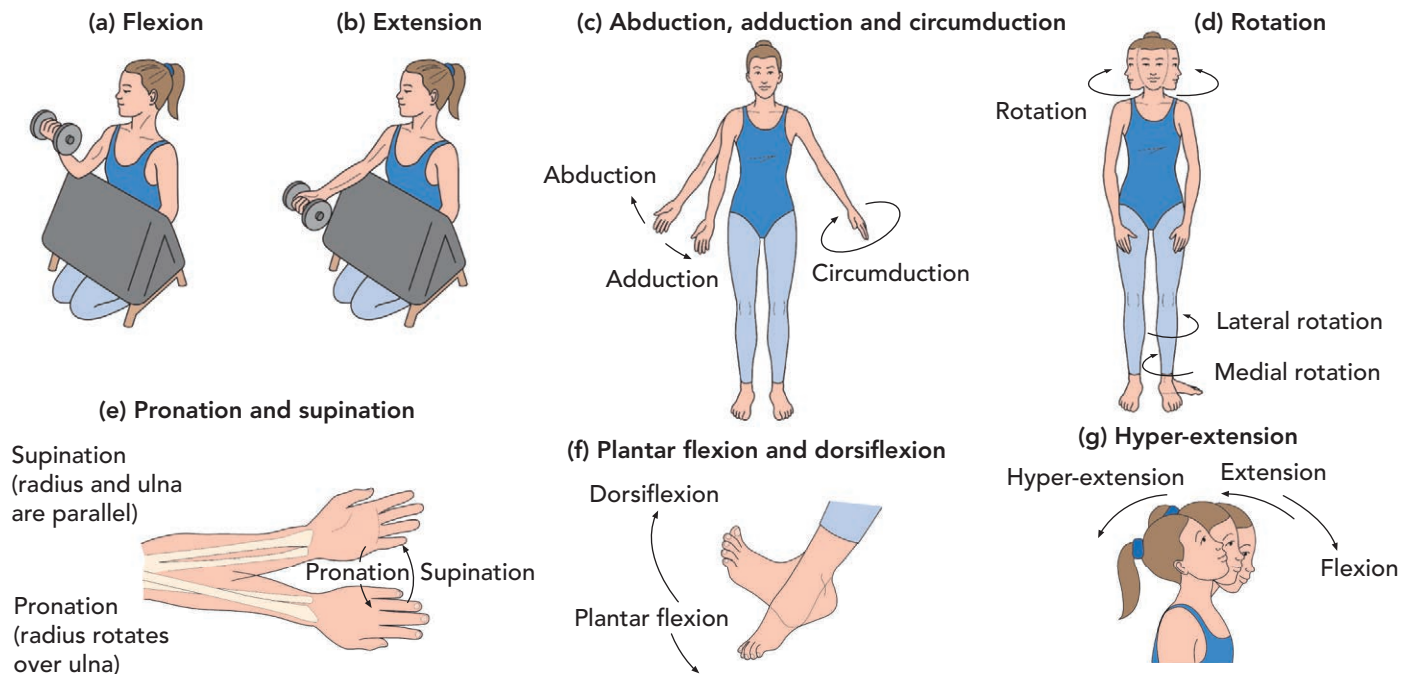


Figure 1.13: Anatomical and biomechanical terms relating to muscle action

Assessment activity 1.1

P1 P2

BTEC

A fitness instructor regularly draws on anatomical knowledge to design and develop fitness programmes for clients.

1. Draw two large tables to describe the structure and function of the axial and appendicular

skeletons. Your descriptions should include the location of all the major bones of the skeleton and their different types. **P1**

2. Describe the different classifications of joints and the range of movement each provides. **P2**

Grading tips

P1 Describe the axial and appendicular skeletons and locate and name all the following major bones: cranium, clavicle, ribs, sternum, humerus, radius, ulna, scapula, ilium, pubis, ischium, carpals, metacarpals, phalanges, femur, patella, tibia, fibula, tarsals, metatarsals, vertebral column, vertebrae – cervical, thoracic, lumbar, sacrum and coccyx.

P2 You must be able to describe all three classifications of joint and the movement available at each, including the movement allowed at each of the synovial joints. Examine each of the three classifications of joints, including all six synovial joints, and explain how and why the range of movement allowed at these joints differs. Use sporting examples to support your explanation.

PLTS

Researching the structure and function of the skeletal system and examining the range of movement at joints using a variety of sporting examples will evidence your development as an **independent enquirer**.



Functional skills

Describing the structure and function of the axial and appendicular skeletons and the different classifications of joints and their range of movement will demonstrate your **English** skills.



2. Know the structure and function of the muscular system

2.1 The muscular system

Approximately 40 per cent of your body mass is muscle, whose key function is to move your bones. The muscles that move your bones during activity are skeletal muscles. There are over 640 named muscles in the human body. In this section you will learn about the principal skeletal muscles, their associated actions, and muscle fibre types.

Your muscles are generously supplied with arteries to convey nutrients and oxygen, and veins to remove waste products. Your skeletal muscles work to move either parts of your body or your body as a whole. Most sporting movements involve the coordinated action of muscles rather than muscles working in isolation.

Major muscles

Remembering the names, locations and actions of all the major muscles is a huge task. Therefore, from a sport and exercise perspective, the main ones you should remember are outlined in Table 1.2 on page 15.

Remember

To bring your body into action, different parts of your muscular skeletal system work under the influence of your nervous system to produce voluntary movements. Your skeletal muscles contract when stimulated via impulses from your nervous system. At the point of contraction your muscles shorten and pull on the bones to which they are attached. When a muscle contracts, one end normally remains stationary while the other end is drawn towards it. The end that remains stationary is known as the **origin**, and the end that moves is called the **insertion**.

Key terms

Origin – the end of a muscle that is attached to the immovable (or less movable) bone.

Insertion – the end of a muscle that is attached to the movable bone.

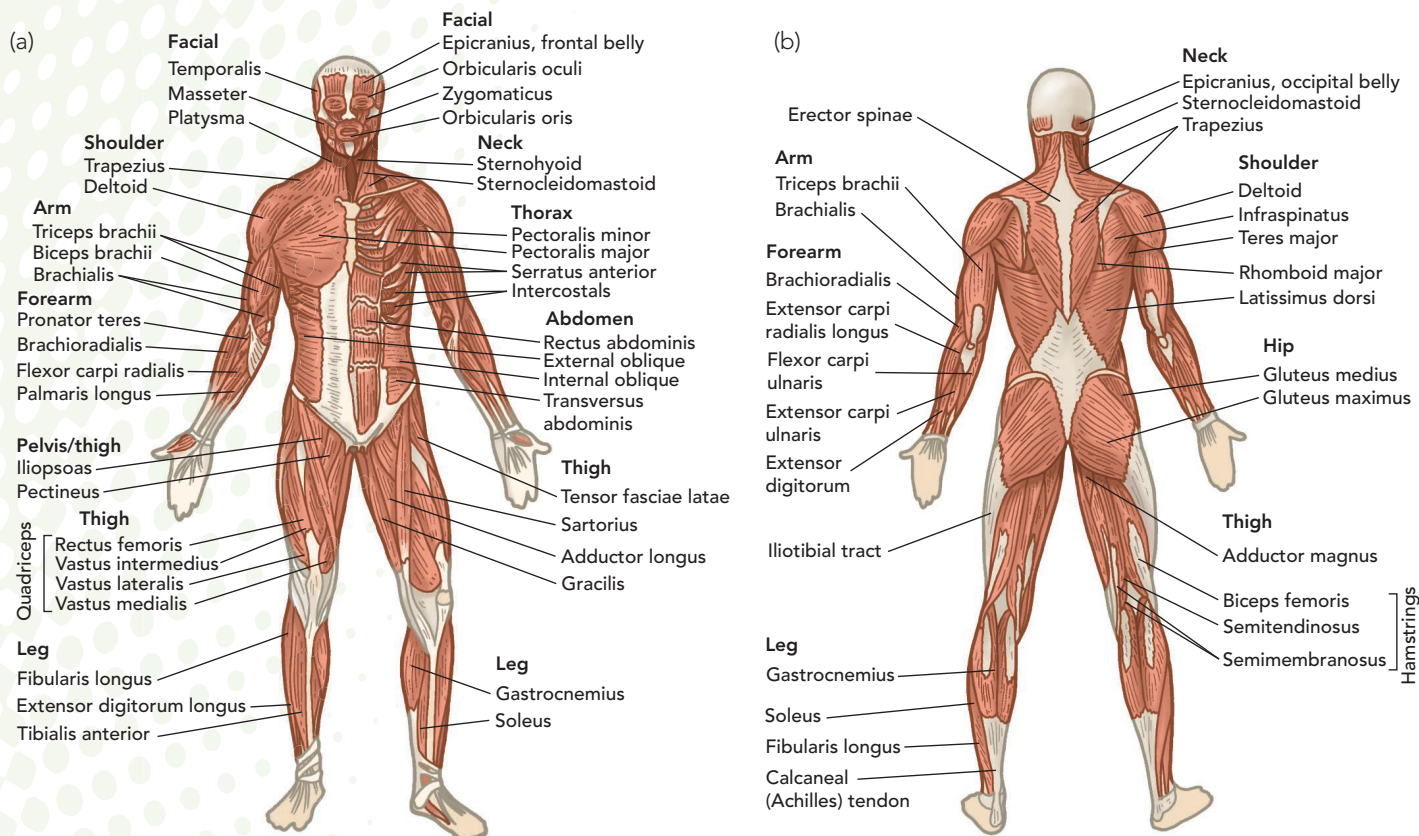


Figure 1.14: (a) Anterior muscular system and (b) posterior muscular system

Muscle	Function	Location	Origin	Insertion	Exercise/Activity
Biceps	Flexes lower arm	Inside upper arm	Scapula	Radius	Arm curls, chin-ups
Triceps	Extends lower arm	Outside upper arm	Humerus and scapula	Olecranon process	Press-ups, dips, overhead pressing
Deltoids	Abducts, flexes and extends upper arm	Forms cap of shoulder	Clavicle, scapula and acromion	Humerus	Forward, lateral and back-arm raises, overhead lifting
Pectorals	Flexes and adducts upper arm	Large chest muscle	Sternum, clavicle and rib cartilage	Humerus	All pressing movements
Rectus abdominis	Flexion and rotation of lumbar region of vertebral column	'Six-pack' muscle running down abdomen	Pubic crest and symphysis	Xiphoid process	Sit-ups
Quadriceps – rectus femoris – vastus lateralis – vastus medialis – vastus intermedius	Extends lower leg and flexes thigh	Front of thigh	Ilium and femur	Tibia and fibula	Knee bends, squats
Hamstrings – semimembranosus – semitendinosus – biceps femoris	Flexes lower leg and extends thigh	Back of thigh	Ischium and femur	Tibia and fibula	Extending leg and flexing knee (running)
Gastrocnemius	Plantar flexion, flexes knee	Large calf muscle	Femur	Calcaneus	Running, jumping and standing on tip-toe
Soleus	Plantar flexion	Deep to gastrocnemius	Fibula and tibia	Calcaneus	Running and jumping
Tibialis anterior	Dorsiflexion of foot	Front of tibia on lower leg	Lateral condyle	By tendon to surface of medial cuneiform	All running and jumping exercises
Erector spinae	Extension of spine	Long muscle running either side of spine	Cervical, thoracic and lumbar vertebrae	Cervical, thoracic and lumbar vertebrae	Prime mover of back extension
Teres major	Rotates and abducts humerus	Between scapula and humerus	Posterior surface of scapula	Intertubercular sulcus of humerus	All rowing and pulling movements
Trapezius	Elevates and depresses scapula	Large triangular muscle at top of back	Continuous insertion along acromion	Occipital bone and all thoracic vertebrae	Shrugging and overhead lifting
Latissimus dorsi	Extends and adducts lower arm	Large muscle covering back of lower ribs	Vertebrae and iliac crest	Humerus	Rowing movements
Obliques	Lateral flexion of trunk	Waist	Pubic crest and iliac crest	Fleshy strips to lower eight ribs	Oblique curls
Gluteus maximus	Extends thigh	Large muscle on buttocks	Ilium, sacrum and coccyx	Femur	Knee-bending movements, cycling

Table 1.2: Major muscles and their functions

Remember

- The **olecranon process** forms part of the elbow; located at the proximal end of the ulna.
- The **acromion** is the roughened triangular projection on top of the scapula.
- The **xiphoid process** forms the inferior (or sword-like) end of the sternum.
- The **pubic crest** is an inferior and anterior portion of the pelvis located next to the pubic arc.
- The **calcaneus** is the major portion of the heel bone.
- The **occipital bone** forms most of the skull's posterior wall and base.
- The **iliac crest** can be found when you rest your hands on your hips.

Remember

Tendons attach muscle to bone.
Ligaments attach bone to bone.

Types of muscle

There are three main types of muscle tissue in your body:

- **skeletal muscle** – also known as striated or striped muscle because of its striped appearance when viewed under a microscope. This type of muscle is voluntary, which means it is under conscious control.
- **smooth muscle** – an involuntary muscle that works without conscious thought, functioning under the control of your nervous system. It is located in the walls of your digestive system and blood vessels and helps to regulate digestion and blood pressure.
- **cardiac muscle** – found only in the wall of your heart. It works continuously. It is involuntary, which means it is not under conscious control. It is composed of a specialised type of striated tissue that has its own blood supply. Its contractions help to force blood through your blood vessels to all parts of your body. Each contraction and relaxation of your heart muscle as a whole represents one heartbeat.

Remember

Muscles only pull on your bones – they do not push.

2.2 Function of the muscular system

Muscles must cross the joints they move. When a muscle contracts, it exerts a pulling force on the bones, causing them to move together around the joint. The bones act like levers and the joint like the fulcrum. If a muscle did not cross a joint, no movement could occur.

Under normal circumstances, muscles are in a state of partial contraction, ready to react to a stimulus from your nervous system. Without this muscle tone, your body would collapse. When a stimulus from the nerve supply occurs, muscle fibres work on an 'all or nothing' basis – either contracting completely or not at all.

The strength of muscle contraction in response to the stimulus depends on the number of muscle fibres brought into use, a process known as muscle fibre recruitment. To bring about contraction, the muscle requires oxygen and a fuel source, either fat or glucose. Muscle cells use up much more energy than other cells in your body and convert chemical energy into mechanical energy. When you exercise, your muscles use energy at a rate that is directly proportional to the intensity of the exercise. If this energy is not replaced as it is used up, your muscles are unable to maintain their work rate and you have to reduce the intensity of the activity or stop it.

Antagonistic muscle pairs

Muscles do not work in isolation. They are assembled in groups and work together to bring about movement. They act only by contracting and pulling. They do not push, although they are able to contract without shortening, and so hold a joint firm and fixed in a certain position. When the contraction passes off, the muscles become soft but do not lengthen until stretched by the contraction of the opposing muscles. They can act in the following ways to bring about movement.

Activity: Muscles at work

When your body is in action during sport and exercise, your muscles shorten, remain the same length or lengthen.

1. Pick up a dumb-bell (or a bag of sugar or a heavy book). Bend your arm at the elbow to bring your forearm up towards your shoulder in a bicep curl action.
2. Think about what your bicep muscle appears to be doing as you bring the weight closer to your shoulder. Has the muscle shortened, remained the same length or lengthened?
3. Return the dumb-bell to the starting position and consider what has to happen to your muscle to allow this action to take place. Do you think the bicep shortened, remained the same length or lengthened?
4. Curl the arm again, but this time only to a 90° angle. Hold your object in this position for a sustained period of time. What does the bicep muscle appear to be doing now? Do you think it is shortening, remaining the same length or lengthening?



Agonist

The muscle that shortens to move a joint is called the agonist or prime mover. This is the muscle principally responsible for the movement taking place – the contracting muscle.

Antagonist

The muscle that relaxes in opposition to the agonist is called the antagonist. This is the muscle responsible for the opposite movement, and the one that relaxes as the agonist works. If it did not relax, movement could not take place. Antagonists exert a 'braking' control over the movement.

Synergist

Synergists are muscles that work together to enable the agonists to operate more effectively. They work with the agonists to control and direct movement by modifying or altering the direction of pull on the agonists to the most advantageous position.

Fixator

These muscles stop any unwanted movement throughout the whole body by fixing or stabilising the joint or joints involved. Fixator muscles stabilise the origin so that the agonist can achieve maximum and effective contraction.

Take a complex action like riding a bike: your quadriceps and calf muscles are the agonists, the contracting muscles. The antagonists are the muscles of your hamstrings and shins. Other leg muscles act as synergists and muscles of your back and abdomen act as fixators to stop you falling off.



Figure 1.15: Riding a bike involves a complex series of muscular movements

Remember

Each agonist must contract just sufficiently, and each antagonist must relax equally to allow movement to take place smoothly without jerking. This concerted action of many muscles is called muscle coordination.



Types of contraction

Muscle contraction can be described as isometric, concentric, eccentric or isokinetic.

Isometric

During an isometric contraction the length of a muscle does not change and the joint angle does not alter. The muscle is actively engaged in holding a static position, for example when stopping halfway up in a press-up or squat, or holding an abdominal plank position. This type of muscle work is easy to undertake but rapidly leads to fatigue. It can cause sharp increases in blood pressure as blood flow is reduced. See Figure 1.16.

Concentric

This occurs when a muscle shortens against a resistance, for example in a bicep curl. The brachialis and bicep shorten, bringing your forearm towards your upper arm. Concentric contractions are sometimes known as the positive phase of muscle contraction. See Figure 1.17.

Eccentric

This occurs when a muscle returns to its normal length after shortening against resistance. Using the bicep curl as an example, this is the controlled lowering of your arm to its starting position. At this point your muscles are working against gravity and act like a braking mechanism. This contraction can be easier to perform, but it does produce muscle soreness. Eccentric contractions occur in many sporting and daily activities. Walking downstairs and running downhill involve eccentric contraction of your quadriceps muscles. Eccentric contraction can be a significant factor in the stimulus that promotes gains in muscle strength and size. Eccentric contractions are sometimes known as the negative phase of muscle contraction.

Isokinetic

During isokinetic contractions the muscle contracts and shortens at a constant speed. For this type of strength training you need specialised equipment that detects when the muscle is speeding up and can increase the load.



Figure 1.16: The rings in men's gymnastics demonstrate many isometric contractions



Figure 1.17: In a concentric contraction the muscle shortens

Activity: Movement and resistance

1. Lie on your back with both knees bent and both feet on the floor in a curl-up position. Place your hands on your thighs and slowly raise your head and shoulders, sliding your hands up your thighs until they touch your knees. Slowly return to the floor. Repeat this action six to eight times.
 - a) Consider the type of movement you have just performed. What forms the resistance for this activity?
 - b) There are two phases to this movement. Which phase can be described as the positive phase?
 - c) Which joints and muscles are involved in this movement?
2. Hold a set of light dumb-bells or two small books at your sides. Keeping your elbows slightly bent but the arms long, with the palms facing downwards, raise your arms until your hands are at eye level. Slowly return the weights under control to your sides. Repeat this action six to eight times.
3. Consider the type of movement you have just performed. What forms the resistance for this activity?
4. Name the muscle groups targeted by this exercise. Are any other muscles working to bring about this movement?

Take it further

Health and fitness equipment targets specific muscle groups. Visit your local leisure centre or health club to analyse its fitness equipment. Draw up a table of your findings to include information on:

- the range of equipment available
- the muscle groups targeted by each piece of equipment and the actions they bring about.

Fibre types

All skeletal muscles contain a mixture of fibre types. The mix of fibres varies from individual to individual, and within the individual from muscle group to muscle group. To a large extent this fibre mix is inherited. However, training can influence the efficiency of these different fibre types. Two main types of striated skeletal muscle can be distinguished on the basis of their speed of contraction: Type 1 (slow twitch) and Type 2 (fast twitch).

Characteristics of Type 1 muscle fibres

Type 1 (slow-twitch) fibres contract slowly with less force. They are slow to fatigue and suited to longer duration **aerobic** activities. They have a rich blood supply and contain many mitochondria to sustain aerobic metabolism. Type 1 fibres have a high capacity for aerobic respiration. They are recruited for lower-intensity, longer-duration activities such as long-distance running and swimming.

Characteristics of Type 2a muscle fibres

Type 2a fibres (also called fast-twitch or fast-oxidative fibres) are fast-contracting and able to produce a great force, but are also resistant to fatigue. These fibres are suited to middle-distance events.

Characteristics of Type 2b muscle fibres

Type 2b fibres (also called fast-twitch or fast-glycolytic fibres) contract rapidly and have the capacity to produce large amounts of force, but they fatigue more readily, making them better suited to **anaerobic** activity. They depend almost entirely on anaerobic

metabolism and are recruited for higher-intensity, shorter-duration activities. They are important in sports that include many stop-go or change-of-pace activities.

Key terms

Aerobic – requiring oxygen.

Anaerobic – not requiring oxygen.

Case study: Peter, athletic sprinter

Peter is a member of his college's athletics sprint team. Before a race he spends some time warming up: he walks around the start area, shakes his arms and legs, and does a few strides and stretches. The starter calls the athletes to the line. Peter settles into his starting blocks, the starter announces the set position and Peter waits for the gun to sound. When it fires, he bursts out of the blocks and runs as hard as he can all the way through the tape, recording a 100 metres personal best time.

- What muscle fibres were creating the force required while Peter was walking around the start area?
- During the entire warm-up, were all muscle fibres recruited acting maximally?
- When Peter burst out of the blocks and sprinted towards the finish line, which muscle fibres were recruited?

Sports associated with each fibre type

All types of muscle fibre are used in all types of activity. Although Type 1 fibres are particularly adapted to low-intensity aerobic endurance work, they are generally employed at the beginning of exercise, regardless of the intensity of effort. Type 2 fibres adapt to high-intensity anaerobic exercise involving explosive or powerful movements, but are increasingly employed as fatigue sets in during low-intensity endurance work. Table 1.3 identifies the sports associated with the different fibre types.

Characteristic of muscle fibre types	Type 1	Type 2a	Type 2b
Colour	Red	Red	White
Contraction speed	Contract slowly	Contract rapidly (but not as fast as Type 2b)	Contract rapidly
Aerobic or anaerobic	Aerobic	Aerobic	Anaerobic
Type of activity	Endurance-based	Middle-distance	Speed- and strength-based
Endurance	Can contract repeatedly	Fairly resistant to fatigue	Easily exhausted
Force	Exert minimal force	Exert medium force	Exert great force
Type of sports associated with each fibre type	Endurance sports such as running, cycling, swimming, skiing	Middle-distance running such as 800 m and 1500 m	Explosive sports such as sprinting, jumping, throwing, weightlifting

Table 1.3: Characteristics of each muscle fibre type and sports associated with each fibre type

Assessment activity 1.2

P3 P4 M1 D1

BTEC

Continuing the theme from Assessment activity 1.1, design and develop a general fitness programme for a client that targets all of the major muscle groups outlined in this unit.

1. Write up the programme on client-friendly programme cards, identifying the location of the muscle groups exercised in the programme. **P3**
2. In a short written account, describe the function of the muscular system and the different types of muscle fibre. **P4**
3. Produce a short PowerPoint presentation to further explain the function of the muscular system and the different fibre types. **M1**
4. Develop your presentation further to analyse the function of the muscular system and the different fibre types. **D1**

Grading tips

- P3** Make sure you identify the location of the biceps, triceps, deltoids, pectorals, rectus abdominis, quadriceps, hamstrings, gastrocnemius, soleus, tibialis anterior, erector spinae, teres major, trapezius, latissimus dorsi, obliques and gluteus maximus.
- P4** You must be able to describe the function of the muscular system and the three different fibre types (Type 1, Type 2a and Type 2b).
- M1** You must be able to explain the function of the muscular system and the three different fibre types (Type 1, Type 2a and Type 2b). Use sporting examples to support your explanations.
- D1** Analysing requires you to take a more critical approach to your presentation. You may find it useful to undertake some practical research to support your answer.

PLTS

When you locate the muscle groups exercised in the fitness programme, you will be using your skills as a **reflective learner**.



Functional skills

When you develop and write the fitness programme and also write a short account on the function of the muscular system, you will be demonstrating **English** skills.

Creating a PowerPoint presentation will demonstrate your **ICT** skills.

