INQUIRY QUESTION
How do bones and joints assist movement in sprinting?
The skeletal and muscular systems work together to produce movement in physical activity, and one cannot function without the other. The different bones and joints have a number of functions and work together with muscles, creating the various anatomical movements.

**KEY KNOWLEDGE**
- The structure and function of the skeletal system including bones of the human body, classification of joints and joint actions

**KEY SKILLS**
- Use and apply correct anatomical terminology to the working of the musculoskeletal system in producing human movement
- Perform, observe and analyse a variety of movements used in physical activity, sport and exercise to explain the interaction between bones, muscles, joints and joint actions responsible for movement

**CHAPTER PREVIEW**

The skeletal and muscular systems work together to produce movement in physical activity, and one cannot function without the other. The different bones and joints have a number of functions and work together with muscles, creating the various anatomical movements.
The skeletal system is an essential body system for physical activity. It provides the framework for muscles to attach to so that movement can occur. It also interacts with other body systems providing protection, mineral storage and a site for blood cell formation.

The musculoskeletal system is made up of the skeletal system (bones, joints, ligaments and tendons) and muscular system (muscles). The skeletal system is made up of 206 bones and encompasses all of the bones, every joint and corresponding ligaments.

Functions of the skeletal system
The skeletal system has five main functions in bodily health:
- body movement (the most important function to understand in physical education)
- framework
- protection
- mineral storage
- production of red blood cells.

Body movement
The human body has 206 bones, all of which provide sites for muscle attachment. The bones act as levers and work with the muscular system to create movement. When a muscle contracts, it pulls on the bone to which it is attached and thus movement occurs. Any irregularity on a bone’s surface provides a possible site for a muscle attachment. Figure 2.1 illustrates the sites for the triceps muscle attachments.

**FIGURE 2.1** Bones offer ready attachments for muscle tendons.
Framework and protection

The skeleton provides a solid framework for the body and helps battle the forces of gravity. Everyone has a solid skeleton, but the differences in people’s posture indicate the interdependence of the skeletal and muscular systems in maintaining correct posture.

The strong protective skeletal layer provides protection for many vital body organs. This is particularly evident when the rib cage is examined (figure 2.2). This naturally enclosing shell effectively protects the heart and lungs from all but the most traumatic of injuries.

There are two main types of bone tissue:
- Compact bone, which is found in the shaft or diaphysis of the long bone. This comparatively solid bone surrounds the cavity of the long bone (figure 2.3), offering an extremely strong structure that gives the body its rigid framework. Collagen is a central ingredient in providing compact bone rigidity and tensile strength (as it is with cancellous bone). In some ways the skeleton is stronger and more durable than concrete.
- Cancellous bone (also described as spongy bone, being less dense than compact bone), which provides some of the shock absorption required at the end of long bones or at the edges of more irregular bones.

Mineral storage

Bone tissue efficiently stores a number of minerals that are important for health. Calcium, phosphorus, sodium and potassium all contribute to the health and maintenance of bone tissue as well as carrying out other roles in the body. Calcium also assists with muscular activity.

Calcium is a mineral found mainly in the hard part of bones and is essential for healthy bones. It is also important for muscle contraction, nerve transmission, enzyme activity and blood clotting.
Production of red blood cells

Essential production of new red blood cells occurs within the cavity of long bones. Production levels are high during growth years, diminishing as age increases and the need for high rates of red blood cells decreases. Such cells are essential for oxygen transportation throughout the body. Haemoglobin, a protein inside red blood cells, transports oxygen molecules from the lungs to the body. Much of an adult's bone cavity is filled with yellow bone marrow, which is a source of long-term energy (figure 2.3).

Major bones of the skeletal system

The major bones of the skeletal system are shown in figure 2.4.
Types of bones

There are five types of bones in the human body, distinguished by their shape.

1. Short bones (figure 2.5a) are roughly cubical, with the same width and length; for example, the carpals of the wrist and the tarsals of the foot.
2. Long bones (figure 2.5b) are longer than they are wide, and they have a hollow shaft containing marrow (figure 2.3); for example, femur, phalanges and humerus.
3. Sesamoid bones (figure 2.5c) are small bones developed in tendons around some joints; for example, the patella at the knee joint.
4. Flat bones (figure 2.5d) provide flat areas for muscle attachment and usually enclose cavities for protecting organs; for example, scapula, ribs, sternum and skull.
5. Irregular bones (figure 2.5e) have no regular shape characteristics; for example, vertebrae and bones of the face.

**Figure 2.5** Examples of bone types: (a) short bones, (b) a long bone, (c) a sesamoid bone, (d) a flat bone, (e) an irregular bone
The vertebral column (also called the spine) provides the central structure for the maintenance of good posture. If a person maintains the correct levels of strength and flexibility in all the muscle groups that connect with the vertebral column, then they are likely to avoid postural problems.

The vertebral column has some special features:

- Each vertebra has a hollow centre through which travels the spinal cord that controls most conscious movement within the body. In this way the cord is protected (figure 2.5e).
- The vertebrae increase in size as they descend from the cervical to the lumbar region (figure 2.6). This helps them support the weight of the body.
- Movement between two vertebrae is very limited. But the range of movement of the vertebral column as a whole is great, allowing bending and twisting.
- Intervertebral discs separate each of the vertebrae in the cervical, thoracic and lumbar regions. They absorb shock caused by movement and allow the vertebral column to bend and twist.

**FIGURE 2.6** Side view of the vertebral column showing the five main sections

**Bone growth and health**

Epiphyseal plates, also known as growth plates, are the centres for bone growth. Found at the ends of the diaphysis or shaft of the long bone, these plates are visible under x-ray and may be damaged in injury. The rate of growth of a leg, for example, may diminish if the leg is broken during growth years. However, following injury repair, the leg's rate of growth will usually accelerate until the legs are again growing equally. The majority of bone growth occurs during infancy and adolescence and has usually stopped by early adulthood.
TEST your understanding

1 Using the correct anatomical terminology, analyse the movement depicted in the image at the start of this chapter on page 12 by:
   (a) identifying the bones and joints utilised in this sprinting activity
   (b) identifying the joint actions required in the sprinting activity responsible for movement.

2 Download the 'Skeleton' document from your eBookPLUS. Label the major bones of the skeleton.

3 Discuss the five main functions of the skeletal system.

4 The function of some bones is to provide protection for vital organs. Identify these bones and the vital organs they protect.

5 Identify and describe the two types of bone tissue.

6 List the five types of bones in the skeletal system and provide one example of each.

7 Identify the bones that form each of the following joints:
   (a) shoulder
   (b) elbow
   (c) hip
   (d) knee
   (e) ankle.

8 Revise what you know about the vertebral column.
   (a) List the five main sections of the vertebral column.
   (b) Identify how many vertebrae are in each section.
   (c) Describe how the vertebrae change along the length of the vertebral column.
   (d) Provide some possible reasons for this change.
   (e) List the main functions of the vertebral column.

9 Copy and complete the table below.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Anatomical name</th>
<th>Type of bone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shin bone</td>
<td>Tibia</td>
<td>Long</td>
</tr>
<tr>
<td>Jaw</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breast bone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder blade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip bone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collar bone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thigh bone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee cap</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ankle bones</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

APPLY your understanding

10 Practical activity: participate in a game of tennis
   (a) Identify all the skills/movements required in the activity you have participated in.
   (b) For each skill/movement, list the bones responsible for helping to create that movement.
**2.2 Joint classification and structure and anatomical movements**

**KEY CONCEPT** A joint is the intersection of two or more bones. Joints and their actions are essential for human movement as movement occurs via muscles crossing joints, attaching to bones and pulling on them to allow contractions to occur.

**Classification of joints**

The skeleton has three major joint types. These joints are classified by how the bones are joined together and by the movement that each joint permits:

- **Fibrous (immoveable) joints** offer no movement. Examples include the skull (figure 2.7), pelvis, sacrum and sternum.
- **Cartilaginous (slightly moveable) joints** are joined by cartilage and allow small movements. Examples include the vertebrae (figure 2.8) and where the ribs join the sternum.
- **Synovial (freely moveable) joints** offer a full range of movement and move freely in at least one direction. Examples include the knee or shoulder (figure 2.11 on page 22).

**Connective tissue**

Connective tissue plays an important role in the function of both the skeletal and muscular systems. It is classed as soft tissue because it does not have the rigidity of bone whereas it does have the flexibility of soft tissue along with the strength that collagen provides.

**Cartilage**

- **Cartilage** is a smooth, slightly elastic tissue found in various forms within the body:
  - hyaline cartilage coats the ends of the bones in synovial joints
  - discs of cartilage separate the vertebrae of the spine (figure 2.8)
  - the ribs attach to the sternum via cartilage
  - the hard part of the ear and the tip of the nose are also cartilage.

**Ligaments**

- **Ligaments** cross over joints, joining bone to bone. Their slight elasticity allows small movement from the bones of the joint. The main function of ligaments is to provide stability at the joint, preventing dislocation (figure 2.9). If ligaments are seriously damaged in an accident, they may not be able to repair themselves and may require surgery.
**Tendons**

Tendons are inelastic and very strong, allowing movement by helping muscles pull through the joint and on the bones. The biceps muscle (figure 2.10) is an example of a muscle that works through two joints. It has two tendinous origins at the scapula (allowing the humerus to flex away from the body), and the tendinous insertion into the radius in the forearm allows the forearm to flex upwards towards the humerus.

**Synovial joints**

Synovial joints are the joints of most interest to physical activity as they are directly involved in producing skilled movement. They are classified by a number of qualities (figure 2.11):
- free movement in at least one direction
- cartilage that offers protection and cushioning at the ends of bones and reduces friction
The human body in motion

Joint classification and structure and anatomical movements

- ligaments that secure bones in place and allow controlled ranges of movement
- enclosure by a joint capsule (a layer of tissue that surrounds the joint and provides stability in the joint by holding it together)
- a synovial membrane that lines the inside of the joint capsule and secretes synovial fluid, promoting lubricated movement by the joint.

**Types of synovial joints**

There are six types of synovial joints (figure 2.12). These joints are classified by the shape of the bones that articulate at the joint as well as the amount and type of movement possible at each joint.

**Six types of synovial joints**

- **Pivot joint**: Where one bone rotates about another (rotation), e.g. atlas/axis in neck, radius and ulna in forearm
- **Carpal bone**
- **Metacarpal bone**
- **Radius**
- **Ulna**
- **Humerus**

- **Saddle joint**: Allows movement in two directions (sideways, backwards/forwards), e.g. thumb
- **Ball and socket joint**: Allows a wide range of movement (sideways, backwards/forwards, rotation), e.g. hip, shoulder
- **Condyloid joint**: Allows movement in two directions (backwards/forwards, sideways), e.g. wrist
- **Gliding joint**: Allows only gliding or sliding movements (sideways, backwards/forwards), e.g. carpals of the wrist, tarsals of the ankle
- **Hinge joint**: Allows movement in only one direction (backwards/forwards), e.g. elbow, knee

**Figure 2.11** Basic structure of a synovial joint

**Figure 2.12** Six types of synovial joints

**Ebookplus**

Video
- Animation of joint movements
- Searchlight ID: eles-2578

**Weblink**
- Six types of synovial joints
**Anatomical position, terms of reference and movements**

**Anatomical position and terms of reference**

When discussing synovial joints and the movements they create, it is also important to understand the anatomical position and common terms of reference. The anatomical position is defined as standing erect, facing forward with arms by the side and palms facing forward. The terms of reference shown in table 2.1 help to describe where a body part is in relation to another body part. For example, the patella is located on the anterior (front) aspect of the body.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superior</td>
<td>Towards the head or upper part of the body</td>
<td>The cranium is superior to the sternum.</td>
</tr>
<tr>
<td>Inferior</td>
<td>Towards the feet or lower part of the body</td>
<td>The tarsals are inferior to the femur.</td>
</tr>
<tr>
<td>Anterior</td>
<td>Towards the front of the body</td>
<td>The patella is on the anterior side of the body.</td>
</tr>
<tr>
<td>Posterior</td>
<td>Towards the back of the body</td>
<td>The scapula is posterior to the sternum.</td>
</tr>
<tr>
<td>Medial</td>
<td>Towards the midline of the body</td>
<td>The sternum is medial to the rib cage.</td>
</tr>
</tbody>
</table>

(continued)
### TABLE 2.1 Continued

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral</td>
<td>Towards the outer side of the body</td>
<td>The fibula is lateral to the tibia.</td>
</tr>
<tr>
<td>Proximal</td>
<td>Closer to the trunk of the body</td>
<td>The femur is proximal to the patella.</td>
</tr>
<tr>
<td>Distal</td>
<td>Further away from the trunk of the body</td>
<td>The phalanges are distal to the humerus.</td>
</tr>
<tr>
<td>Superficial</td>
<td>Towards the surface of the body</td>
<td>The rib cage is superficial to the heart.</td>
</tr>
<tr>
<td>Deep</td>
<td>Towards the inner part of the body</td>
<td>The liver is deep to the skin.</td>
</tr>
<tr>
<td>Prone</td>
<td>Face down</td>
<td>Lying on the stomach</td>
</tr>
<tr>
<td>Supine</td>
<td>Face up</td>
<td>Lying on the back</td>
</tr>
</tbody>
</table>
**Anatomical movements**

A variety of movements can occur at synovial joints. These are called anatomical movements, and there is a specific term to describe each movement (table 2.2).

### Table 2.2 Terms for anatomical movements in various activities

<table>
<thead>
<tr>
<th>Anatomical movement</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>Decrease in the angle of the joint</td>
<td>Bending the elbow or knee</td>
</tr>
<tr>
<td>Extension</td>
<td>Increase in the angle of the joint</td>
<td>Straightening the elbow or knee</td>
</tr>
<tr>
<td>Abduction</td>
<td>Movement of a body part away from the midline of the body</td>
<td>Lifting arm out to side (out phase of star jump)</td>
</tr>
<tr>
<td>Adduction</td>
<td>Movement of a body part back towards the midline of the body</td>
<td>Returning arm into body or towards midline of the body</td>
</tr>
<tr>
<td>Circumduction</td>
<td>Movement of the end of the bone in a circular motion</td>
<td>Drawing a circle in the air with straight arm</td>
</tr>
<tr>
<td>Rotation</td>
<td>Movement of a body part around a central axis</td>
<td>Turning head from side to side</td>
</tr>
</tbody>
</table>

(continued)
### TABLE 2.2 Continued

<table>
<thead>
<tr>
<th>Anatomical movement</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pronation</td>
<td>Rotation of the hand so that the thumb moves in towards the body</td>
<td>Palm facing down</td>
</tr>
<tr>
<td>Supination</td>
<td>Rotation of the hand so that the thumb moves away from the body</td>
<td>Palm facing up</td>
</tr>
<tr>
<td>Eversion</td>
<td>Movement of the sole of the foot away from the midline</td>
<td>Twisting ankle out</td>
</tr>
<tr>
<td>Inversion</td>
<td>Movement of the sole of the foot towards the midline</td>
<td>Twisting ankle in</td>
</tr>
<tr>
<td>Dorsi flexion</td>
<td>Decrease in the angle of the joint between the foot and lower leg</td>
<td>Raising toes upwards</td>
</tr>
<tr>
<td>Plantar flexion</td>
<td>Increase in the angle of the joint between the foot and the lower leg</td>
<td>Pointing toes to the ground</td>
</tr>
<tr>
<td>Elevation</td>
<td>Movement of the shoulders towards the head</td>
<td>Shrugging shoulders</td>
</tr>
<tr>
<td>Depression</td>
<td>Movement of the shoulders away from the head</td>
<td>Returning shoulders to normal position</td>
</tr>
</tbody>
</table>
TEST your understanding

1. Discuss the three joint types and provide an example of each.
2. Outline the common features of synovial joints. Draw a picture to illustrate.
3. Copy and complete the table below in relation to synovial joints.

<table>
<thead>
<tr>
<th>Joint</th>
<th>Type of synovial joint</th>
<th>Anatomical movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elbow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wrist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ankle</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Describe the anatomical position.
5. Using your knowledge of the anatomical terms of reference, select the correct option in relation to the bones of the human body.
   (a) The skull is (superior/inferior) to the sternum.
   (b) The scapula is found on the (anterior/posterior) side of the body.
   (c) Carpals are found at the (proximal/distal) end of the arm.
   (d) The fibula is on the (medial/lateral) side of the body.
   (e) A situp is performed in the (prone/supine) position.

APPLY your understanding

6. Practical activity: Conduct the following activities and identify and define the anatomical movement that is taking place.
   (a) The knee when kicking a football
   (b) The arm when performing a star jump
   (c) The shoulder during an underarm pitch
   (d) The shoulders during a volleyball dig

7. Practical activity: For each of the anatomical movements listed in table 2.2, demonstrate a sporting example that illustrates the movement.

8. Practical activity: participating in a team sport such as netball or touch football
   (a) List all the skills required to complete the activity successfully.
   (b) For each skill, identify:
      (i) the joints used and the type of each joint
      (ii) the anatomical movement performed.
KEY SKILLS

- Use and apply correct anatomical terminology to the working of the musculoskeletal system in producing human movement
- Perform, observe and analyse a variety of movements used in physical activity, sport and exercise to explain the interaction between bones, muscles, joints and joint actions responsible for movement

UNDERSTANDING THE KEY SKILLS

To address these key skills, it is important to remember the following:

- correct anatomical names for the major bones in the body
- understand how joints are classified
- understand, identify and explain the various types anatomical movements.

PRACTICE QUESTION

By referring to types of joints and anatomical movements, discuss the similarities and differences of the elbow and the shoulder joints (4 marks).

Sample response

The elbow and shoulder joints are similar as they are both freely moveable and classified as synovial joints. The differences are shown with the types of synovial joints and anatomical movements as the hinge joint (elbow) only allows movement in one direction, flexion and extension, whereas the ball and socket (shoulder) joint allows a range of movements such as flexion, extension, abduction, adduction and rotation.

PRACTISE THE KEY SKILLS

1. Compare the gliding joint and condyloid joint.
2. State the name and type of bone in the:
   a. lower leg
   b. forearm.
3. Name the bones, joints and movements required to produce the body action of jumping.

KEY SKILLS EXAM PRACTICE

Complete the following table on types of synovial joints and anatomical movements.

<table>
<thead>
<tr>
<th>Joint</th>
<th>Type of synovial joint</th>
<th>Anatomical movement/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder</td>
<td>Hinge</td>
<td>Flexion, extension</td>
</tr>
<tr>
<td>Elbow</td>
<td></td>
<td>Flexion, extension</td>
</tr>
<tr>
<td>Ankle</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4 marks

CHAPTER REVIEW

CHAPTER SUMMARY

Skeletal system

- The skeletal system has five main functions:
  - body movement
  - framework
  - protection
  - mineral storage
  - production of red blood cells.
- Bones act as levers and work with the muscular system to create movement.
- There are five types of bones: long bones, short bones, flat bones, irregular bones and sesamoid bones.
- The vertebral column provides the central structure for the maintenance of good posture.
Joints and anatomical movements

- The major joint types within the skeleton are:
  - fibrous (immoveable)
  - cartilaginous (slightly moveable)
  - synovial (freely moveable).

- Connective tissue includes cartilage, ligaments and tendons.

- Synovial joints are classified into six main types via the shape of the bones they articulate and the movements they allow:
  - ball and socket
  - hinge
  - pivot
  - saddle
  - gliding
  - condyloid.

- The anatomical position is standing erect, facing forward with arms by the sides and palms facing forward. Terms of reference help to describe where a body part is in relation to another body part.

- Anatomical movements include flexion, extension, abduction, adduction, circumduction, rotation, pronation, supination, eversion, inversion, dorsi flexion, plantar flexion, elevation and depression.

MULTIPLE CHOICE QUESTIONS

1. From inferior to superior, the curvatures of the spine are the
   (A) cervical, thoracic, lumbar, sacral, coccyx.
   (B) coccyx, sacral, lumbar, thoracic, cervical.
   (C) sacral, coccyx, lumbar, cervical, thoracic.
   (D) cervical, thoracic, sacral, lumbar, coccyx.

2. The humerus joins with the radius and ulna to form a
   (A) saddle joint.
   (B) pivot joint.
   (C) gliding joint.
   (D) hinge joint.

3. Bones are attached to each other by
   (A) ligaments.
   (B) muscle.
   (C) joints.
   (D) cartilage.

4. Muscles are attached to bones by
   (A) ligaments.
   (B) tendons.
   (C) connective tissue.
   (D) joints.

5. Pushups are done in which position?
   (A) Supine
   (B) Lateral
   (C) Superior
   (D) Prone

6. The movement that causes the angle of the joint to decrease is
   (A) abduction.
   (B) flexion.
   (C) extension.
   (D) adduction.

7. The five main functions of the skeletal system are
   (A) production of white blood cells, body movement, mineral storage, framework and protection.
   (B) production of white blood cells, body movement, mineral production, framework and protection.
   (C) production of blood cells, body posture, mineral production, framework and protection.
   (D) production of red blood cells, body movement, mineral storage, framework and protection.

8. The tarsals of the foot are examples of a
   (A) long bone.
   (B) flat bone.
   (C) short bone.
   (D) sesamoid bone.
9 The two main types of bone tissue are
(A) hard bone and spongy bone.
(B) collagen bone and compact bone.
(C) compact bone and cancellous bone.
(D) spongy bone and solid bone.

10 The skeleton has three major joint types. They are classified as
(A) fibrous (freely movable), cartilaginous (slightly moveable) and synovial (immovable).
(B) fibrous (slightly movable), cartilaginous (freely moveable) and synovial (immovable).
(C) fibrous (immovable), cartilaginous (slightly moveable) and synovial (freely moveable).
(D) fibrous (freely movable), cartilaginous (immovable) and synovial (slightly moveable).

EXAM QUESTIONS

Question 1

a. Name the anatomical movement responsible for raising the athlete up from the floor to the position shown in the picture. 1 mark
b. Describe the type of anatomical movement required to raise the athlete up from the floor to the position shown in the picture. 1 mark

Question 2

Discuss one function of the skeletal system. 2 marks

Question 3

a. Describe the action of the elbow joint when the weight is lowered. 1 mark
b. List the bones in the upper and lower arm that are involved in this movement. 2 marks
Question 4
State the types of bones in the knee joint and upper leg.  
2 marks

Question 5
Use the diagram below of the skeletal system to answer the following questions.

**a.** Circle clearly and label an example of each of the following joint types.  
4 marks

i. saddle
ii. hinge
iii. ball and socket
iv. gliding

**b.** Select two of the above joint types and using arrows and words describe the types of movements possible at each joint.  
2 marks

Joint type 1: 
Movements possible: 
Joint type 2: 
Movements possible: 