1.1 The Structure and Functions of the Musculo-Skeletal System

Teacher Answer Booklet
<table>
<thead>
<tr>
<th>Topic</th>
<th>Description from Specification</th>
<th>Pupil comments – How confident do you feel on this topic?</th>
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<tbody>
<tr>
<td>1.1.1</td>
<td>The functions of the skeleton applied to performance in physical activities and sports: protection of vital organs, muscle attachment, joints for movement, platelets, red and white blood cell production, storage of calcium and phosphorus</td>
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<tr>
<td>1.1.2</td>
<td>Classification of bones: long (leverage), short (weight bearing), flat (protection, broad surface for muscle attachment), irregular (protection and muscle attachment) applied to performance in physical activities and sports</td>
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<tr>
<td>1.1.3</td>
<td>Structure: cranium, clavicle, scapula, five regions of the vertebral column (cervical, thoracic, lumbar, sacrum, coccyx), ribs, sternum, humerus, radius, ulna, carpals, metacarpals, phalanges (in the hand), pelvis, femur, patella, tibia, fibula, tarsals, metatarsals, phalanges (in the foot), and their classification and use applied to performance in physical activities and sports</td>
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<tr>
<td>1.1.4</td>
<td>Classification of joints: pivot (neck – atlas and axis), hinge (elbow, knee and ankle), ball and socket (hip and shoulder), condyloid (wrist), and their impact on the range of possible movements</td>
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<td>1.1.5</td>
<td>Movement possibilities at joints dependant on joint classification: flexion, extension, adduction, abduction, rotation, circumduction, plantar-flexion, dorsi-flexion and examples of physical activity and sporting skills and techniques that utilise these movements in different sporting contexts</td>
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<tr>
<td>1.1.6</td>
<td>The role of ligaments and tendons, and their relevance to participation in physical activity and sport</td>
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<tr>
<td>1.1.7</td>
<td>Classification and characteristics of muscle types: voluntary muscles of the skeletal system, involuntary muscles in blood vessels, cardiac muscle forming the heart, and their roles when participating in physical activity and sport</td>
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<td>1.1.8</td>
<td>Location and role of the voluntary muscular system to work with the skeleton to bring about specific movement during physical activity and sport, and the specific function of each muscle (deltoid, biceps, triceps, pectoralis major, latissimus dorsi, external obliques, hip flexors, gluteus maximus, quadriceps, hamstrings, gastrocnemius and tibialis anterior)</td>
<td></td>
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<tr>
<td>1.1.9</td>
<td>Antagonistic pairs of muscles (agonist and antagonist) to create opposing movement at joints to allow physical activities (e.g. gastrocnemius and tibialis anterior acting at the ankle -plantar flexion to dorsi flexion; and quadriceps and hamstrings acting at the knee, biceps and triceps acting at the elbow, and hip flexors and gluteus maximus acting at the hip – all flexion to extension)</td>
<td></td>
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<tr>
<td>1.1.10</td>
<td>Characteristics of fast and slow twitch muscle fibre types (type I, type IIa and type IIx) and how this impacts on their use in physical activities</td>
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</tbody>
</table>
What is the musculo-skeletal system?

The muscles of the body and the bones of the body and how they interact and work together.

What are the four main functions of the musculo-skeletal system?

Useful Anagram

M Movement
S Stability
P Posture
P Protection

How do each of these functions help you in a sport that you take part in?

Example for football:

1. Movement- The muscles pull on the bones to allow movement to take place at a joint. The quadriceps muscle allows you to shoot the ball with power during a football match.

2. Stability- The Musculo-skeletal system helps to control your body and remain balanced. If you are dribbling at pace down the wing it is important to remain balanced and stay on your feet.

3. Posture- The Musculo-skeletal system enables you to hold your body with the correct alignment in a position. Good posture will be required when trying to head the ball powerfully towards the goal.

4. Protection- The Musculo-skeletal system protects the vital organs such as the heart and lungs. A clash of heads can often occur in football. Therefore it is important the cranium protects the brain.
The Functions of the Skeleton for Sport

The bones which make up your skeleton help to protect your vital organs, give your muscles somewhere to attach and create joints so that you can move effectively.

The five main functions of the skeleton are:

- Protection of Vital Organs
- Muscle Attachment
- Joints for Movement
- Storing Calcium and Phosphorus
- Red and White Blood Cell Production

How does Courtney Lawes’s skeleton help him to function as a rugby player? Use the above reasons to help you.

As a professional rugby player, Courtney Lawes’s skeleton plays an important role in his performance. All five functions of the skeleton are crucial to enable him to perform at his optimal level.

Lawes’s flat bones protect his vital organs, especially when involved in a tackle. His cranium would protect his brain, whilst his clavicle and ribs play a role in protecting his heart and lungs.

Lawes’s skeleton helps him to function as a rugby player through movement. Joints allow movement and rotation to take place. For example, the picture above shows Lawes carrying the ball. For this movement to occur, he would experience movement from the hinge joint at the knee. Muscles also play an important role when wanting to create movement. Muscles are attached to the bones via tendons. For a particular movement to occur; for example carrying the ball whilst running, the muscles would need to pull on the bones.

An essential function of the skeleton for Lawes is the storage of calcium and phosphorus. These minerals play a vital role in maintaining strong and healthy bones. This is important for a rugby player. Having strong bones minimises the chance of a fracture during contact in a ruck or a tackle.

The last function of the skeleton that is important to Lawes is the production of red and white blood cells. Rugby is a physically demanding sport. As rugby players are constantly training their cardiovascular system, the bone marrow responds to the needs of the activity and creates more red blood cells in the long term. This is important for a rugby player who needs to be able to perform aerobically for 80 minutes.
Which one of the five main functions of the skeleton are most important to you in your sport?

As a gymnast, joints for movement is the most important function of the skeleton. Gymnastics involves a range of fine and gross movements that requires the body to move in a variety of directions. For example, when performing a back flick, the ball and socket joint at the shoulder plays a vital role in the execution of the skill.

**Bone Growth and Development**

All bones are formed from **cartilage**, except the clavicle (collarbone) and some parts of the cranium (skull). Bone growth begins in the centre of the bone, so growth goes both upwards and downwards. Cartilage remains around the bone until growth is complete. The process from cartilage to bone is known as **ossification**.

If ossification doesn’t take place effectively in a child, how might they experience weakness?

Ossification is the process of development from cartilage to bone. If it does not take place effectively, a child would be small and quite weak. When they take part in sport, they might find that their soft, low density bones fracture easily due to the impact.
The Structure of the Skeletal System

- Mandible
- Clavicle
- Humerus
- Sternum
- Ribs
- Pelvis
- Femur
- Patella
- Tarsals
- Metatarsals
- Phalanges
- Radius
- Ulna
- Maxilla
- Phalanges
## Classification of Bones

<table>
<thead>
<tr>
<th>Type of Bone</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Bones</td>
<td>Longer than they are wide  &lt;br&gt;Has a shaft plus two ends  &lt;br&gt;Includes fibula, radius and phalanges</td>
</tr>
<tr>
<td>Short Bones</td>
<td>Roughly same size in length, width and thickness  &lt;br&gt;Includes the carpals and tarsals</td>
</tr>
<tr>
<td>Flat Bones</td>
<td>Protect vital organs  &lt;br&gt;Include patella, cranium, sternum and clavicle  &lt;br&gt;Offer a good surface for muscles to attach to</td>
</tr>
<tr>
<td>Irregular Bones</td>
<td>Have odd shapes and perform a range of functions  &lt;br&gt;Include the vertebrae</td>
</tr>
</tbody>
</table>

Pick out the features below and place them with the correct type of bone.

- ‘Roughly same size in length, width & thickness’
- ‘Include the carpals and the tarsals’
- ‘Protect vital organs’  ‘Longer than they are wide’
- ‘Have odd shapes and perform a range of functions’
- ‘Include patella, cranium, sternum and clavicle’
- ‘Has a shaft plus two ends’
- ‘Includes the vertebrae’  ‘Include fibula, radius and phalanges’
- ‘Offer a good surface for muscles to attach to’
Describe how a diver’s flat bones can help protect their organs during a dive?

When a diver enters the water, their flat bones protect their vital organs. For example, their cranium would protect their brain and their clavicle, sternum and ribs would protect their heart and lungs against the impact of the water.

The Vertebral Column:

Useful Mneumonic

Test a partner on the five groups of the vertebral column.
**Joints:**

A joint is a place where two or more bones meet. Joints are important for movement and rotation.

**Pivot Joints** allow bones to rotate. You have three pivot joints in your body: in your wrist, elbow and neck.

How does a badminton player use a pivot joint during a match?

When a badminton player turns their head to look at the shuttlecock in the air, they use the pivot joint in the neck.

**Hinge Joints** allow only backward and forward motion, just like the hinge on a door. There are three hinge joints; the knee, elbow and ankle.

Give an example of how a footballer might use a hinge joint?

A footballer bends their lower leg at the knee (flexion) then straightens it (extension) to kick the ball.

**Ball and Socket Joints** are when a long bone fit into a cup shaped hole, allowing circumduction. The shoulder and hip joints are examples.

Name two sports whereby a ball and socket joint is important.

**Tennis** – from the shoulder – when serving

**Cricket** – from the shoulder – when bowling the ball

**A Condyloid joint** allows circular motion but doesn’t allow full circumduction. The wrist is a condyloid joint.

How might a cricket player make use of a condyloid joint?

When a cricketer bowls the ball he could add spin to it using the condyloid joint at the wrist. This would involve him twisting the wrist.
Joints and Movement:

Joints are what make it possible to move our body in certain ways. Each type of joint allows for a different type of movement.

1. Flexion: Movement decreasing the angle between body parts (bending).
2. Extension: Movement increasing the angle between body parts (straightening).
3. Dorsi-Flexion: Flexing the toes so that they move closer to the shin
4. Plantar-Flexion: Extending the toes down, away from the shin
5. Adduction: Movement of a body part toward the body's midline
6. Abduction: Movement of a body part away from the body's midline
7. Rotation: the action of rotating around an axis or centre.

Useful Hint:

ADDuction = add to the body
Abduction = Take Away

Useful Hint:

PLANTar-Flexion = Plant your toes on the ground
What type of movements result in the following sporting actions?

Kicking a ball in football - flexion to extension (knee)

Serving in tennis - flexion, extension, abduction, adduction, rotation, circumduction (shoulder)

Hand Stand – flexion (wrist), extension (elbow) and rotation (at the shoulder)

Ten Pin Bowling - flexion to extension (elbow) abduction to adduction and rotation (shoulder)

Bowling a cricket ball- flexion, extension, abduction, adduction, rotation, circumduction (shoulder) dorsi-flexion (ankle)

Performing a bicep curl – flexion to extension (elbow)

‘Pointe’ in Ballet (standing on toes) plantar- flexion (ankle) extension (knee)

Performing a squat- flexion to extension (knee) flexion to extension (hip)

Forehand shot in Table Tennis – flexion (elbow) abduction to adduction (shoulder)

Useful Hint:

Think about different exercises that you can perform in the gym. What type of movement does each exercise require?
The clean and jerk is a technique used in weightlifting. Explain the action of movement present at the knee joint at the start and finish of the lift.

As the weight lifter bends down to lift the weight, the hamstrings contract to cause flexion at the knee. As the weight is lifted the quadriceps contract to cause extension at the knee.

The images above show the stages involved in bowling a ball in cricket. Explain the action of movement present at the shoulder in order to bowl a cricket ball.

Initially, the arm must extend from the shoulder in order to reach up to its highest point. The arm must then show circumduction from the shoulder in order to rotate 360 degrees and bowl the ball.
The image above shows a forehand shot in tennis. Explain the actions of movement present at the shoulder joint during the preparation and follow through of the shot.

As the player prepares the shot he must use abduction to take his arm away from the mid-line of his body. As he then hits the ball he must show adduction in order to follow through and generate power.

The image above shows a person performing a calf raise exercise. Explain the action of movement present at the ankle joint in order to complete this exercise.

The ankle must show plantarflexion in order to raise up onto the balls of the feet and perform the calf raise.
Ligaments and Tendons:

Ligaments and tendons are both strong fibrous tissue.

Ligament = Elastic fibre that join bone to bone

Tendon = Non-elastic fibre joining muscle to bone

Task:

Damaging ligaments and tendons is very common in sport and can be a very serious injury. Research three sports people who have suffered from such injuries. State how exactly the injury occurred, how long the person was sidelinened for and how the person treated the injury to aid recovery.

Example answer: Kurt Zouma (CFC) landed awkwardly on his leg after an aerial tackle. Due to the positioning of his landing foot, Zouma had a lack of support which caused hyperextension at the right knee. This lead to him tearing his anterior cruciate ligament (ACL) in his right knee. This is one of the crucial ligaments that connects the femur to the tibia. At the site of the injury, Zouma would have received first aid training to reduce the swelling and the pain through the use of ice, elevation and compression. He then would have used a splint or crutches for a few days, before going through a rehabilitation stage of strengthening and mobility exercises. Usual recovery time for this type of injury is between 6 months to a year, occasionally resulting in a reconstructive surgery. Luckily this was not the case for Zouma. After five months, he started training again.
**Muscle Types:**

How many muscles can you name which you can voluntarily control?

Deltoids, biceps, triceps, latissimus dorsi, pectoralis major, external obliques. Hip flexors, gluteals, hamstrings, quadriceps gastrocnemius, tibialis anterior

Can you name any muscles which you cannot voluntarily control?

Diaphragm and Intercostal muscles

**Voluntary Muscles** – Muscles which are under your control. You can choose when to **contract** or **relax** them. All of these muscles are attached to the skeleton by **Tendons**. They are therefore also known as **skeletal** muscles

**Involuntary Muscles** – Are not under your control. They **contract** and **relax** automatically. Involuntary muscles can be found in your circulatory, digestive and urinary systems. The involuntary muscles in your **stomach** help to digest food.

**Cardiac Muscle** – Is only found in the wall of the **heart**. Cardiac muscle is a type of **involuntary** muscle as we cannot control when it contracts or relaxes. When you **exercise** the cardiac muscles in your heart help to **pump** blood around the body faster.

<table>
<thead>
<tr>
<th>Fill the following words into the gaps left above:</th>
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</thead>
<tbody>
<tr>
<td>Tendons</td>
</tr>
<tr>
<td>Control</td>
</tr>
<tr>
<td>Digestive</td>
</tr>
<tr>
<td>Exercise</td>
</tr>
</tbody>
</table>
Voluntary Muscles of the Body:

Antagonistic Muscle Pairs:

- Biceps & Triceps
- Quadriceps & Hamstrings
- Gastrocnemius & Anterior Tibialis
- Hip Flexors & Gluteals
- Pectoralis Major & Deltoids
- Latissimus Dorsi & External Obliques
<table>
<thead>
<tr>
<th>Muscle</th>
<th>Location in the body</th>
<th>Movement action used for</th>
<th>Attached to which joints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deltoids</td>
<td>Shoulder</td>
<td>Moves the arm in all directions</td>
<td>Ball and Socket (Shoulder)</td>
</tr>
<tr>
<td>Pectoralis major</td>
<td>Chest</td>
<td>Adduct the arm at the shoulder</td>
<td>Ball and Socket (shoulder)</td>
</tr>
<tr>
<td>Latissimus dorsi</td>
<td>Extends from the lower region of the spine to the upper arm</td>
<td>Adduct and extend the arm at the shoulder</td>
<td>Ball and Socket (Shoulder)</td>
</tr>
<tr>
<td>Biceps</td>
<td>Front of the upper arm</td>
<td>Flex the arm at the elbow</td>
<td>Hinge joint (Elbow)</td>
</tr>
<tr>
<td>Triceps</td>
<td>Back of the upper arm</td>
<td>Extend the arm at the elbow</td>
<td>Hinge joint (Elbow)</td>
</tr>
<tr>
<td>External obliques</td>
<td>Runs from the lower half of the ribs to the pelvis</td>
<td>Pulls the chest downwards</td>
<td>Ball and Socket (Pelvis)</td>
</tr>
<tr>
<td>Gluteals</td>
<td>Form the buttocks</td>
<td>Adduct and extend leg at the hip</td>
<td>Ball and Socket (Pelvis)</td>
</tr>
<tr>
<td>Hip flexors</td>
<td>In the front of the hip connecting the pelvis and abdomen</td>
<td>Flex the hip, helps move the leg and knee up towards the body</td>
<td>Ball and Socket (Pelvis)</td>
</tr>
<tr>
<td>Quadriceps</td>
<td>Four muscles found on the front of the upper leg</td>
<td>Extend the leg at the knee</td>
<td>Hinge joint (Knee)</td>
</tr>
<tr>
<td>Hamstrings</td>
<td>Back of the leg, stretching from the bottom part of the pelvis to the tibia</td>
<td>Flex the leg at the knee</td>
<td>Hinge joint (Knee)</td>
</tr>
<tr>
<td>Gastrocnemius</td>
<td>From the back of the femur to the back of the ankle</td>
<td>Points the toes (plantar-flexion)</td>
<td>Hinge joint (Ankle)</td>
</tr>
<tr>
<td>Tibialis anterior</td>
<td>Runs down the shin</td>
<td>Pulls the toes to the shin (dorsiflexion)</td>
<td>Hinge joint (Ankle)</td>
</tr>
</tbody>
</table>

Which muscle and what type of movement action is responsible for each of the following sporting examples?

<table>
<thead>
<tr>
<th>Sporting Example</th>
<th>Muscle used and movement action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performing a side plank in the gym</td>
<td>External oblique’s, gluteals, biceps, flexion</td>
</tr>
<tr>
<td>Lifting the knees high during sprinting</td>
<td>Hip flexors, flexion, hamstrings, flexion</td>
</tr>
<tr>
<td>Throwing the ball up to serve in tennis</td>
<td>Deltoids Latissimus dorsi, extension</td>
</tr>
<tr>
<td>Pulling the arm back ready to throw a dart</td>
<td>Biceps, flexion</td>
</tr>
<tr>
<td>Throwing a dart</td>
<td>Triceps extension</td>
</tr>
<tr>
<td>Jogging</td>
<td>Biceps, triceps flexion and extension, external obliques, latissimus dorsi, hamstrings and quadriceps, flexion and extension</td>
</tr>
<tr>
<td>Performing a squat</td>
<td>Quadriceps, flexion- hamstrings, extension</td>
</tr>
<tr>
<td>Lifting the feet during a ski jump</td>
<td>Tibialis anterior Dorsi-flexion</td>
</tr>
<tr>
<td>Pulling the leg back before kicking a ball</td>
<td>Hamstrings, flexion</td>
</tr>
<tr>
<td>Kicking a ball</td>
<td>Quadriceps, extension</td>
</tr>
<tr>
<td>Playing a forehand shot in tennis</td>
<td>Triceps, Extension</td>
</tr>
<tr>
<td>Swimming front crawl</td>
<td>(upper body) Deltoids, pectoralis major, latissimus dorsi, external obliques, biceps, triceps, flexion, extension, adduction, rotation (lower body) hip flexors, quadriceps, hamstrings gastrocnemius, tibialis anterior, flexion and extension, dorsiflexion vand plantar- flexion</td>
</tr>
</tbody>
</table>
Antagonistic Pairs

A muscle is only capable of pulling during a contraction. Muscles cannot push. Therefore some muscles work in twos, known as antagonistic pairs. Whilst one muscle contracts (pulls), the other muscle in the pair will relax. The muscle contracting is known as the agonist, whereas the muscle relaxing is known as the antagonist.

Explain how an antagonistic pair of muscles work together to perform a press up.

The biceps and triceps are the antagonistic pair involved in the press up.

During the downward phase of a press up, the biceps contracts and shortens, (known as the agonist) whilst the triceps relaxes and lengthens (known as the antagonist).

This results in flexion occurring at the hinge joint as the body moves towards the floor.

During the upward phase of the press up, the triceps contract and become the agonist, whilst the biceps relax and become the antagonist. This results in extension occurring at the hinge joint. The body moves away from the floor.

Explain how an antagonistic pair work together whilst performing a squat.

The antagonistic pair of muscles involved in the squat are the quadriceps and hamstrings. During the downward phase, the hamstrings contract (agonist) and the quadriceps relax (antagonist). This action creates flexion at the knee (hinge joint).

As the quadriceps contract (agonist) and the hamstrings relax (antagonist) the legs straighten and extension occurs at the knee (hinge joint).

Explain how an antagonistic pair work together during a hurdles race?

When the gastrocnemius contracts and shortens (agonist), the tibialis anterior relaxes and lengthens (antagonist). Plantar flexion takes place at the ankle (hinge joint). When the gastrocnemius relaxes and lengthens (antagonist) the tibialis anterior contracts and shortens (agonist). This causes dorsi- flexion to occurs at the ankle (hinge joint).
Fast and Slow Twitch Muscle Fibres

All muscles are made up of individual fibres, each containing myofibrils, which are small strands which work together to make your muscles contract.

Muscle fibres can either be slow twitch (type I) or fast twitch (type IIa and type II X).

Athletes with slow twitch fibres tend to do better in endurance events such as long distance running and cycling. This type of muscle fibre may contract slowly but it can work for long periods of time without rest.

Athletes with fast twitch fibres tend to better in events that require a short burst of intense exercise such as sprinting and jumping.

Most muscles contain both slow twitch and fast twitch muscle fibres. Name 3 sports where it is important to have both slow twitch and fast twitch muscle fibres. Explain why.

Football, Rugby and Netball.

All three of these sports require a mixture of both type 1 slow twitch and type IIa and type IIx fast twitch fibres. Invasion game players need the slow twitch fibres which contract slowly enabling them to perform at a moderate intensity, aerobic level for a full quarter/half of a match without rest. However, they equally need fast twitch fibres. They would need type IIa fibres to generate short bursts of energy to change direction quickly when dodging a player. They would also need type IIx which would allow them to generate power repeatedly within a match.

Slow twitch muscle fibres are darker in colour because they have a good oxygen supply and contain myoglobin (used to transport oxygen to muscles).

Fast twitch muscle fibres are lighter in colour because they contain less oxygen.
Key Terms:

**Tendons** – Fibrous tissues that join bone to muscle

**Ligaments** – Strong, flexible fibre that connects bones to other bones

**Flexion**: Movement decreasing the angle between body parts *(bending)*

**Extension**: Movement increasing the angle between body parts *(straightening)*

**Dorsi-Flexion**: Flexing the toes so that they move closer to the shin

**Plantar-Flexion**: Extending the toes down, away from the shin

**Adduction**: Movement of a body part toward the body's midline

**Abduction**: Movement of a body part away from the body’s midline

**Rotation**: The action of rotating around an axis or centre

**Circumduction**: Moving in a circular shape. Allows for 360 degrees of movement

**Voluntary Muscle**: A muscle which is controlled by an individual

**Involuntary Muscle**: A muscle which is not under an individual’s control

**Cardiac Muscle**: An involuntary muscle found in the wall of the heart

**Antagonistic Pair**: Two muscles working together. One contracts while the other relaxes.

**Agonist**: The muscle which is contracting. Also known as the ‘prime mover’.

**Antagonist**: The muscle which is relaxing.

**Type I**: Slow twitch muscle fibre

**Type IIA**: Fast twitch muscle fibre

**Type IIX**: Fast twitch muscle fibre