Anatomy and Physiology

Skeletal and Muscular systems

**Key terms**

*Tendon* - A very strong connective tissue that attaches skeletal muscle to bone

*Growth plate* - A plate of cartilage between the diaphysis and epiphysis that allows the cone to grow in length

*Collagen* - A rope-like protein that forms a structural framework in many parts of the body, for example; bones and skin

*Osteoporosis* - is a skeletal disorder characterised by compromised bone strength predisposing a person to an increased risk of fracture

*Osteoarthritis* - is a type of arthritis that is caused by the breakdown and eventual loss of the cartilage of one or more joints. Cartilage is a protein substance that serves as a ‘cushion’ between the bones of the joints

*Skeleton* - bony framework upon which the rest of the body is built. It provides attachment for the muscular system and carriers and protects the cardiovascular and respiratory systems.

*Joint* - A place in the body where two or more bones meet

*Appendicular skeleton* - The bones of the upper and lower limbs and their girdles that join to the axial skeleton

*Axial skeleton* - this forms the long axis of the body and includes the bones of the skull, spine and rib cage

*Ligament* - A tough band of fibrous, slightly elastic connective tissue that attaches one bone to another. It binds the end of the bones together to prevent dislocation.
**Synovial Joints**

-Joints identified on the specification are in this table:

<table>
<thead>
<tr>
<th>Condyloid</th>
<th>Gliding</th>
<th>Pivot</th>
<th>Ball and socket</th>
<th>Hinge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wrist</td>
<td>Intervertebral</td>
<td>Atlas and axis</td>
<td>Hip joint</td>
<td>Elbow joint</td>
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<tr>
<td></td>
<td>joints</td>
<td></td>
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<tr>
<td>Radio ulnar joint</td>
<td>Shoulder joint</td>
<td></td>
<td>Knee joint</td>
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<td></td>
<td></td>
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<td>Ankle joint</td>
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</table>

-Hip and shoulder joint movement does differ
- more stability is required at hip joint
- much **harder** to displace the hip than the shoulder joint and this is because of the structure of the joint

- The socket on the scapula (glenoid fossa) is small and shallow making the joint less stable
- The joint capsule is very loose (allowing separation between the two bones) allowing more movement
- Head of the humerus is rounded, but not as ‘ball like’ as the head of the femur; therefore it does not sit as deeply into the glenoid fossa
- Shoulder joint stabilise by the rotar cuff muscles but these are not as strong as the muscles surrounding the hip.
- Relatively easy to dislocate shoulder joint

- Socket on the pelvis (acetabulum) is deep and cuplike in shape making the joint more stable
- Ring of fibrocartilage adds depth to acetabulum, adding to stability
- Head of femur is very spherical and fits snugly into the acetabulum
- Joint is supported by five strong ligament; such as the iliofemoral ligament which is very strong
- The hip joint is surrounded by large muscle groups that aid it’s stability,
  - e.g. gluteus maximus
-this is important in lifelong involvement in physical activity because it prevents excess pressure being put on the lumbar spine, which causes lower back pain.

**Posture and physical activity**

-right type of physical activity will improve your posture
-Aerobic exercise will control your body weight meaning less strain is put on the muscles and joints and it becomes easier to maintain the correct body alignment when standing, sitting and exercising.
-Strength training or Swiss ball training will increase the muscle tone in the postural muscles of the trunk and develop core stability

**Basic concepts of biomechanics (chapter 2)**

**Motion**

-motion is the process of chaining place or position or movement
-Three types of motion

<table>
<thead>
<tr>
<th>Type of motion</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear motion</td>
<td>When a body moves in a straight or curved line, with all its parts moving the same distance, in the same direction, and at the same speed. *An example, the performer sitting a toboggan and travelling straight down the hill *Curved, e.g. when lying in the skeleton bob event, as they slide around the corners of a downhill track</td>
</tr>
<tr>
<td>Angular motion</td>
<td>When an object acts a radius and moves in a circular path about a fixed point. *An example, the arm action in front crawl. *During one stroke cycle the arm moves in a complete circle about the axis of rotation – the shoulder joint</td>
</tr>
<tr>
<td>General motion</td>
<td>Combination of linear and angular motion. *An example is a wheelchair athlete. The body of that athlete and his chair are displaying linear motion as they move along the track, but the swinging action of the athlete’s arms and the turning of the chair’s wheels exhibit general motion</td>
</tr>
</tbody>
</table>

- For a body to move, the force that acts on it must be large enough to overcome the inertia of the body.
  - A force acting a tennis ball may cause the tennis ball to move but the same force may not be large enough to make a medicine ball move.
  - If a body is in motion it will remain in motion until a force changes its state of motion.
Relationship between and resting values of, heart rate, stroke volume and cardiac output

**Heart Rate (HR)**

- Represents the number of times the heart ventricles beat in one minute
- Average resting heart rate is 70-72 beats per minute (bpm)
- Maximal heart rate is calculated using the following equation:
  \[ 220 - \text{Age} = \text{Max HR} \]

- **bradycardia** is resting heart rate below 60 beats per minute.
- May indicate a high level of aerobic fitness
- May also be due to **hypertrophy** which is an increase in size/thickness of the heart muscle wall

**Stroke volume (SV)**

Volume of blood ejected by heart ventricles per beat
- Average resting stroke volume is approximately 70 ml
  
  - **End diastolic volume (EDV)** before contraction, is the volume of blood left in the ventricles at the end of the relaxation/filling stage of the cardiac cycle.
  
  - **End systolic volume (ESV)** after contraction, is the volume of blood left in the ventricles at the end of the contraction/emptying stage of the cardiac cycle

- To calculate SV:
  \[ \text{EDV} - \text{ESV} = \text{SV} \]

**Cardiac output (Q)**

- Volume of blood ejected by heart ventricles in one minute

\[ \text{Q} = \text{SV} \times \text{HR} \]

(Litres/min) = (ml/beat) x (Bpm)

Average:
\[ 5 \text{ l/m} = 70\text{ml} \times 72 \]
Oxygen and carbon dioxide transport

- Q increases with exercise intensity
- Blood consists of 45% blood cells and 55% plasma

Oxygen Transport

-Achieved in two ways:
  - (97%) transported within the protein haemoglobin, and packed with red blood cells. As oxyhaemoglobin (HbO2)
  - (3%) within blood plasma
-Having high affinity for oxygen, haemoglobin happily combines with oxygen when it is available
-readily gives up oxygen to oxygen in tissues where oxygen concentrations are low
-each haemoglobin molecule can carry four oxygen molecules

Carbon dioxide transport

Achieved in three ways:
  - (70%) combined with water in red blood cells as carbonic acid
  - (23%) combined with haemoglobin as carbaminohaemoglobin
  - (7%) dissolved in plasma

Oxygen and carbon dioxide transport and performance

-effient oxygen and carbon dioxide transport aids participation in physical activity in that it:
  - Prolongs duration of anaerobic and, especially, aerobic activity
  - Delays anaerobic threshold, which increases the possible intensity/work rate for the activity
  - Speeds up recovery during and after exercise

Smoking’s impact on oxygen transportation

-cigarette smoke contains carbon monoxide (CO)
Haemoglobin has higher affinity (240x) to carbon monoxide, so binds with CO in preference to O2
-This reduces oxyhaemoglobin association in the lungs and therefore the performers maximal uptake
-as a result O2 transport is reduced with the net effect of reducing both the supply of O2 to the working muscles, and the lactate threshold which decreases optimal performance
-especially so in aerobic activities

Net Effect: decreases optimal performance especially in aerobic activities. Hence, all the positive effects of efficient oxygen and carbon dioxide are reversed
**External (Alveoli) respiration**

- Inspired air entering the alveoli in lungs has a high PP of oxygen and a low PP of carbon dioxide compared with the deoxygenated blood in the alveoli capillaries which has a high PP of Carbon dioxide and a low PP of oxygen.
- These two pressure gradients cause diffusion of:
  - **Oxygen** from the alveoli into the blood of the capillaries to be transported back to the left atrium, and (diffusion of)
  - **Carbon dioxide** from the capillary blood into the alveoli of the lungs where it is expired.

<table>
<thead>
<tr>
<th>Where?</th>
<th>External respiration</th>
<th>Internal respiration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alveolar-capillary membrane, between alveoli air and blood in alveolar capillaries</td>
<td>Tissue-capillary membrane, between the blood in the capillaries and the tissue (muscle) cell walls</td>
</tr>
<tr>
<td>Movement</td>
<td>O2 in alveoli diffuses to blood; CO2 in blood diffuses into blood</td>
<td>O2 in blood diffuses to tissue; CO2 in tissue diffuses to blood</td>
</tr>
<tr>
<td>Why? – O2</td>
<td>PP of O2 in alveoli higher than PP of O2 in the blood so O2 diffuses into the blood</td>
<td>PP of O2 in blood is higher than the PP of O2 in the tissue so O2 diffuses into the myoglobin within the tissues</td>
</tr>
<tr>
<td>Why? – CO2</td>
<td>PP of CO2 in the blood is higher than the PP of CO2 in the alveoli so CO2 diffuses into alveoli</td>
<td>PP of CO2 in the tissue is higher than the PP of CO2 in the blood so CO2 diffuses into the capillary blood</td>
</tr>
</tbody>
</table>

**Internal (Tissue) respiration**

- Oxygenated blood is pumped around the systemic circulation until it reaches the capillaries surrounding the body tissues and muscles.
- Capillary blood has a high PP of oxygen and a low PP of carbon dioxide compared with the tissue/muscle cells, which have a low PP of oxygen and a high PP of carbon dioxide having used their oxygen for energy production and given off carbon dioxide as a bi-product.
- Oxygen passed into the muscle cells is transferred from the haemoglobin in the blood capillaries to myoglobin within the muscle tissue, and transports the oxygen to the mitochondria where it is used for energy production.
- CO2 is transported in the blood as carbonic acid (70%), carbaminohaemoglobin (20%) and plasma (7%) back to right atrium of heart.

**Changes in gaseous exchange due to exercise**

- Both internal and external respiration increase during exercise in order to increase the supply of oxygen to the working muscles.
- Need to look at oxygen-haemoglobin dissociation curve.

**Oxygen-Haemoglobin dissociation curve**

- Informs us of the amount of haemoglobin saturated with oxygen.