Unit 1 – The Human Body in Motion

Area of Study 1 - How does the Musculo-Skeletal System work to produce movement?
The Muscular System

AREA OF STUDY 1 - HOW DOES THE MUSCULO SKELETAL SYSTEM WORK TO PRODUCE MOVEMENT?
There are about 650 muscles in the human body and they make up nearly half of its weight.

Muscles produce movement and maintain posture.

Muscles play roles in the following body functions:

- Heart
- Breathing
- Circulation
- Digestion
The Muscular System

- **Types of Muscle:**
  - **CARDIAC MUSCLE** – is the muscle that makes up the heart walls and is responsible for controlling the heart.
  - Cardiac muscle is IN VOLUNTARY and requires no conscious thought control as it works automatically.
The Muscular System

- Types of Muscle:
- **SMOOTH MUSCLE** - is found in the intestines and blood vessels.
- Smooth muscle is **IN Voluntary** and like cardiac muscle you have no control over it.
The Muscular System

Types of Muscle:

- **SKELETAL MUSCLE** - is controlled VOLUNTARILY and is the muscle used to perform movements and control posture.
- Skeletal muscles are attached to bones by tendons and are used to perform physical activity.
The Muscular System

- Bicep
- Pectorals
- Abdominals
- Quadriceps
- Gastrocnemius
- Wrist Flexors
- Deltoid
- Latissimus Dorsi
- Tibialis Anterior

Anterior View
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<th>MAJOR OR MOVEMENT</th>
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<td>TRICEPS</td>
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Movement

- Movement is made possible when muscles contract or shorten and pull on the bones to which they are attached.
- Muscles work in pairs so that when one muscle contracts to create a desired movement, its “partner” must relax and stretch to allow the bones to move.
- This process is known as “RECIPROCAL INHIBITION”.
- Example - When doing a bicep curl up-phase the bicep contracts and shortens and the tricep relaxes and stretches.
In the “reciprocal inhibition” relationship:

- The muscle creating the movement is known as the AGONIST or PRIME MOVER.
- The muscle that relaxes is known as the ANTAGONIST.

Also, to assist this process the surrounding bones need to be stable to allow effective movement. Muscles that contract to hold the surrounding bones still are known as STABILISERS.
Muscular contractions are controlled by conscious thought in the brain:

1. Brain sends signal
2. Electrical impulse travels along spinal chord to motor neuron (nerve)
3. Impulse travels along chain of neurons (neural chain)
4. Message arrives at muscle fibres
5. Muscle fibres are stimulated to contract.
Nervous Control

- **Cell Body** – the body of the cell
- **Nucleus** – control centre of the neuron
- **Dendrites** – receive information from other neurons
- **Axon** – conducts the electrical impulses (it is covered in a protective myelin sheath)
Muscles are made up of thousands of muscle fibres running side by side the whole length of the muscle.

Each muscle fibre is made up of smaller fibres called MYOFIBRILS.

These myofibrils are made up of tiny protein structures called FILAMENTS.

There are two types of filament:

- thick filaments made of MYOSIN.
- thin filaments made of ACTIN.

The ACTIN filaments slide over the MYOSIN filaments to create movement.
Structure of a Muscle

- Bundles of Fibres
- Muscle Fibres
- Myofibrils
- Filaments
Sliding Filament Theory

- Sarcomere
- Z Line
- Actin Filament
- Myosin Filament
- Crossbridges
- I Band
- A Band
- H Zone
- Z Line
1. Electrical impulse arrives at the relaxed muscle via the CNS
1. Electrical impulse arrives at the relaxed muscle via the CNS.

2. Calcium is released which bonds the cross bridges to the ACTIN.
3. Cross bridges begin to pull the ACTIN filaments towards middle
3. Cross bridges begin to pull the ACTIN filaments towards middle

4. Muscle contracts and shortens.
3. Cross bridges begin to pull the ACTIN filaments towards middle

4. Muscle contracts and shortens.
Sliding Filament Theory

**ANIMATION**

MYOSIN cross bridges sliding the ACTIN filaments and contracting the muscle
Sliding Filament Theory

**ANIMATION**

**MYOSIN** cross bridges sliding the **ACTIN** filaments and contracting the muscle
**Sliding Filament Theory**

**ANIMATION**

*MYOSIN* cross bridges sliding the *ACTIN* filaments and contracting the muscle
Sliding Filament Theory

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Sliding Filament Theory

ANIMATION

MYOSIN cross bridges sliding the ACTIN filaments and contracting the muscle
THE ALL OR NOTHING PRINCIPLE

- When the electrical impulse reaches the muscle fibres of a particular motor unit (the neuron & the muscle fibres it activates) it must be over a certain threshold to stimulate a contraction.

- If the electrical impulse does not reach the threshold – nothing will happen.

- When the threshold is surpassed, a contraction is stimulated and ALL fibres in the motor unit will contract MAXIMALLY and at the same time.

THEREFORE:

- For a maximum contraction (throwing a ball as far as you can) - ALL motor units will be activated and contract MAXIMALLY.

- For a sub-maximal contraction (a short throw) - only SOME of the motor units will be activated and contract MAXIMALLY.
There are three types of muscle contractions:

1. **ISOINERTIAL** - muscle action where the load or resistance against the muscle is constant throughout the motion.
   - **CONCENTRIC** - the muscle length decreases
   - **ECCENTRIC** - the muscle length increases

3. **ISOMETRIC** - the muscle length remains unchanged (gripping a racquet handle)

4. **ISOKINETIC** - the resistance changes according to joint angle (requires special machines like the cybex & nautilus which allows maximum contractions through the full range of movement).
Muscle Fibres

**MUSCLE FIBRE ARRANGEMENT**

**FUSIFORM MUSCLES**

- Fusiform muscles are long and thin.
- The muscle fibres run the length of the muscle in the same direction as the tendon.
- Fusiform muscles can contract rapidly but produce low forces.

The biceps is an example of a fusiform muscle.
**Muscle Fibres**

**Muscle Fibre Arrangement**

- In pennate muscle fibre arrangements the muscle fibres run on angles from the tendons.
- A larger number of muscle fibres in this arrangement allows pennate muscles to generate greater forces than fusiform muscles but they are slower.

**Unipennate**
- Fibres on one side of a tendon.
- Eg: semimembranosus

**Bipennate**
- Fibres on both sides of a tendon.
- Eg: gastrocnemius

**Multipennate**
- Fibres branch out from a number of tendons.
- Eg: deltoid
Muscle Fibres

Muscles are constructed of two different muscle fibres:

1. **SLOW TWITCH FIBRES** - are best suited to endurance (aerobic) activities as they:
   - contract slowly with less force.
   - have an increased capacity to use oxygen.
   - have the capacity to contract for longer time periods.
   - don’t fatigue easily.
   - have high capillary density.
   - have high mitochondria density.
   - have high myoglobin concentration.
   - have high fat stores.

Distance runners have a high proportion of slow twitch fibres in their legs.
Muscle Fibres

Muscles are constructed of two different muscle fibres:

2. **FAST TWITCH FIBRES** - are best suited to high intensity (anaerobic) strength & power activities as they:

- contract rapidly.
- contract with greater force.
- have a large fibre diameter.
- have the capacity to contract for only shorter time periods.
- fatigue easily.
- have high phospho-creatine stores.
- have high glycogen stores.

Sprinters have a high proportion of fast twitch fibres in their legs.
Muscle Fibres

- The proportion of a person’s slow twitch and fast twitch fibres will be determined genetically.
- Also, the proportion from one body part to another may be different.
- Therefore, a person may have a high proportion of fast twitch fibres in the legs yet a high proportion of slow twitch fibres in the upper body.
- Basically, an athlete’s suitability and ability for particular events will mostly be determined genetically.
- Athletes with high proportions of fast twitch fibres will be best suited to speed, strength, power activities.
- Athletes with high proportions of slow twitch fibres will be best suited to endurance, distance activities.
**Muscle Fibres**

Average proportion of fast & slow twitch fibres in various muscles.

(Johnson et al 1972)
Muscle Fibres

Proportion of fast & slow twitch fibres in various athletes

(Johnson et al 1972)
Revision Questions

Which of these arrangements of muscle fibres allows for the greatest strength?

- A/ fusiform
- B/ pennate
- C/ skeletal
- D/ smooth

The muscles mainly responsible for making movements are known as:

- A/ stabilisers.
- B/ antagonists.
- C/ agonists.
- D/ fixators.

Which pair of muscles does not have an agonist-antagonist relationship?

- A/ trapezius - rhomboids
- B/ biceps - triceps
- C/ quadriceps - hamstrings
- D/ erector spinae - abdominals

The muscle fibres responsible for explosive movements are:

- A/ fast twitch.
- B/ quick twitch.
- C/ slow twitch.
- D/ ballistic twitch.
Name and give an example of the three different types of muscle.

- Smooth - intestines
- Cardiac - heart
- Skeletal - biceps

Explain the process known as reciprocal inhibition.

Muscles work in pairs - when the agonist contracts, the antagonist must relax and vice versa. Eg: biceps / triceps.

Name the three types of muscle contraction and briefly define each.

- Isoinertial - muscle action where the load or force against the muscle is constant throughout the motion.
- Isometric - muscle length is unchanged (remains fixed) during contraction.
- Isokinetic - special machines (eg: cybex) allow maximal tension throughout the full range of motion.

Which muscle is mainly responsible for sit ups?

- Abdominals

Which muscle is mainly responsible for push ups?

- Pectorals (triceps)