PE Studies Functional Anatomy Notes

Structure of Skeletal Muscle:

Skeletal Muscle:
- Named for its location ~ Attached to bones(skeleton) by bundles of collagen fibres known as tendons.
- Links 2 bones across its connecting joint
    - As a result is responsible for moving the skeleton via the contraction or shortening of muscles. This process occurs via voluntary control.
- Is striated in appearance which means the fibres contain alternating light and dark bands that are perpendicular to the fibres.
- There are 2 distinct types of skeletal muscle which are determined by their colour:
    - Fast Twitch Fibres (White)
    - Slow Twitch Fibres (Red)

Structure of skeletal muscle:
Epimysium: Connective tissue sheath surrounding each muscle
Perimysium: Connective tissue which surrounds each bundle of muscle fibres
Endomysium: Connective tissue which surrounds each individual muscle fibre
Fascicle: A bundle of skeletal muscle fibres surrounded by the perimysium
Myofibril: Small, threadlike strands

EpiPen = Epi - P - En

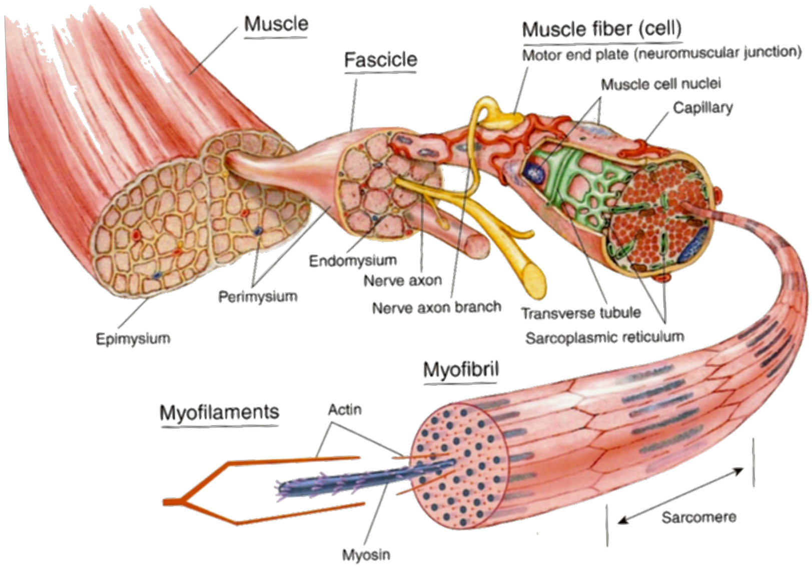
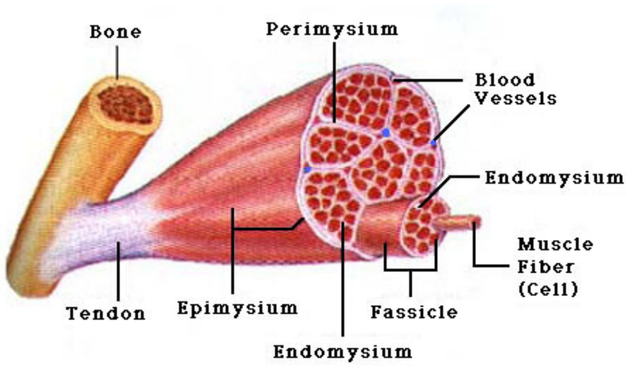


Figure 1-1 Muscle structure



Producing Movement:
- Skeletal muscles which are consciously controlled (voluntary) are attached to bones
- When we want to produce movement e.g. walking, swimming, the CNS sends a message from the brain to the relevant muscle to contract, resulting in "pulling the bone" causing movement to occur.
- This enables the human body to respond quickly to changes in the external environment e.g. changing direction in a game of sport

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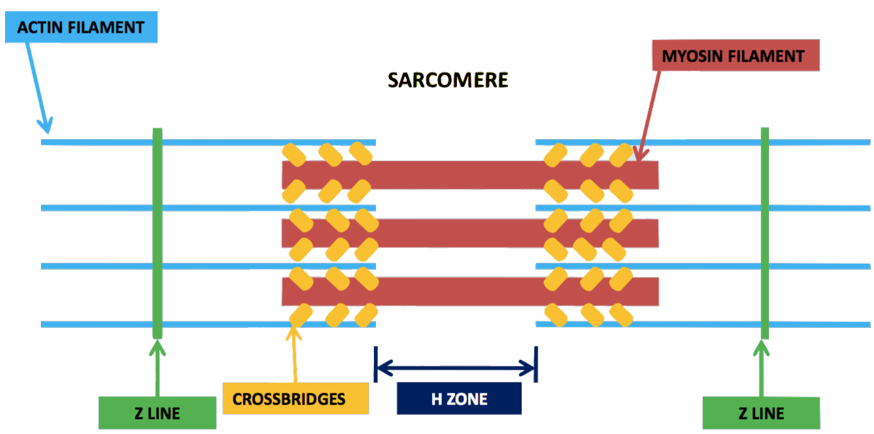
Attachment Points: Muscles have two attachment points onto the skeleton. Each attachment is on a different bone and across a joint.
Origin:
- The origin of a muscle us the attachment onto the bone that does not move when the muscle contracts.
- The origin of a muscle is the point which is usually at the proximal end.

Insertion:
- The insertion is attached to the bone which moves more when the muscle contracts
- The insertion of a muscle is the point which is usually at the distal end

How do muscles help us to move?:
- When a muscle contracts, it pulls on 1 of the 2 bones to which it is attached, creating movement.
- The origin and insertion points of a muscle are its two attachment points on the skeleton.
- All muscles bridge a joint and when contraction occurs, movement takes place altering the joint angle.
- Once a muscle contracts to move a bone, another muscle must contract to return the bone to its original position ~ hence muscles work in pairs.

Muscle Pairs:
- When muscles produce movement, they work in pairs.
    - This is because muscles can only pull, not push
- The prime mover involved in ant movement is refer to as the Agonist
- The muscle which relaxes to allow the movement to occur passively is referred to as the Antagonist.
- The term reciprocal inhibition is used to describe the coordinated relaxing of muscles on one side of a joint to accomodate contraction on the other side of that joint.

Structure of a Sarcomere: The diagram below shows the part of a myofibril called a sarcomere. This is the smallest unit of skeletal muscle that can contract. Each myofibril is made up of many sarcomeres joined into end which are separated by their Z-lines.
- Sarcomere: Comprises the unit between the two Z-lines and it makes up the functional unit of a muscle fibre
- Z-lines: Found at either end of the sarcomere
- Actin: The thin protein filament attached to the Z-line
- Myosin: The thick protein filament attached to cross-bridges
- Cross-bridges: Tiny projections on myosin filaments that attach on the actin filaments, pulling the actin filaments upon contraction
- H-Zone: Space between the actin filaments



The Myosin brings more actin together which makes the H-zone smaller
=
The MC brings the acts in which makes the house zone smaller

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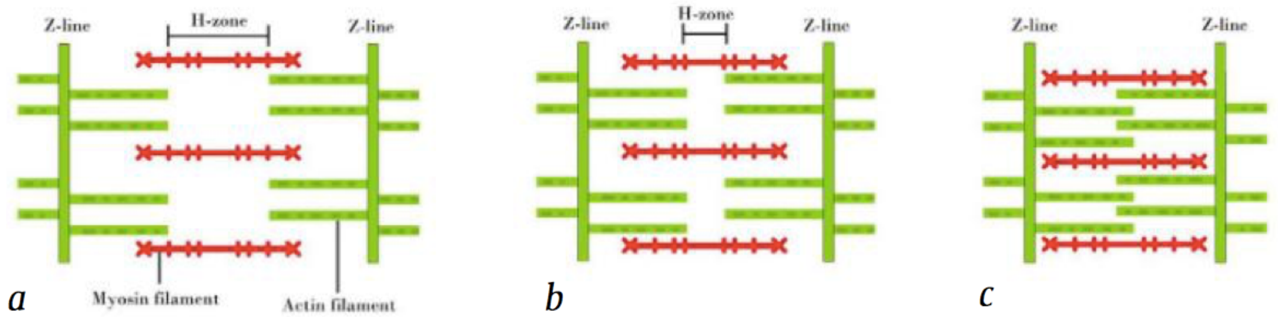
Sliding Filament Theory:

1. The Action Potential released by the Central Nervous System(CNS) causes the release of Acetylcholine that stimulates muscular contraction at the neuromuscular junction. It does this by releasing calcium into the muscle. This promotes a reaction in each muscle fibre between the myosin and actin filaments.
2. Myosin filaments heads form cross-bridges at regular intervals. The myosin head binds with the actin filament to form a cross-bridge. These myosin cross-bridges attach and reattach at different times along the actin pulling on them to create movement and maintain tension.
3. This causes the actin to move into the midline of the sarcomere, shortening the myofibril and causing the actin and myosin filaments to be almost fully overlapped when in a fully contracted position.
4. As each sarcomere shortens, so does the total length of each muscle fibre.
5. When the contraction finishes, the myosin detaches from the cross-bridges so it can attach further along the actin filament.



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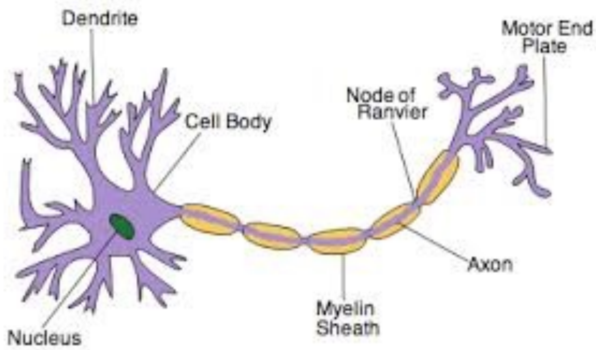
Nervous Control of Muscular Contractions:

Nervous System Control: The structures within the nervous system that enable movement of the musculoskeletal system. It consists of;
- A Sensory Neuron: Eyes receive visual information. Other major sensory organs are hearing(sound and balance) and touch.
- Dendrites: The sensory receptors signalling/sensing movement has occurred
- The Brain(CNS): Interprets information and makes decisions based on these inputs. E.g. Flex at the elbow joint.
- Spinal Chord: Part of the Central Nervous System and connects to the Peripheral Nervous System(PNS). Contains the pathways for the motor information. Cant include proprioreceptive information received from the body.
- Motor Neuron: Transmits in its axons the stimuli/motor instructions to innervate the muscle fibres.
- Motor Unit: The motor neuron and the muscle fibres that it innervates.

Neurological pathway for muscular contractions:
1. The sensory receptors(dendrites, eyes, ears, proprioreceptors) detect a stimulus and send a message along the motor neuron, back up the peripheral nervous system and spinal chord towards the CNS.
2. The CNS initiates a response, sending a stimulus in the form of an action potential back along the spinal chord to the motor neuron and motor unit.
3. The motor unit is the motor neuron and the muscle fibre it innervates.
4. The cell body of the motor neuron directs the neuron's activities towards the muscle fibre it innervates.
5. The motor endplates of the motor neuron then release a neurochemical stimulation of calcium into the muscle fibre/s which initiates a reaction between actin and myosin proteins filaments according to the sliding film in theory.

Nervous control of muscular contractions:
- In order to contract or shorten, muscle fibres must be stimulated by nerve or electrical impulses sent via motor neurons or nerves.
- For this to take place, a message is sent from the brain, in the form of an action potential, down the spinal chord through to the motor neuron, which innervates required muscle fibres.
    - The spinal chord is responsible for the transmission of messages between the brain and the muscle fibres.

Motor Neurons: Neurons located in the CNS that project their axons outside the CNS and directly or indirectly control muscles.
- It is responsible for carrying impulses away from the spinal chord and brain to the muscles or glands. It consists of;
  - A cell body: Directs the neurons activities
  - Dendrites: The sensory receptors signalling/sensing movement has occurred
  - An axon: Transmits electrical signals/stimulation(from cell body) to muscle fibres.
  - Motor end plates: Attach to the muscle fibres.



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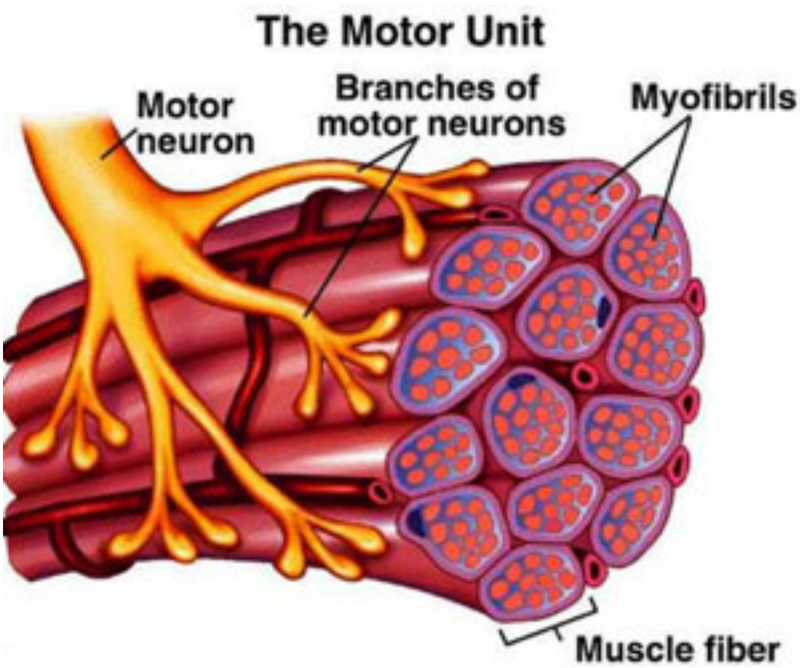
Motor Unit: A single motor neuron and all of the corresponding muscle fibres it innervates.

- When a motor unit is activated, all of its fibres contract;
  - This is known as the 'all-or-none principle' which states that all muscle fibres in a motor unit will either contract with 100% force or none at all.
  - This is determined by whether or not the single transmitted from the brain is above or below the threshold required for contraction.
  - To increase the strength of contraction, the brain simply sends more signals resulting in the recruitment of more motor units.

- The number of muscle fibres within each units can vary;
  - E.g. The muscles of the thigh might have 1000 fibres in each unit whilst the muscles of the eye might have 10.
  - In general;
    - The smaller of the motor unit i.e. innervates a small number of muscle fibres, the more precise the action of the muscle. E.g. The eye.
    - The larger the motor unit i.e. innervates a large number of muscle fibres, usually results in the recreation of gross motor skills. E.g. The muscles of the quadriceps when kicking a ball.



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Types of Muscle Fibres:

Fast Twitch - Type IIa:
- Fast contraction speed - used for speed endurance based activities
- Moderate force of contraction
- Fatigue resistance but not as much as slow twitch fibres
- Generate greater force and more powerful contractions as they are larger than red fibres
- Possess some Aerobic characteristics such as moderate levels of myoglobin, mitochondria and blood capillaries
- Stimulated by relatively large motor neurons and are stimulated a moderate frequency
- E.g. 800 meter runner (up to 70% fast twitch)

Fast Twitch - Type IIb:
- Rapid contraction speed - used for speed, strength and power based activities
- High force of contraction
- High capacity for anaerobic ATP production
- Fatigue very quickly - no oxygen
- Generate greater force and more powerful contractions as they are larger than red fibres
- Possess very few aerobic characteristics such as low levels of myoglobin, mitochondria and blood capillaries, but very high anaerobic characteristics such as high levels of glycogen, PCR and glycolytic enzymes
- Stimulated by very large motor neurons and are stimulated at a very high-frequency
- E.g. Sprinter (up to 80% of fast twitch)

Slow Twitch - Type I (Red):
- Slow contraction speed - used for endurance activities
- Low force of contraction
- High capacity for ATP production - generates ATP using the aerobic system
- Fatigue resistant
- Contract repeatedly for continuous activity
- Possess more aerobic characteristics such as high levels of myoglobin, mitochondria and blood capillaries
- Stimulated by relatively small motor neurons and are stimulated at a low frequency
- E.g. Endurance cyclist (up to 80% slow twitch)

You are stuck with what you have got - they are inherited and the ratio cannot be altered

Recruitment of muscle fibres:
- Type 1 fibres have a lower activation level then type 2 fibres and are more easily recruited
- During low intensity exercise, type 1 fibres are predominantly recruited
- At high-level intensity, type IIb fibres are predominantly recruited

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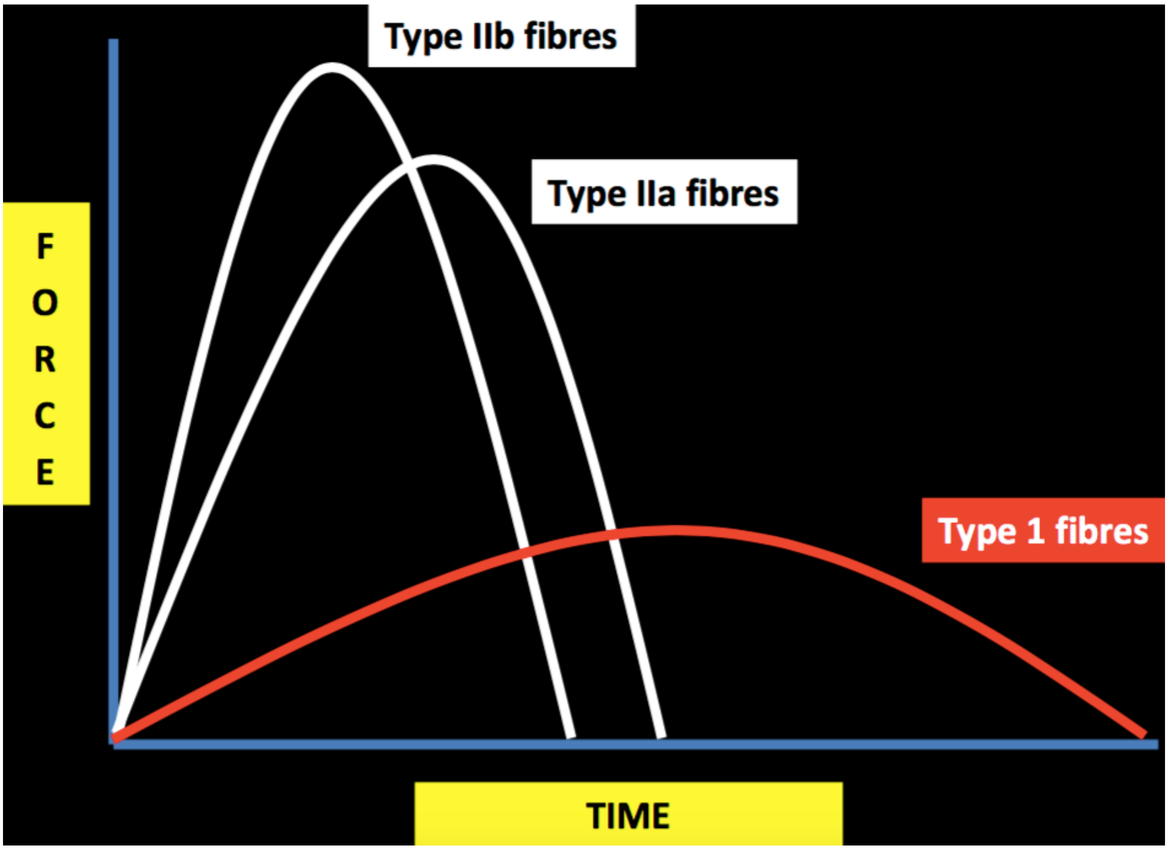

Fibre Type	Slow Twitch (Type 1)	Fast Twitch (Type 2A)	Fast Twitch (Type 2B)
Contraction Time	Slow	Fast	Very Fast
Size of Motor Neuron	Small	Large	Very Large
Resistance to Fatigue	High	Medium	Low
Activity used for	Aerobic	Long term Anaerobic	Short term Anaerobic
Force Production	Low	High	Very High
Capillary Density	High	Intermediate	Low
Oxidative Density	High	Moderate	Low
Glycolitic Capacity	Low	High	High
Major Fuel Source	Triglycerides and glycogen	Creatine phosphate and glycogen	Creatine phosphate and glycogen

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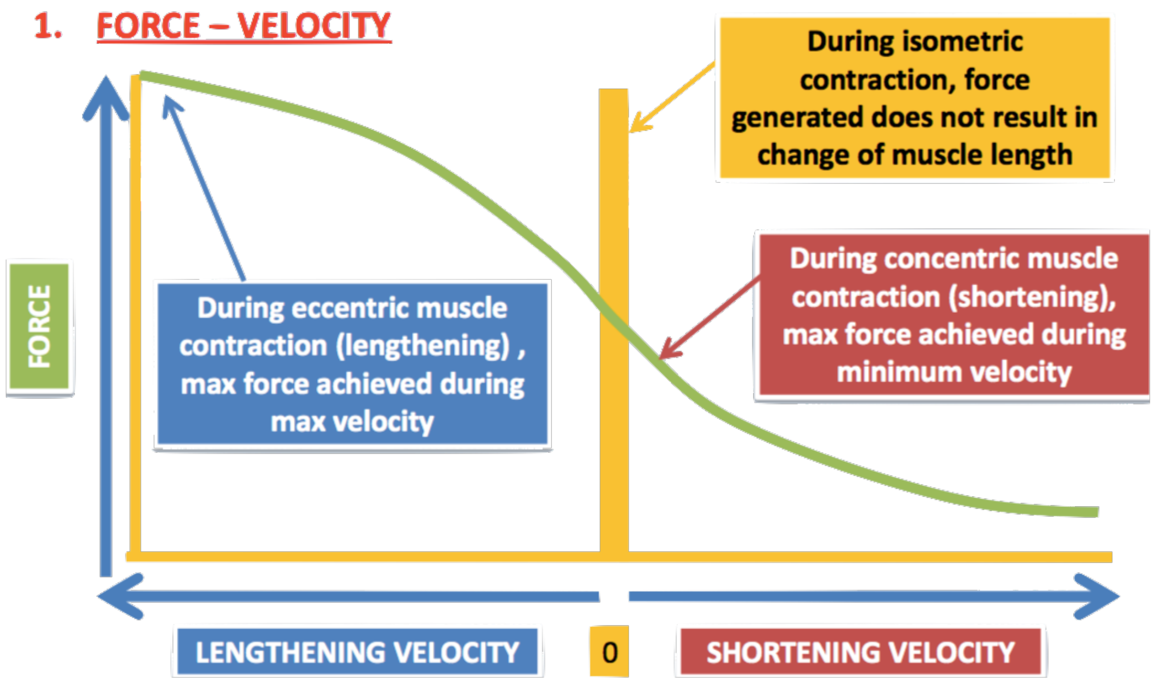
Mechanical Characteristics of a Muscle:

1. Force - Velocity:
- Muscle can increase force with a decreased velocity of concentric contraction
- Muscle can resist increased force with an increased velocity of eccentric contraction

Types of Forces:
- Force with motion ~ Isotonic Force: A change in the length of a muscle performed against a constant load. E.g. Performing a triceps extension
    - Isotonic forces can be further broken down into 2 types of muscular contractions, both involving a change in the length of the muscle.
        1. Eccentric muscular contraction
        1. Concentric muscular contraction
- Force with motion ~ Isokinetic Force: A change in the length of a muscle at a constant speed, however is performed against a varying load.
    - This requires the expensive, specialised equipment to ensure the speed of muscular contractions remains constant.
- Force without motion ~ Isometric Force: If the muscle length does not change, then an isometric contraction or force is being applied. E.g. Pushing against an immoveable object, gripping a racquet or bat.



2. Force - Length:
- The length of a muscle affects how well it creates tension
- The muscle can develop the most amount of force at approximately the midpoint of the muscle. Be careful with joint angles, as the midpoint of the muscle is not always the midpoint of the joints.
- The reason for this, is at the midpoint of the muscle, this is where the most amount of actin and myosin fibres are overlapped.