

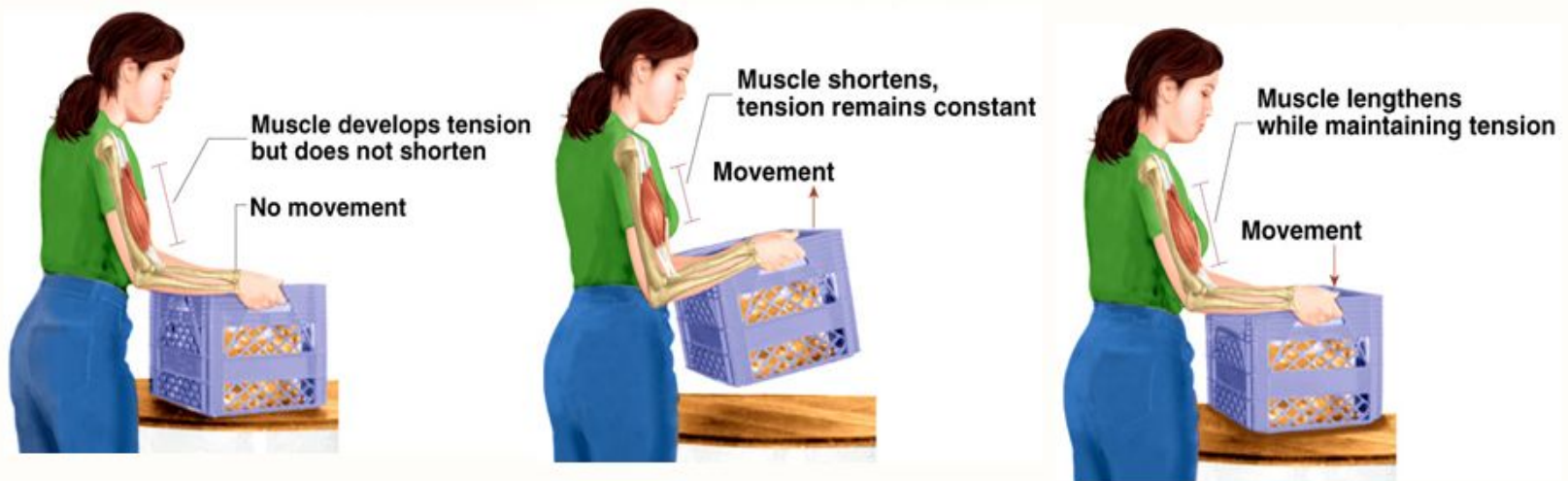
Functional Anatomy

Mechanical Characteristics of Muscle

Force-Velocity Relationship

- **Concentric Action:**
- Velocity increases at the expense of a decrease of force and vice versa
- Optimal force is generated at zero velocity because a large number of cross-bridges are formed
- **Eccentric Action:**
- An increase in velocity increases the force generated by the muscle
- Tension increases with speed of lengthening because the muscle stretches as it contracts

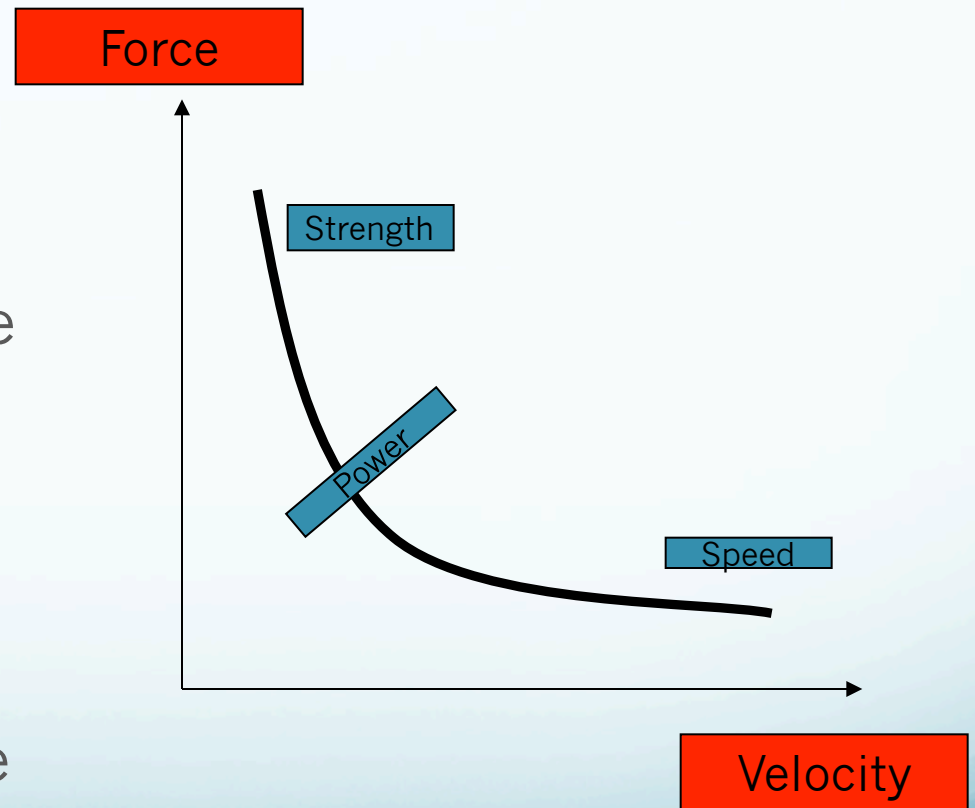
Isometric & Isotonic Contractions



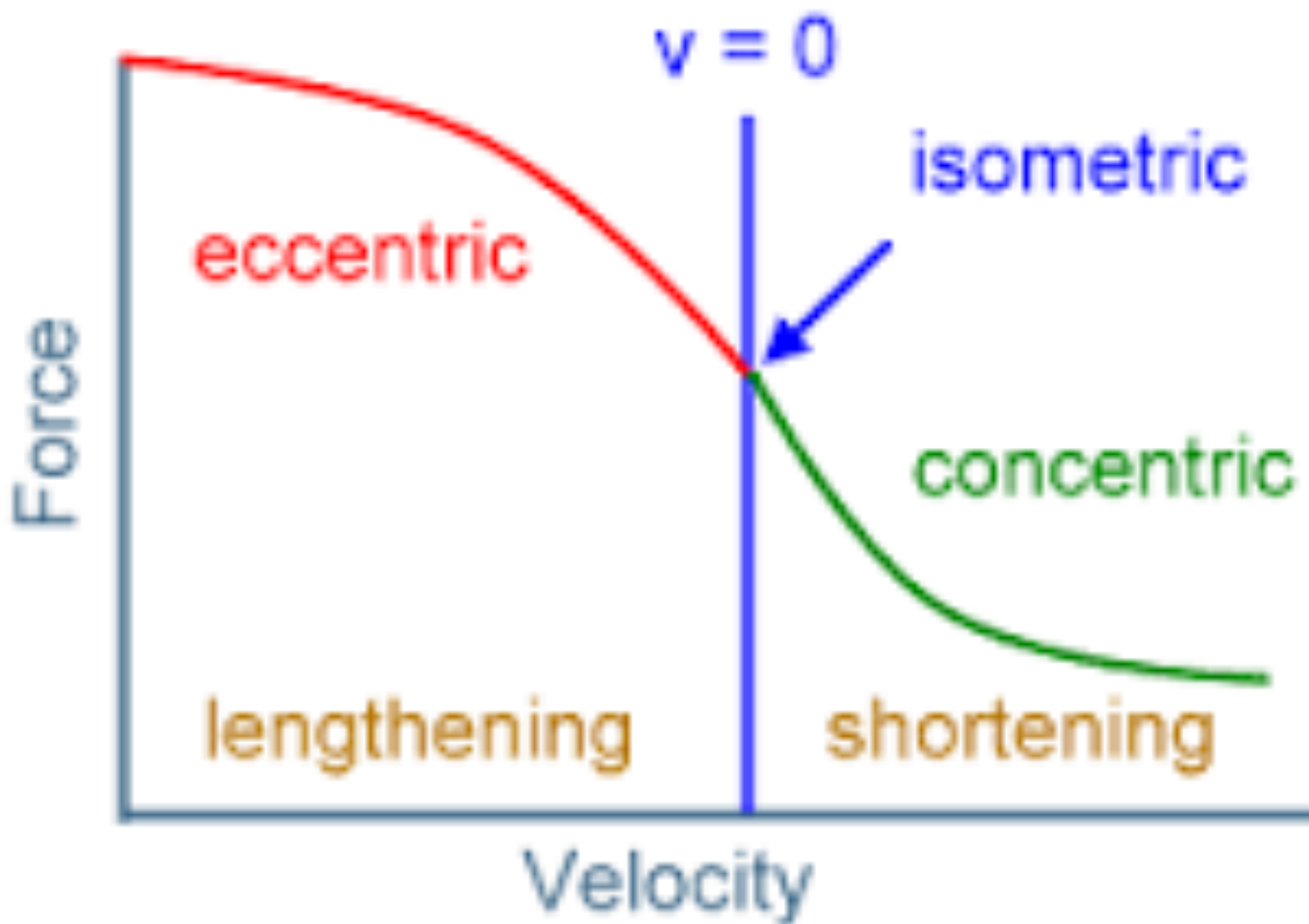
- Isometric muscle contraction
 - develops tension without changing length
- Isotonic muscle contraction
 - tension development while shortening = concentric
 - tension development while lengthening = eccentric

Relationships – Muscle Contraction

- Force-Velocity
- The faster a muscle contracts, the less force it can produce.
- That's why isometric contractions can generate the most force



Force-Velocity Relationship



Force-Velocity Curve of a Muscle

Other Factors that determine force production

- Number of cross-bridges formed
- The cross-section of the individual muscle fibre
- The cross-section of the total muscle
- Muscle fatigue
- Muscle fibre type (Type I, Type IIa/IIb)
- Muscle fibre arrangement (greater in pennate muscles e.g. _____)
- Muscle length

Force-Time Relationship

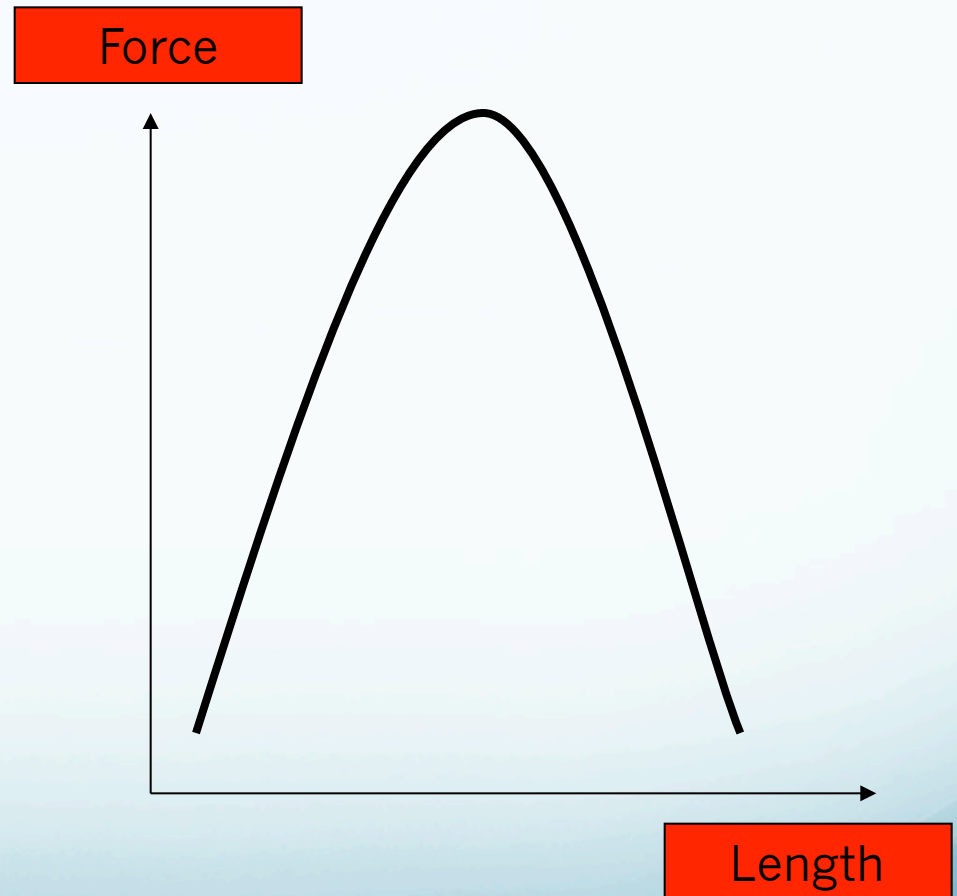
- As a muscle contracts, tendons and connective tissue stretch and absorb some of the force
- If the tendon is slack, the maximum force occurs later and vice versa
- A change in joint position may change the tension in the tendon which may increase or decrease the time to achieve maximal force

Force-length Relationship

- The amount of force that can be produced by a muscle is also related to the length at which the muscle is held
- Maximum force that can be generated occurs when a muscle is at length between 80% and 120% of resting length
- In a shortened state force is low because the actin and myosin filaments are maximally overlapped which reduces cross-bridge activation
- When a muscle is lengthened too much there is a slippage of the cross-bridges and so fewer are able to contract.

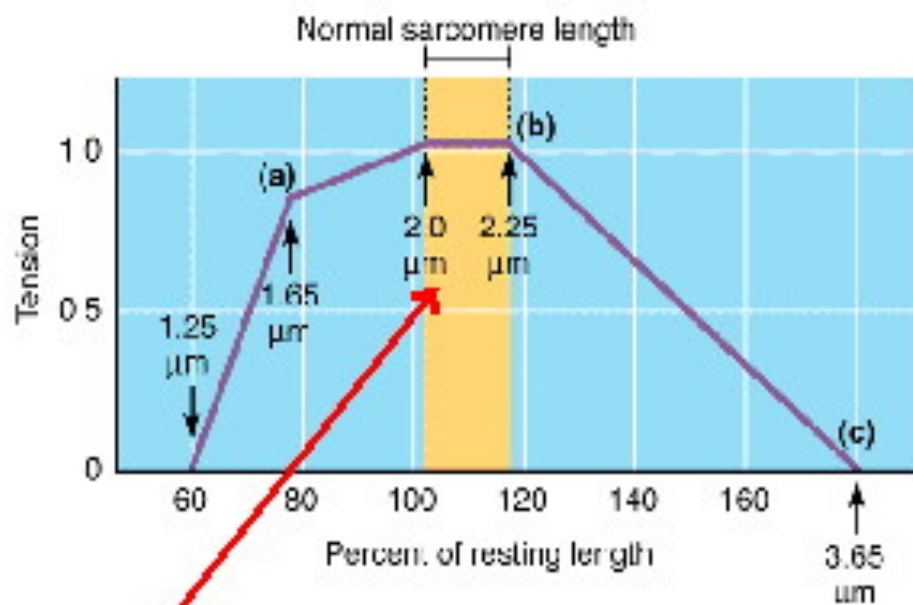
Relationships – Muscle Contraction

- Force – Length
- Muscles can produce maximum force when they are at their resting length. This is usually about the middle of a joints range of motion



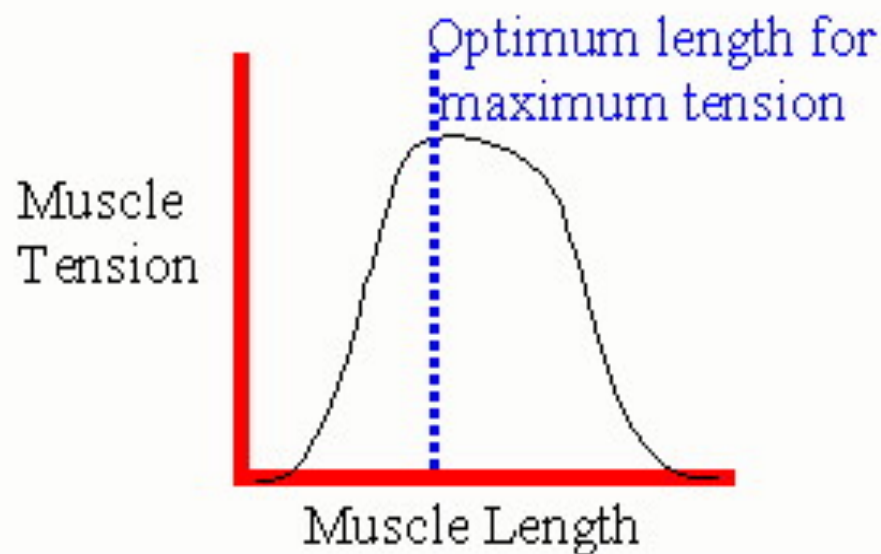
Relationship of Tension to Muscle Length.

The Sarcomere



At this length there is maximum overlap of myofilaments producing maximum number of crossbridges and maximum amount of tension

Whole Muscle

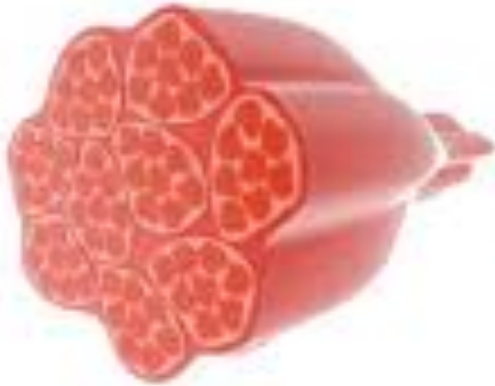


This applies to the entire muscle as well as to individual sarcomeres.

What happens to the sarcomere?

- Watch this clip to work out what happens to the sarcomere
- <http://www.wiley.com/college/interactions/Support/content/Support/musc3a/frameset2.htm>

Which muscle type?



RED MUSCLE

high mitochondrial content



MIXED MUSCLE

medium mitochondrial content



WHITE MUSCLE

low mitochondrial content

Slow Twitch Fibres

+ Slow Twitch (Type 1 fibre)

- Red in colour
- Contract slowly over a longer period of time
- Best suited to aerobic and endurance type activities
- Exert less force and can contract repeatedly



Fast Twitch Fibres

Fast Twitch: used for short explosive movements, stop and go sports.

Type IIA:

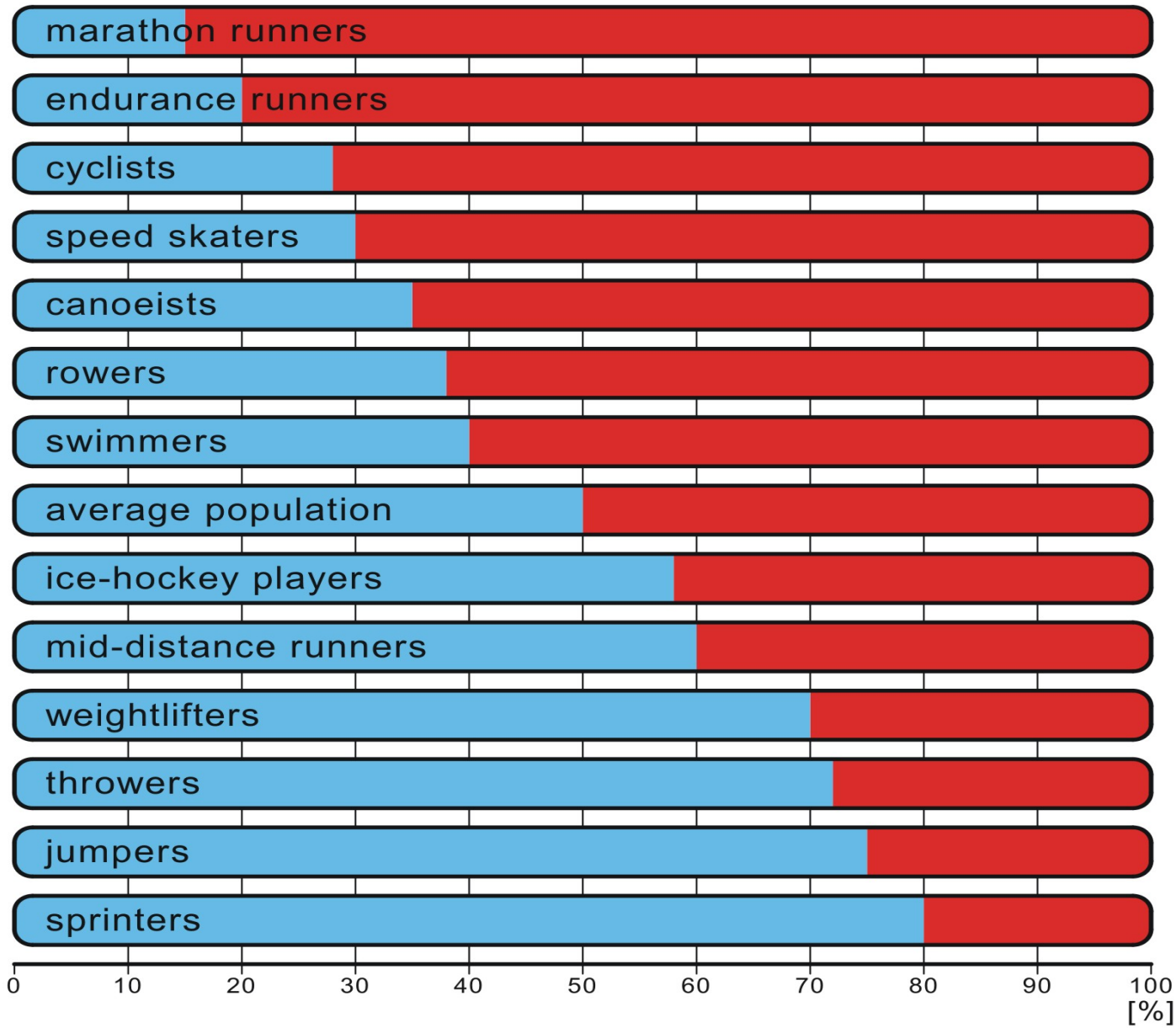
- *large diameter
- *white in color
- *less mitochondria
- *uses both anaerobic and aerobic energy transfer

Type IIB:

- *same physical characteristics as Type IIA, but strictly uses the glycolytic anaerobic system.

Muscle Fibre Types

	Type I Fibres	Type IIa Fibres	Type IIb Fibres
Speed of Contraction	Slow	Fast-intermediate	Fast-explosive
Endurance qualities	High	Low	Very Low
Predominant energy system	Aerobic	Anaerobic	Anaerobic
Size	Small	Large	Large
Colour	Red	White	White
Type of activity	Endurance activity	High intensity/ short duration e.g 400m	Explosive events-e.g. sprints



Muscle Fibre Recruitment

Depends on the type of activity

- Type 1 fibres are always first called upon
- As intensity (workload) increases more Type 2a fibres are recruited.
- If intensity continues to increase Type 2b fibres are recruited

Exam Style Question

- Louise, has for the first time, started a new strength training program that involves lifting weights with 8 repetitions at 80% of one-repetition maximum.
- After two weeks, she has noticed that she can now lift a significantly greater amount and still achieve her 8 repetitions. However, she has not changed the cross-sectional area or size of her muscles. Identify two neuromuscular responses that Louise has potentially experienced. (2 marks)

Answer

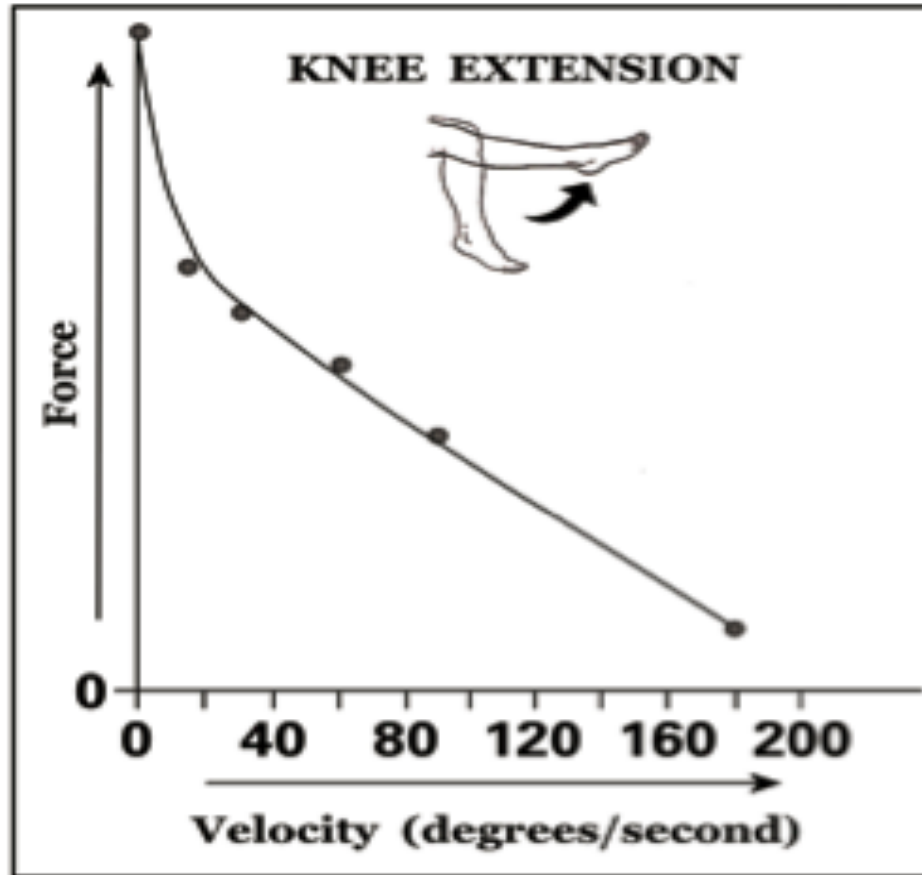
Answer (Choose two of the following):

- Increased firing rate of motor units
- More motor units are being recruited
- The firing rate of the motor units is better coordinated

Exam Style Question

- Louise has been experimenting with the speed of her muscle contractions and realised there is a relationship between the force she can generate and the velocity of the contraction.
- Draw and label a graph to represent the force-velocity relationship of muscle contraction. (2 marks)

Answer



Exam Style Question

- Muscle fibres are not all the same.
- Identify and justify the type of muscle fibres found in postural muscles. (2 marks)

Answer

- Type I, or slow-twitch fibres (red) (1 mark)
- The need to be fatigue resistant (1 mark)

Exam Style Question

- Despite undertaking a well-developed sprint training program over an extended period of time, most all of us will never be elite sprinters. Explain why this is the case. (3 marks)

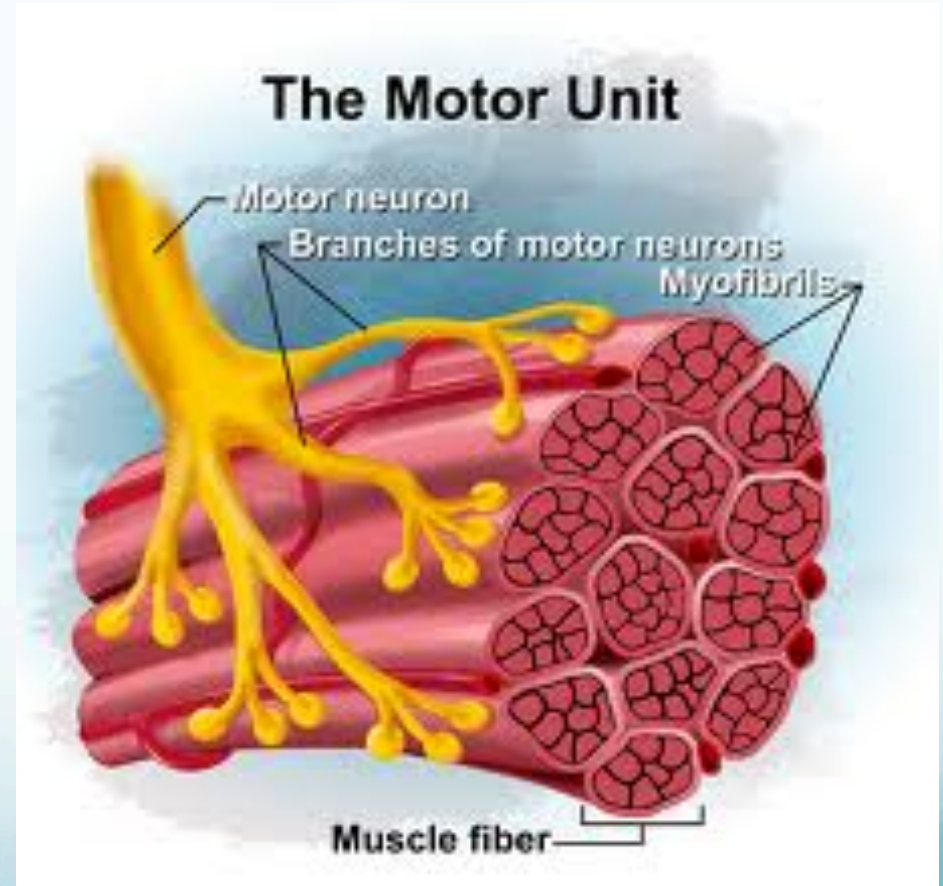
Answer

- Elite sprinters have relatively high percentages of Type II fibres (fast-twitch or white). (1mark)
- The relative percentage of Type II fibres in the muscles required for sprinting are determined at birth – in association with your genetic heritage. The percentage of these fibres does not change with training. (2 marks)

Motor Neurons and Motor Units

Motor Unit

- This is the motor neuron plus all the muscle fibres it attaches to
- Some are small (like in the face) with only 5 muscle fibres involved
- Some are huge (eg in your quads) with up to 1000 muscle fibres involved



The 'All or Nothing' Law

- A motor unit cannot vary the force of its contraction. It can only contract or relax
- Once the electrical impulse reaches the 'threshold' or 'limit', the whole motor unit will contract.
- Think of squeezing a trigger on a gun. It will only fire when the trigger is squeezed to a certain level

Muscle Contraction Force

- How do we get stronger muscle contractions ?
- To lift a feather, the CNS will only trigger a small number of motor units (enough to lift the feather)
- To lift a heavy weight the CNS will trigger more motor units to increase the force of the contraction

Patterns of Motor Unit Firing

- Synchronous

- All motor units fire at the same time
- Generates max force
- Muscle fatigues quick
- Eg Shot put / bench press

- Asynchronous

- Motor units are rotated between (while some relax other work)
- Generates less force
- Muscles take longer to fatigue