Unit 1 - Anatomy and Physiology

Assessment Outcomes

AO1 – Demonstrate knowledge of body systems, structures, functions, characteristics, definitions and other additional factors affecting each body system.

AO2 – Demonstrate understanding of each body system, the short- and long-term effects of sport and exercise on each system and additional factors that can affect body systems in relation to exercise and sporting performance.

AO3 – Analyse exercise and sports movements, how the body responds to short-term and long-term exercise and other additional factors affecting each body system.

AO4 – Evaluate how body systems are used and how they interrelate in order to carry out exercise and sporting movements

AO5 – Make connections between body systems in response to short-term and long-term exercise and sport participation. Make connections between muscular and all other systems, cardiovascular and respiratory systems, energy and cardiovascular systems.

Learning Aim B – The effect of exercise & sports performance on the muscular system

Learning objectives

B1 – To understand the characteristics and functions of the different types of muscles.

B2 – To be able to name the major muscles in the body.

B3 – To identify the movement of muscles in antagonistic pairs.

B4 + B5 – To understand the types of skeletal muscle contraction and muscle fibre types.

B6 – To be able to describe the responses of the muscular system to exercise

B7+8 – To understand the adaptations of the muscular system to exercise and other additional factors.

The muscular system

Muscles are used in everyday life all the time. Sportspeople are reliant on the power of **skeletal muscles** to compete.

Watch me

How many muscle names can you recall?

The characteristics and functions of muscles

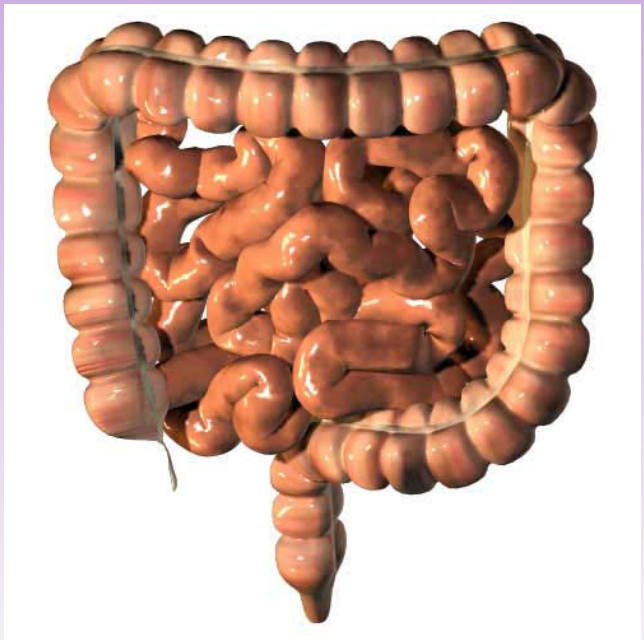
1. Skeletal Muscle

These are also known as striated or striped muscle. These are attached to bones and work under our **conscious control**. In addition skeletal muscles can become fatigued during exercise. *i.e. Biceps & Triceps.*

The characteristics and functions of muscles

2. Smooth Muscle

These muscles are **involuntary** and can be found on the walls of the internal organs.



Food travelling through the **digestive system** and blood through the **blood vessels** are helped along by smooth muscle.

Watch me

What are the differences between voluntary and involuntary muscles?

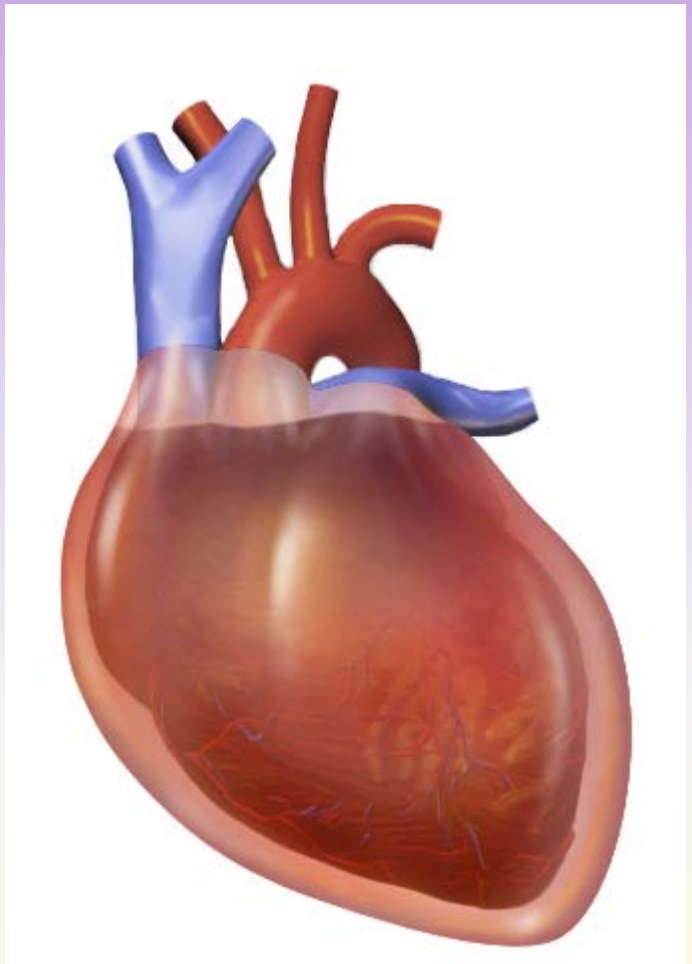
The characteristics and functions of muscles

3. Cardiac muscle

This is a special type of muscle that forms the walls of the heart chambers only.

It is a type of **involuntary** muscle, as it contracts without conscious control.

When it contracts it pumps blood out of the heart and around the body and never fatigues.

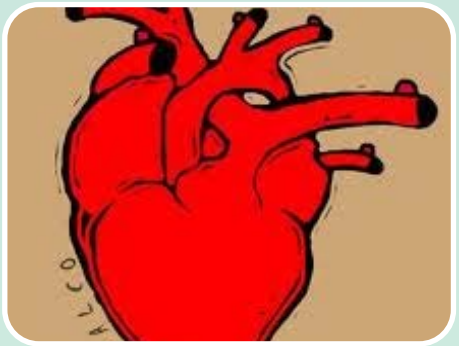


The characteristics and functions of muscles

All three types of muscle are important in physical activity.

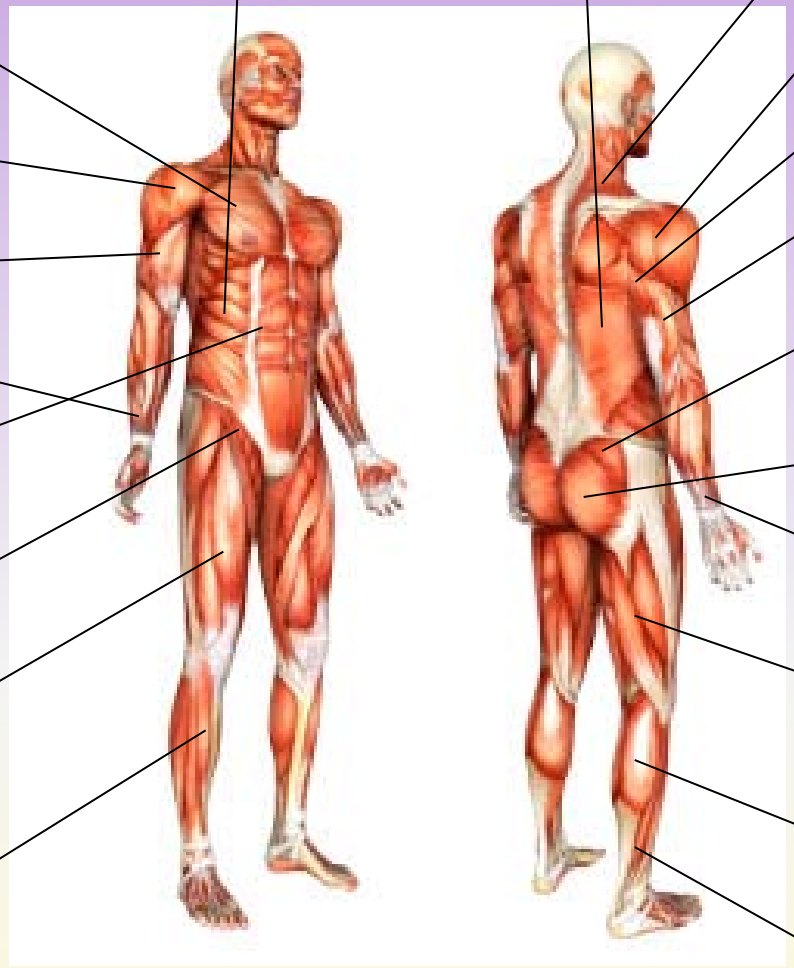
Skeletal muscles enable movement throughout the body.

Smooth muscles are essential in maintaining healthy body systems.



Cardiac muscle is vital in sport because it makes the heart pump. Fitness training will strengthen cardiac muscle making the heart more efficient at pumping blood around the body.

Major muscles



- Pectolaris Major
- Anterior Deltoid
- Biceps Brachii
- Wrist Flexors
- Rectus Abdominals
- Adductor Longus
- Rectus Femoris
- Tibialis Anterior
- External Obliques
- Latissimus Dorsi
- Trapezius
- Posterior Deltoid
- Teres Major
- Triceps Brachii
- Gluteus Medius
- Gluteus Maximus
- Wrist Extensors
- Biceps Femoris
- Gastrocnemius
- Soleus

Antagonistic muscle action

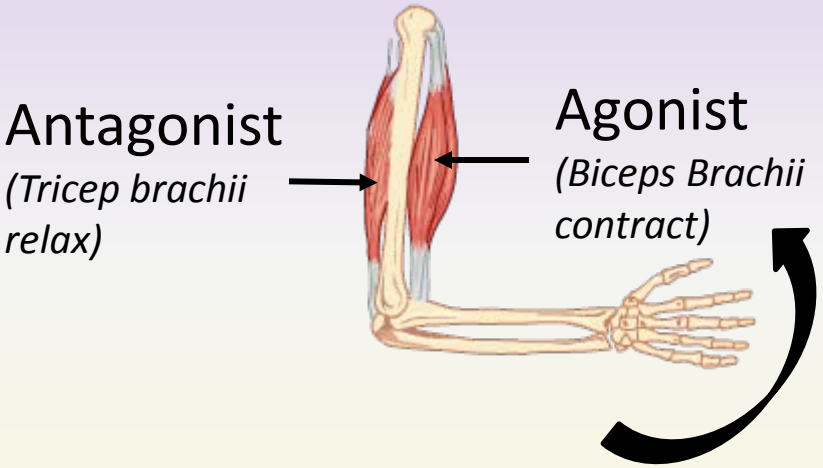
Muscles are arranged in **antagonistic pairs**. As one muscle contracts (shortens) the other relaxes (lengthens). For this to happen, one end of the muscle must remain stationery **(origin)** and the other end causes the movement **(insertion)**

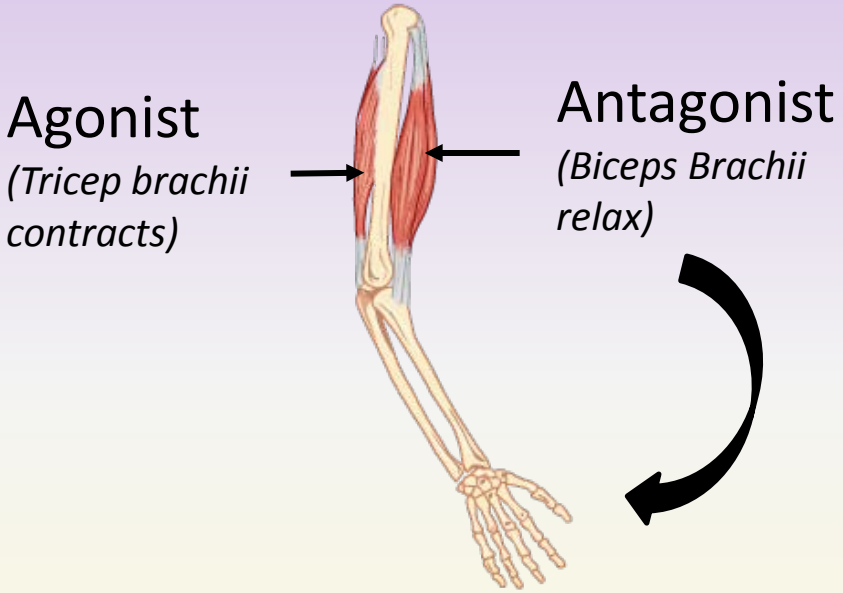
Think. Pair. Share - Can you think of another antagonists pair in the body?

Antagonistic muscle action – Bicep/Tricep

Agonist – the contracting muscle responsible for causing movement.

Antagonist – relaxing + lengthening muscle which allows the movement *(The muscle that works in opposition to the agonist)*





Fixator muscles stabilise the joint stopping any unwanted movement at the **origin**. **Synergists** are muscles that support the agonists.

Antagonistic muscle action – other examples

Plantar Flexion - Gastrocnemius and Soleus (Agonist) and Tibialis Anterior (Antagonist)

Flexion at the knee - Biceps Femoris (Agonist) and Rectus Femoris (Antagonist)
Fixator - Gluteus Maximus

Types of muscular contractions

1. Isometric
2. Isotonic
    a. Concentric
    b. Eccentric

Types of muscular contractions

Isometric contractions – These are muscle contractions that **do not** create movement.

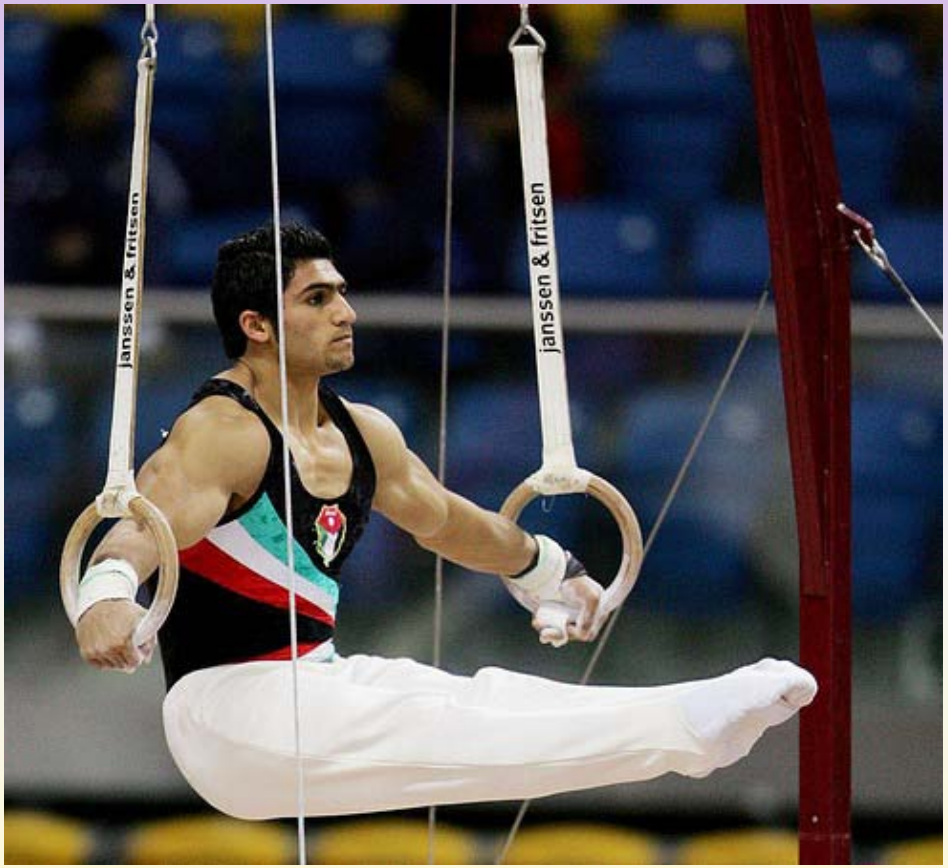
Isometric contraction is when the muscle contracts without lengthening or shortening. The result is that no movement occurs.

To hold the body in a particular static position *(i.e. scrum)*

Think. Pair. Share – Can you name any other sporting actions that are isometric?

Types of muscular contractions

Isometric contractions happen when a movement is still/stationary or held.



Types of muscular contractions

Isotonic contractions – A muscular contraction which changes the length of the muscle. This can occur in two ways;

Concentric contractions – Concentric contraction is when the muscle shortens under tension.

e.g. during the upward phase of an bicep curl, the biceps brachii performs a concentric contraction as it shortens to produce flexion of the elbow.

Types of muscular contractions - isotonic

Eccentric contractions – Eccentric contraction is when the muscle lengthens under tension (and does not relax).

When a muscle contracts eccentrically, it acts as a brake to help control the movement of the body part during negative work. Sometimes known as the **negative phase** of a muscle contraction.

i.e. when landing from a standing jump quadriceps muscles are contracting eccentrically.

Types of muscular contractions – Try this!

Why not use some practical space and explore different muscular contractions and discuss whether they are Isometric or Isotonic, Concentric or Eccentric.

Wall sit – Isometric muscle contraction

Box Jump – Isotonic muscle contraction (Concentric to get to the top of the box, Eccentric to jump off and land)

Joints in action

All sporting actions require different types of muscle contractions using a range of **articulating bones, joints, movement patterns, agonist, antagonist and contraction types** to perform the necessary movements.

Articulating bones = Humerus/Ulna/Radius

Type of Joint = Hinge Joint.

Movement = Extension

Agonist = Triceps Brachii
Antagonist = Biceps Brachii
Contraction = Concentric

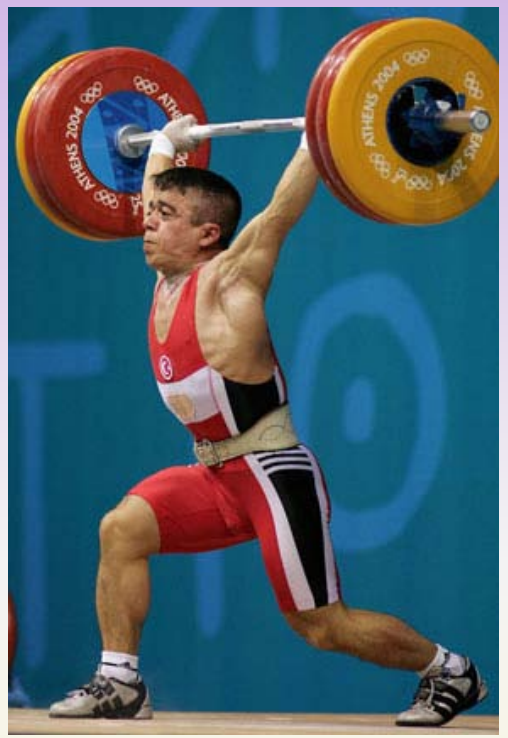
Think. Pair. Share – Analyse the movement above at the elbow.

Joints in action

Think. Pair. Share – Discuss and analyse the movements above.

Muscle fibre types

All skeletal muscles are made up from muscle fibres. These are one of two main categories depending on speed of contraction.

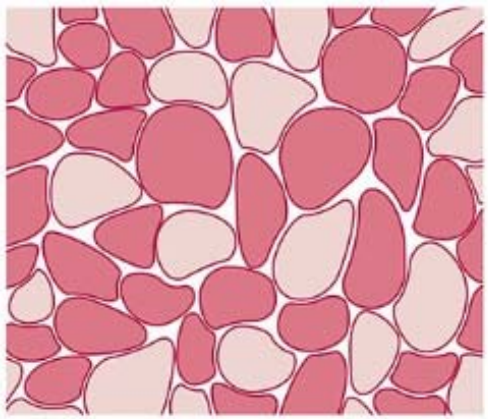


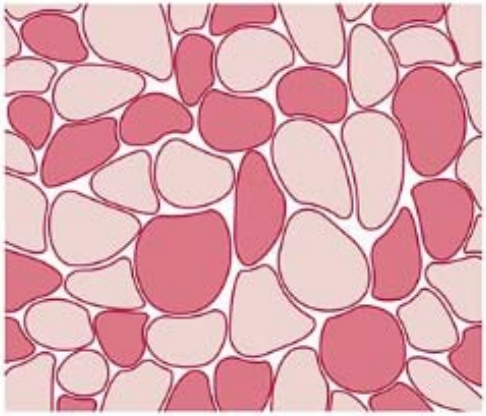
Watch me

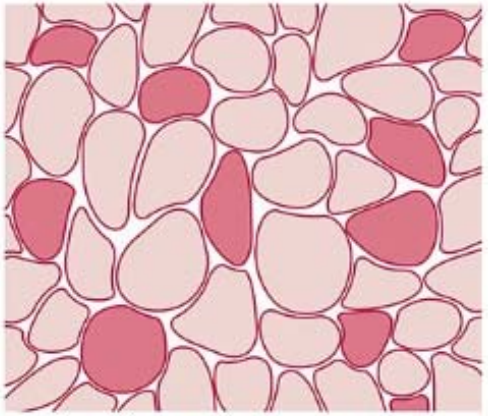
What is the difference between fast twitch and slow twitch muscle fibres?

Muscle fibre types

The images below are a cross section of a number of muscle fibres.







Think. Pair. Share – Describe the difference between each of the images above. Can you predict the muscle fibre types for each?

Muscle fibre types

There are 3 main types of muscle fibre in the body:

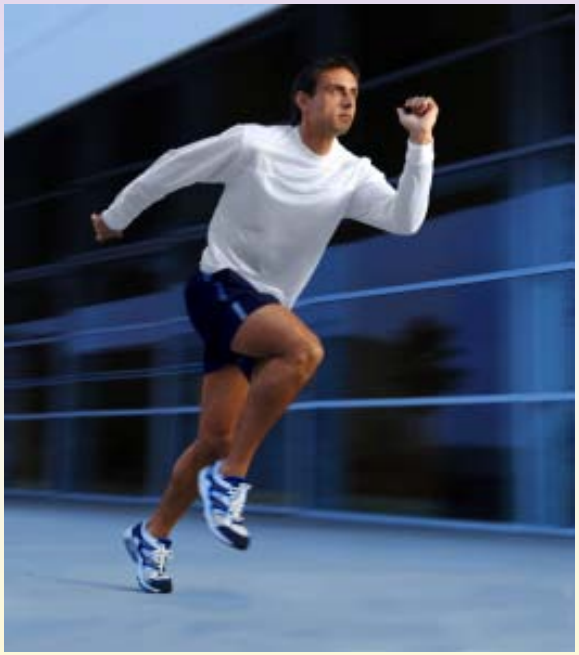
- Type 1 (slow twitch or slow oxidative)
- Type 2a (fast twitch or fast oxidative)
- Type 2x (or 2b) (fast twitch or fast glycolytic)

Our skeletal muscles contain a mixture of all three types of fibre but not in equal proportions. The mix is mainly genetically determined but training can influence this too.

Muscle fibre types

The relative proportion of each fibre type varies in the same muscles of different people.

e.g. an elite endurance athlete will have a greater proportion of slow twitch fibres in the leg muscles, while an elite sprinter will have a greater proportion of fast twitch fibres.



Muscle fibre types

Type 1 - Slow twitch muscle fibres are designed to store oxygen in myoglobin and process it in the mitochondria. This allows aerobic work to take place. Slow twitch fibres have a rich oxygen supply and are best suited to lower-intensity long duration activities.

Type 2a - Fast twitch muscle fibres are designed to work under higher intensities and are suited to speed, power and strength activities. However, fatigue is quick and therefore can only sustain contraction for short periods of time. i.e. 400m sprint

Type 2b – Fast twitch fibres contract rapidly and will produce a large amount of force. These are best suited to anaerobic activity such as the 100m sprint.

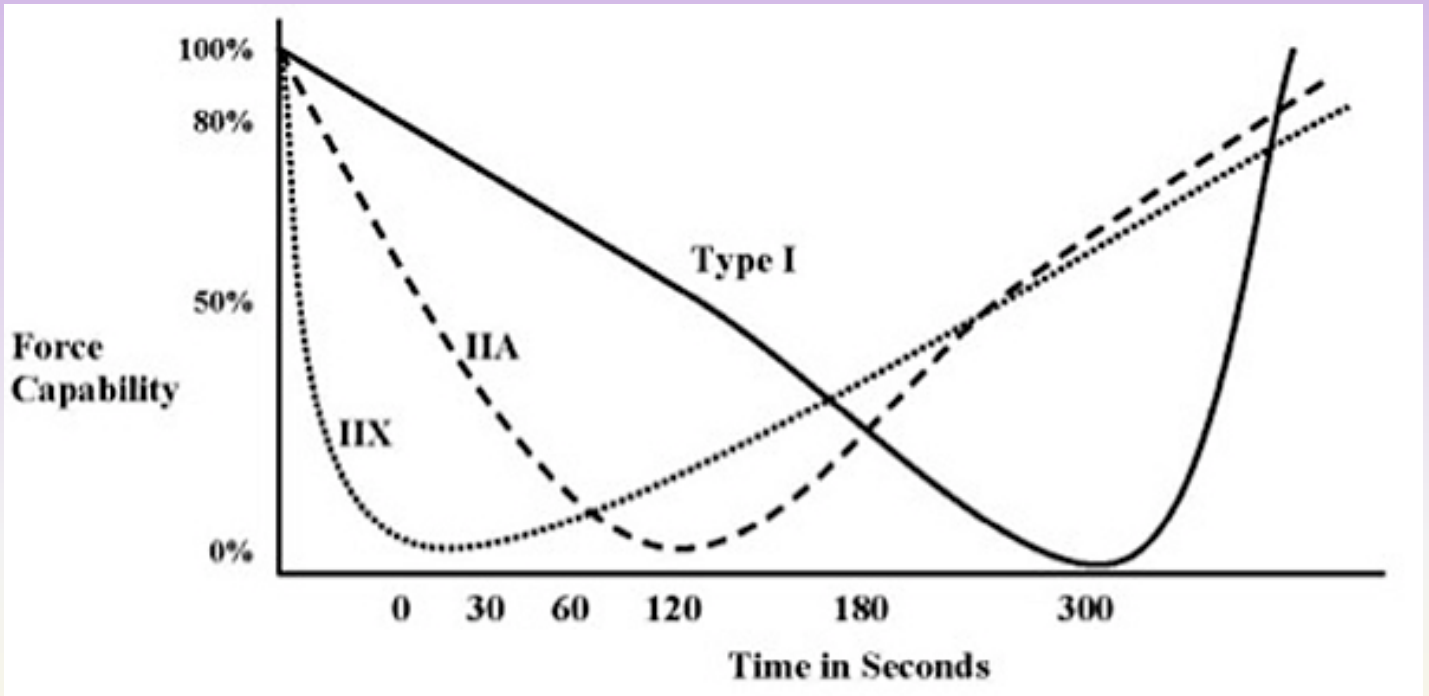
Muscle fibre types

Characteristics of muscles fibre types:

Characteristic	Type I	Type 2a	Type 2b
Contraction speed	Slow	Fast	Fast
Force produced	Low	High	High
Fatigue levels	Low	Medium	High
Myoglobin levels	High	Medium	Low
Glycogen stores	Low	High	High
Triglyceride (fat) stores	High	Medium	Low
Capillary density	High	Medium	Low
Aerobic capacity	High	Medium	Low
Anaerobic capacity	Low	Medium	High

Muscle fibre types

The relationship between muscle fibre type and force production over time is shown below:



Small motor neurones stimulate a small number of fibres and creates slow amount of force but for a sustained period. Larger neurones produce high force but fatigue rapidly.

Muscle fibre types – all or none law

Think. Pair. Share – What is meant by the 'all-or-none' law?

Muscle fibre types – all or none law

For a muscle to contract it must receive a **nerve impulse** that stimulates at least **one motor unit**. Once stimulated it is said to exhibit an all-or-none response.

If an impulse is strong enough then all the muscle fibres in a motor unit will contract. However, if the impulse is less than the threshold required then no muscle action will occur.

Response of the muscular system to exercise

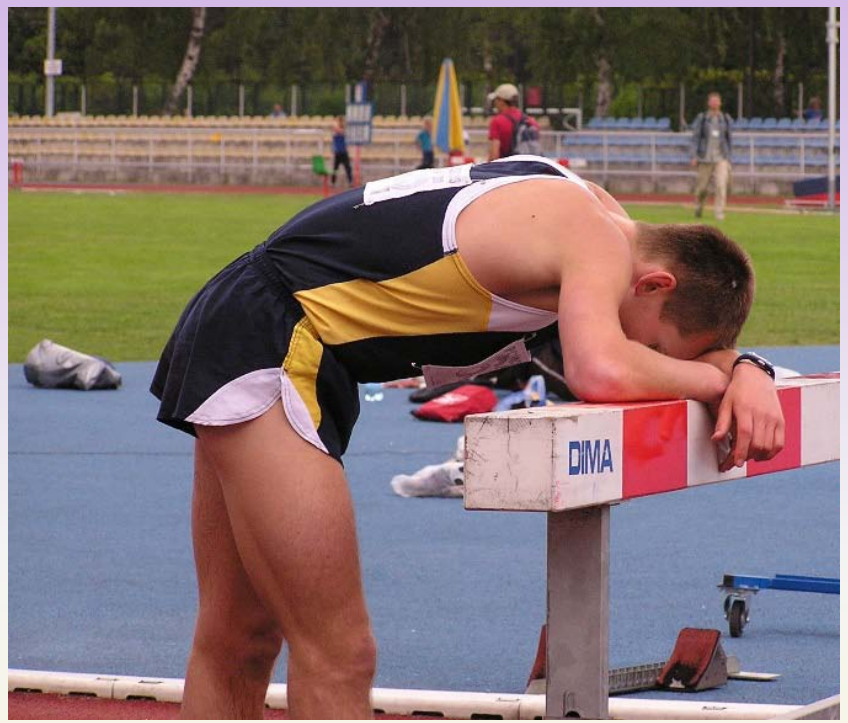
Watch me

How does the body react to the start of any exercise?

Response of the muscular system to exercise

The **short term effects** of exercise on the muscular system include:

1. Working muscles produce heat therefore **increasing muscle temperature**. This is due to chemical reactions producing heat as a by product from respiration.
2. The warming of muscles during activity **increases muscle pliability.** Pliable muscles are less likely to suffer strains.



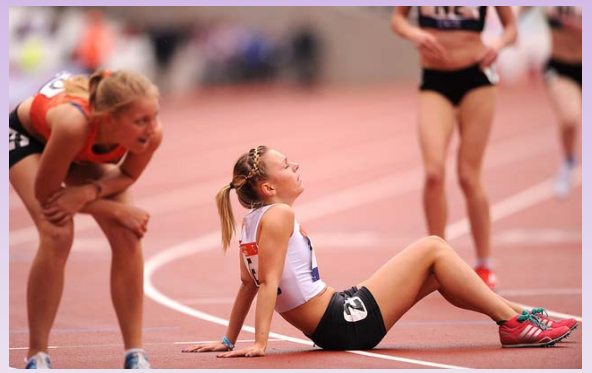
Response of the muscular system to exercise

3. An **increased blood supply** is necessary at working muscles in an attempt to provide more oxygen to these areas. This **re-distribution** is made possible through **vasodilation**. This is the widening of blood vessels to increase blood flow.

Response of the muscular system to exercise

In the **hours** and **days** after exercise, the body can experience the following:

- **Lactate build up** – This is the uncomfortable sensation in your muscles during **high-intensity anaerobic exercise**. This is caused by a build up of lactic acid.
- **Micro-tears** – resistance training involving weights will place the muscle under stress and caused small tears in the muscle fibres. Training adaptions will take place once the body has sufficient **rest and recovery**. **Protein** is often used to aid muscle repair.



Response of the muscular system to exercise

As a result individuals may experience tender and painful muscles up to 48 hours after exercise. This is called **Delayed Onset Muscle Soreness (DOMS)**

This muscle soreness is a result of structural damage to muscle fibres and connective tissue surrounding the fibres.

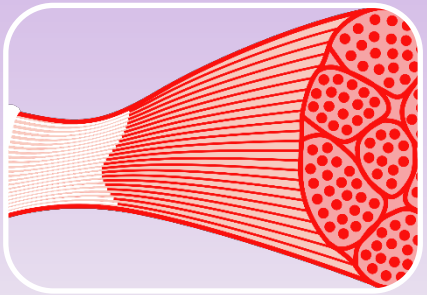
Adaptations of the muscular system to exercise

The **muscular system** adapts in the following ways after sustained training:

1. **Muscle hypertrophy** – the increase in size and strength of muscles due to overload.
2. **Increased tendon strength** – connective tissue surrounding joints will increase in flexibility and strength.
3. **Increased tolerance to lactate** – the body becomes more efficient in its removal post exercise.

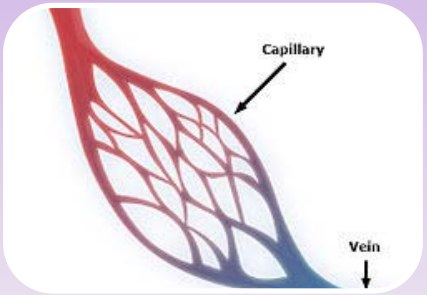
Adaptations of the muscular system to exercise

The **muscular system** also adapts in the following ways after sustained training:

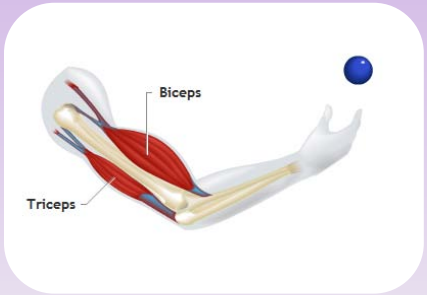


Increased myoglobin stores – myoglobin is a form of haemoglobin found in muscles. It is responsible for binding to oxygen and in turn providing energy.

Increased muscular endurance due to the increased numbers of **mitochondria.**



Increased storage of glycogen – long term exercise enables the muscles to store more glycogen and will be able to train at higher intensities for longer.



Increased storage of fat – well trained athletes use fats more efficiently especially useful when carbohydrates are low.

Additional factors affecting the muscular system

Two primary factors will affect the muscular system:

1. **Age** – Older age can result in a decreased muscle mass leading to a **reduce strength and power**. This may begin around the age of 50 and is known as **sarcopenia.**
2. **Cramp** – a sudden **involuntary contraction** of muscles can be prompted by exercise. It is common in the lower leg and can last for a few seconds up to 5 minutes.

Apply it!

What has stuck with you?

Name the agonist and antagonist muscles at the knee joint during flexion?

Explain what is meant by an antagonistic pair and an example in the body?

Muscular system

Highlight on your body as many major muscle names as possible.

Explain the difference between slow twitch and fast twitch muscle fibres.

Practice it!

Exam questions

1. The image shows someone performing a bicep curl.

Name the agonist and the antagonist muscles used when performing this move. (1)

Agonist: ……

Antagonist: ……

Practice it!

Exam questions

2. Explain how type IIx (2b) muscle fibre types would be beneficial for Tristan when playing football. (3)

3. Consider the following statements: (1)

"A concentric contraction of the biceps brachii causes extension at the elbow."

"A concentric contraction of the pectoralis major causes horizontal flexion at the shoulder."

Which one of the following is true?

A. Both statements are true

B. The first statement is true, the second is false

C. The first statement is false, the second is true.

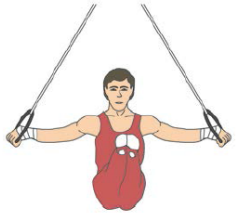
D. Both statements are false

Practice it!

Exam questions

4. Figure 1 shows a gymnast in a crucifix position on the rings.

Figure 1



Complete Table 1 to identify the type of joint, the main agonist and the joint action at the gymnast's shoulder when in the crucifix position. (3)

Table 1

Type of joint	Main agonist	Joint action

Practice it!

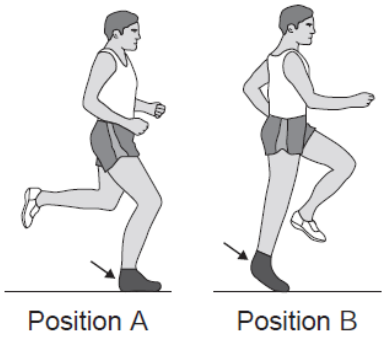
Exam questions

5. Using Figure 1, complete Table 2 to identify the main agonist, the joint action and the type of contraction at the right ankle when moving from Position A to Position B.

Table 2

	Right ankle movement from Position **A** to Position **B**
Main agonist	
Joint action	
Type of contraction	

Figure 1



Practice it!

Exam questions

6. Analyse how the antagonistic muscle pairs, synergists and fixators at the elbow and shoulder, as shown in Figure 3, allow Tristan to complete the bicep curl. (6)

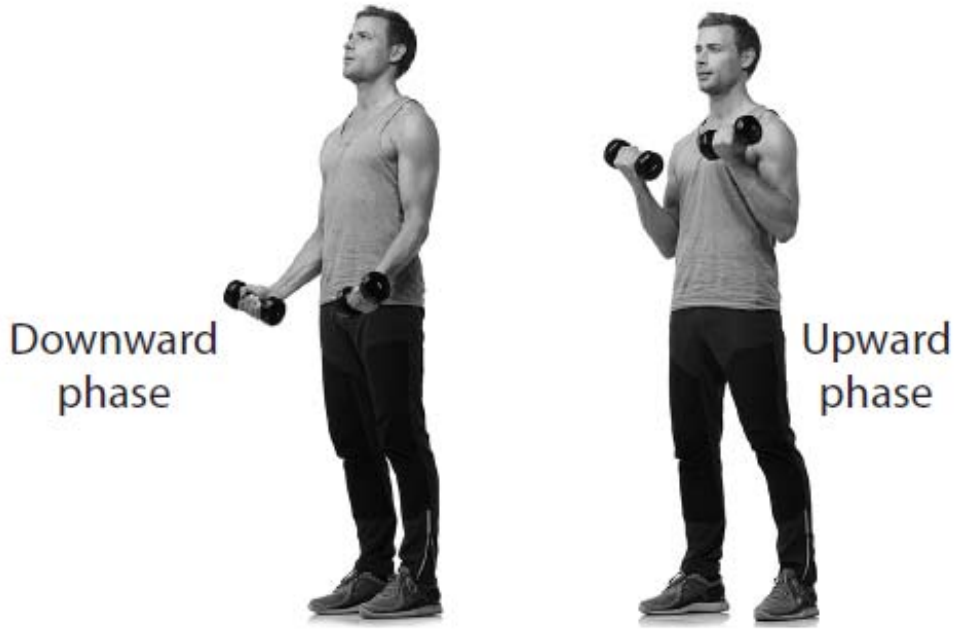


Figure 3

Practice it!

Marks Scheme:

1.Agonist – Biceps
Antagonist – Triceps

2.(Type IIx) Fast Twitch Glycolytic contract producing high force (1) so are used in football for speed /power based movements (1) such as taking a shot/ jumping for a header (1)

3. C

Practice it!

Marks Scheme:

4.

Type of joint	Main agonist	Joint action
Ball and socket	Posterior Deltoid	Horizontal Extension

5. A. Agonist – gastrocnemius, Soleus
   B. Joint action – plantar flexion
   C. Type of contraction – concentric/ isotonic

Practice it!

Marks Scheme:

6. **Downward (Lowering) Phase**

• The agonist during the lowering phase is the bicep (brachii)

• The bicep eccentrically contracts as it gets longer even though it is contracting

• The antagonist muscle is the tricep (brachii) which relaxes to permit contraction of the agonist

• The (anterior) deltoids are the synergist and support the bicep in conducting the movement

• The trapezius muscles are the fixator and they are under an isometric contraction to prevent unwanted movement of the shoulder.

Upward (Lifting) Phase

• The dumb bell is being lifted, the same muscle bicep (brachii) is the agonist

• The muscle is shortening as it is contracting therefore it is a concentric contraction

• The tricep (brachii) is relaxed and remains the antagonist

• Throughout the exercise the shoulder remains, still, the trapezius is therefore acting as a fixator.