1.1.a – Skeletal and muscular systems

Learning objectives

To understand the different types of joint, articulating bones and main agonists and antagonists in the body.

To be able to explain the different types of muscular contractions.

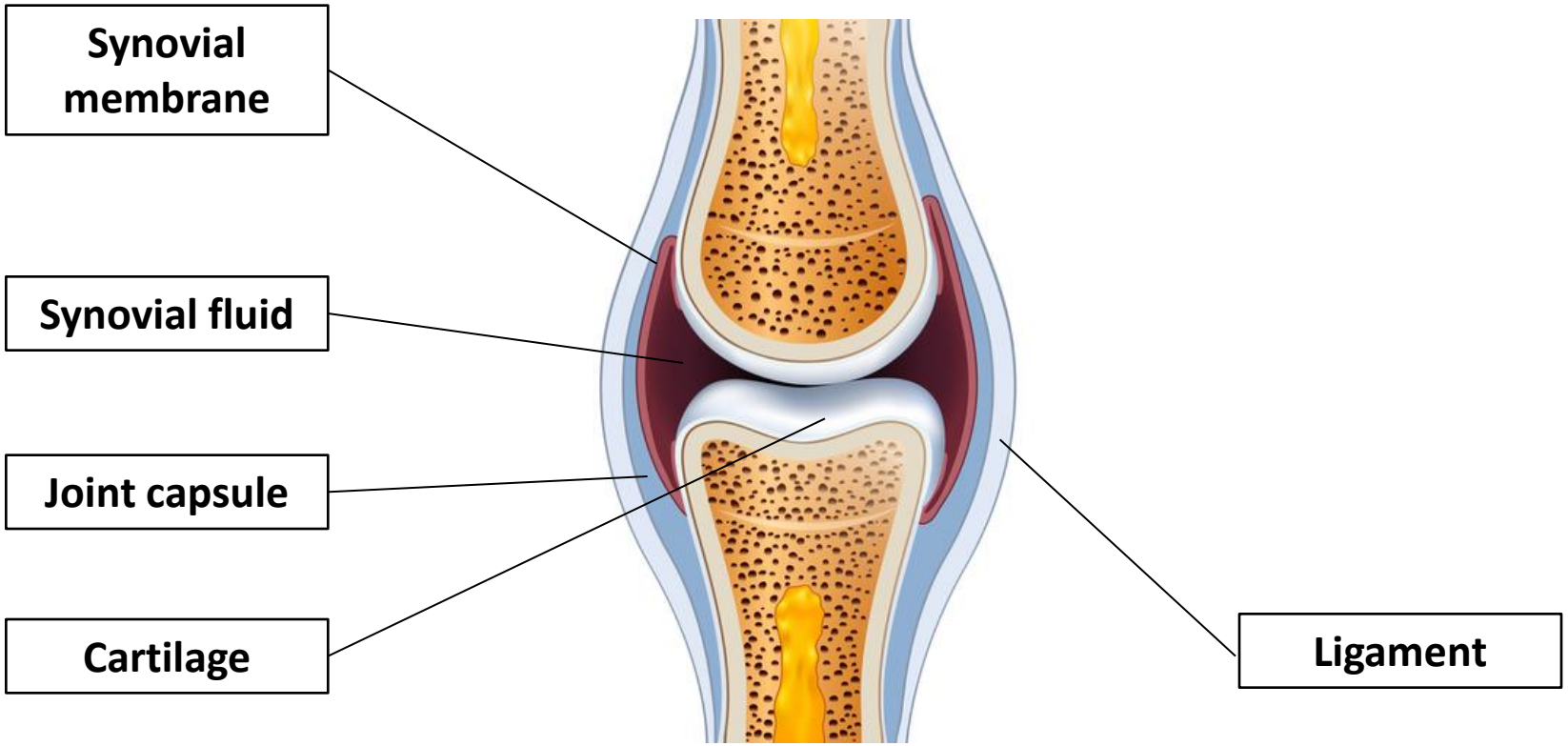
To understand the planes of the body.

To describe the characteristics of slow twitch and fast twitch muscle fibres.

To be able to explain motor unit recruitment in muscle contraction and the ‘all or none law’.

Types of Joints

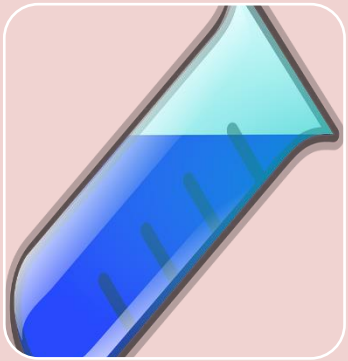
Synovial joints are the most common type of joint in the body. These joints vary in structure for example, the shoulder is a ball-and-socket joint and the knee is a hinge joint. All synovial joints have the following structures.



Types of Joints

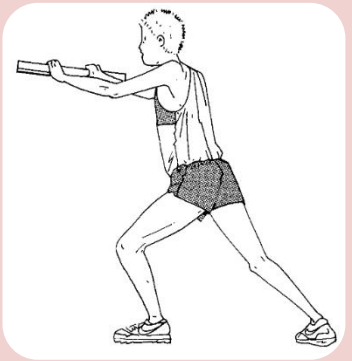
The following structures help prevent injury.

Cartilage prevents the ends of bones rubbing together at joints.



Synovial fluid – lubricates the joint allowing the parts to move freely.

Ligaments – these are tough, elastic fibres that link bones to bones.

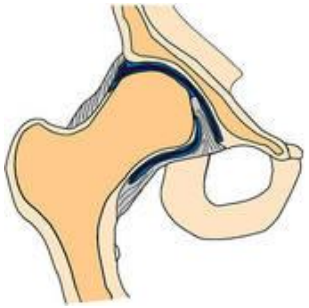


Tendons – These connect muscles to bones.

Types of Joints

1. Ball and socket joints allow movement in **all directions** and is the most mobile joints in the body.

Examples: Shoulders and hips.



Think. Pair. Share – Using examples, how are these joints used in sport? *i.e. tennis serve*

Classification of Joints

2. **Hinge joints -** only allow **forwards and backwards** movement like the hinge on a door.

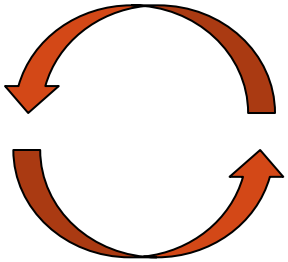
Examples found in the body: The knee and elbow.

Why are these joints important for sport?

These joint are extremely powerful and in conjunction with surrounding muscles can produce power and speed
i.e. Knee drive during a 100m sprint

Classification of Joints

3. Pivot joints have a ring of bone that fits over a bone sticking out. Pivot joints allow **<u>rotation only</u>.**



Examples found in the body: The joint between the **atlas and axis** in the **neck** which allows turning and nodding of head

Why are these joints important for sport?

This joint allows for small movements that assist a larger sporting action

i.e. breathing during a swimming stroke

Classification of Joints

4. Condyloid joints have an oval-shaped bone end which fits into a similar shape. They allow small movement in all directions.

Examples found in the body: Found between the carpals and metacarpals in the wrist joint.

Why are these joints important for sport?

These joint are extremely useful when a sport involves gripping a ball.
i.e. handball throw

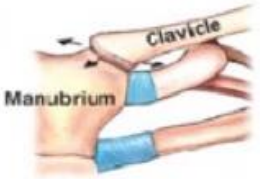
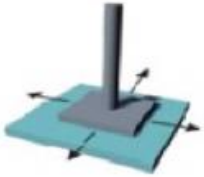
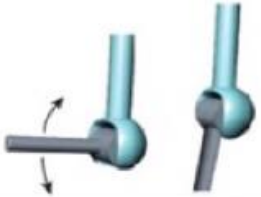
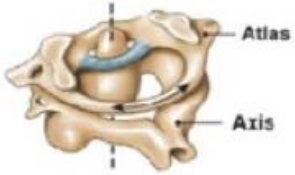
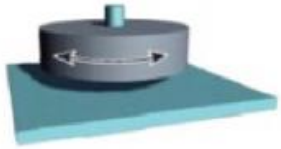
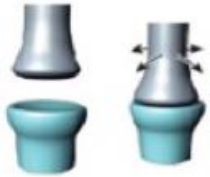
Classification of Joints

5. Gliding joints occur between the surfaces of two flat bones that are held together by ligaments.

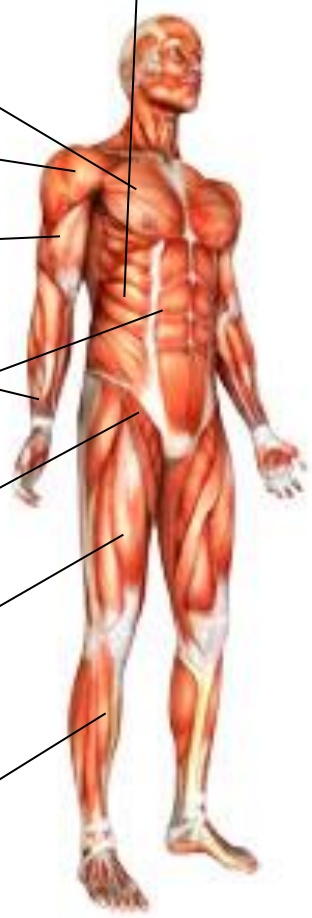
Examples found in the body: The bones in your wrists and ankles as well as the spine.

Why are these joints important for sport?

These joints are used to allow flexibility and movement in the hands, feet and back regions.
i.e. a kicking or catching action or a boxing slip

Types of Synovial Joints	Models of Joint Motion	Examples
Planer 		• Intercarpal and intertarsal joints
Hinge 		• Elbow joints • Knee joints • Ankle joints
Pivot 		• Atlas/axis • Proximal radio-ulnar joints
Condyloid 		• Radiocarpal joints • Metacarpophalangeal joints 2–5 • Metatarsophalangeal joints
Ball-and-socket joint 		• Shoulder joints • Hip joints

Muscle action



External Obliques

Latissimus Dorsi

Pectolaris Major

Anterior Deltoid

Biceps Brachii

Wrist Flexors

Rectus Abdominals

Adductor Longus

Rectus Femoris

Tibialis Anterior

Trapezius

Posterior Deltoid

Teres Major

Triceps Brachii

Gluteus Medius

Gluteus Maximus

Wrist Extensors

Biceps Femoris

Gastrocnemius

Soleus

Antagonistic muscle action

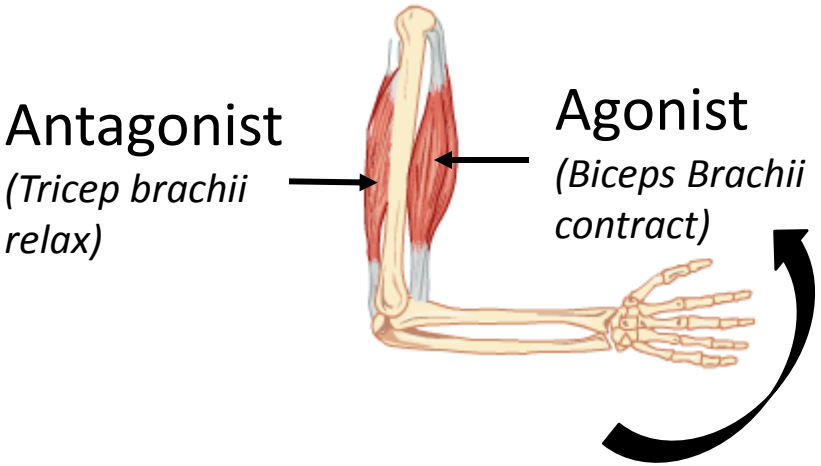
Muscles are arranged in **antagonistic pairs**. As one muscle contracts (shortens) the other relaxes (lengthens).

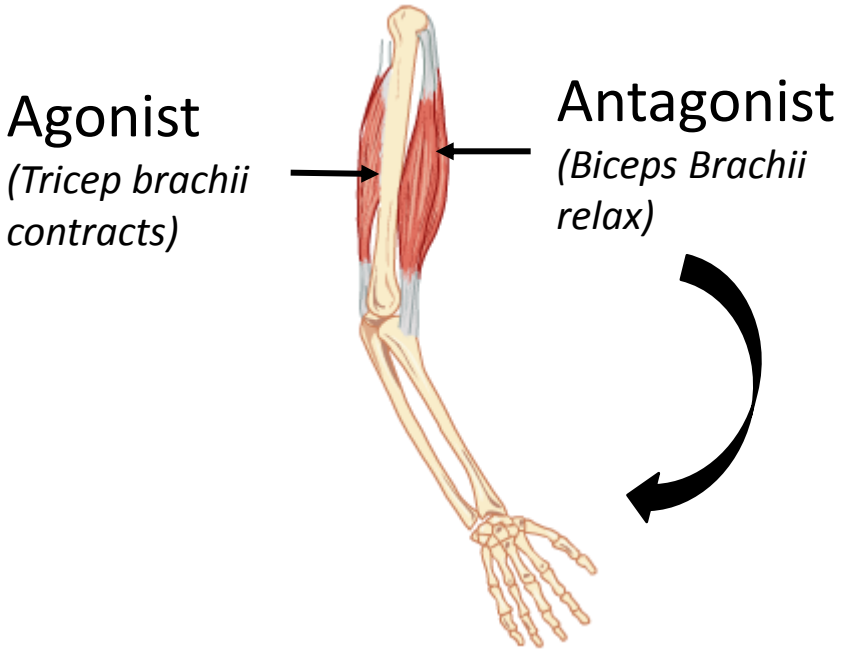
Think. Pair. Share - Can you think of another antagonists pair in the body?

Antagonistic muscle action

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 – a muscle that stabilises one part of a body while the other moves.

Antagonistic muscle action

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.

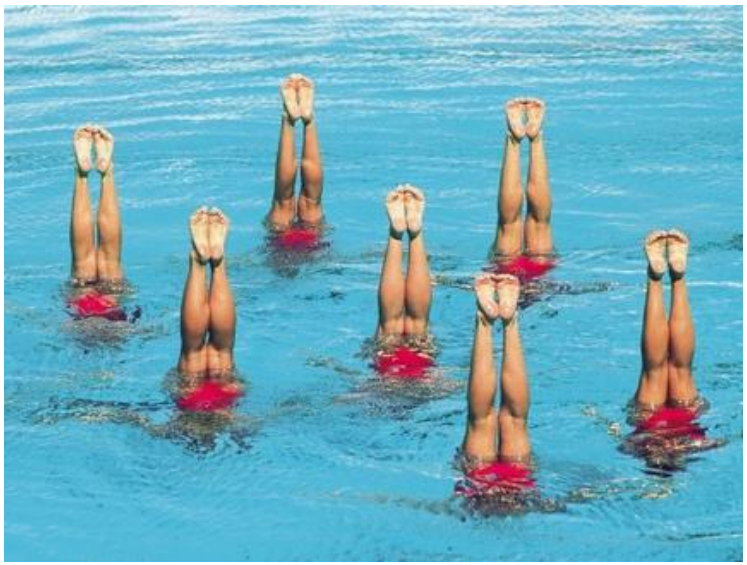
Isometric contraction is when the muscle contracts without lengthening or shortening. The result is that no movement occurs.

To hold the body in a particular position (e.g. 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.

e.g. 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)

Movement analysis

- https://youtu.be/BZMn9ShO08w

Movement analysis

Flexion involves a *decrease* in the angle that occurs around a joint.

i.e. radius and the humerus to decrease.

Movement analysis

Extension involves an increase in the angle that occurs around a joint.

i.e. straightening the elbow causes an increase in the angle between the humerus and the ulna/radius.

Movement analysis

Planter Flexion is a term used solely for the ankle joint. It involves bending the foot downwards, away from the tibia.

i.e. action of moving up onto toes or pointing toes.

Movement analysis

Dorsi Flexion is bending the foot upwards towards the Tibia.

i.e. - Action of pulling up toes towards the body.

Movement analysis

Adduction - Movement towards midline of the body

Abduction - Movement away from midline of the body

Movement analysis

Horizontal flexion:

Movement of the arm across the body in the horizontal (transverse) plane.

Movement analysis

Horizontal extension:

Movement of the arm away from the body in the horizontal (transverse) plane

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 CONTRACTIONS

3 types of Contraction:

1. ISOMETRIC -

2. ISOTONIC -

a. CONCENTRIC -

b. ECCENTRIC -

Joint	Type	Articulating Bones	Movement Allowed	Agonist	Type of Contraction	Antagonist	Type of Contraction
Wrist	Condyloid	Carpals Radius Ulna					

Joint	Type	Articulating Bones	Movement Allowed	Agonist	Type of Contraction	Antagonist	Type of Contraction
Elbow	Hinge	Humerus Radius Ulna					

Joint	Type	Articulating Bones	Movement Allowed	Agonist	Type of Contraction	Antagonist	Type of Contraction
Shoulder	Ball and Socket						
				,		,	

MUSCLE CONTRACTIONS

3 types of Contraction:

1. **ISOMETRIC** - where the muscle length remains the same whilst contracting.

2. **ISOTONIC** - where the muscle is moving whilst contracting. 2 types:

a. **CONCENTRIC** - This where the muscle shortens & contracts.

b. **ECCENTRIC** - Where the muscle lengthens & contracts.

Joint	*Type*	*Articulating Bones*	*Movement Allowed*	*Agonist*	*Type of Contraction*	*Antagonist*	*Type of Contraction*
Wrist	Condyloid	Carpals Radius Ulna	**Flexion**	**Wrist Flexors**	Concentric	Wrist Extensors	Eccentric
			Extension	**Wrist Extensors**	Concentric	Wrist Flexors	Eccentric
			Abduction		Concentric		Eccentric
			Adduction		Concentric		Eccentric

Joint	*Type*	*Articulating Bones*	*Movement Allowed*	*Agonist*	*Type of Contraction*	*Antagonist*	*Type of Contraction*
Elbow	Hinge	Humerus Radius Ulna	**Flexion**	**Biceps Brachii**	Concentric	Triceps Brachii	Eccentric
			Extension	**Triceps Brachii**	Concentric	Biceps Brachii	Eccentric
Joint	*Type*	*Articulating Bones*	*Movement Allowed*	*Agonist*	*Type of Contraction*	*Antagonist*	*Type of Contraction*
Shoulder	Ball and Socket	Head of Humerus Glenoid Fossa cavity of Scapula	**Flexion**	**Anterior Deltoid**	Concentric	Posterior Deltoid	Eccentric
			Extension	**Posterior Deltoid**	Concentric	Anterior Deltoid	Eccentric
			Hz Flexion	**Pectoralis Major**	Concentric	Trapezius	Eccentric
			Hz Extension	**Trapezius**	Concentric	Pectoralis Major	Eccentric
			Adduction	**Lattisimus Dorsi**	Concentric	Middle Deltoid	Eccentric
			Abduction	**Middle Deltoid**	Concentric	Lattisimus Dorsi	Eccentric
			Medial Rotation	**Subscapularis, Teres Major**	Concentric	Infraspinatus, Teres Minor	Eccentric

The Shoulder joint

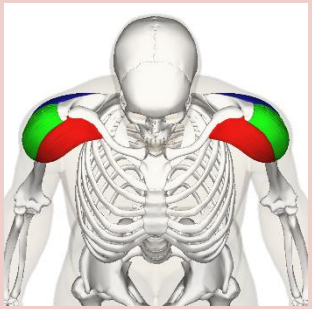
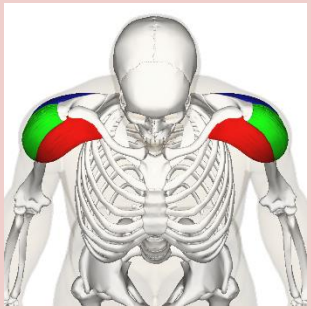
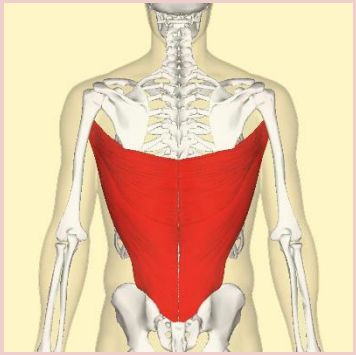
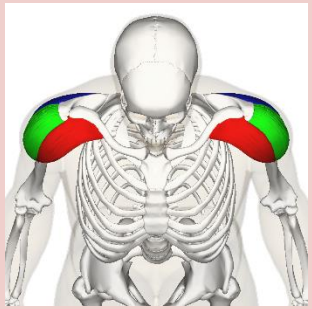
The shoulder is a **ball and socket joint** where the head of the **humerus** fits into a cavity on the **scapula**.

This type of joint allows the most movement.

Its structure also makes it one of the least stable joints, so it is heavily reliant on ligaments and muscles to increase its stability.

The Shoulder joint

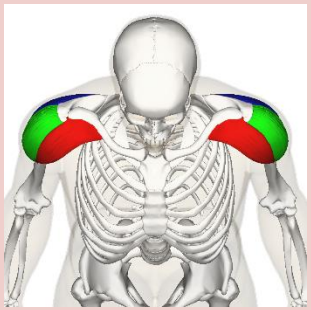
The following muscles listed are the **agonists** responsible for the movement pattern.

Flexion	Extension	Adduction	Abduction
Anterior Deltoid (red) 	**Posterior Deltoid (blue)** 	**Latissimus Dorsi** 	**Middle Deltoid (green)** 

The Shoulder joint

Transverse Plane:

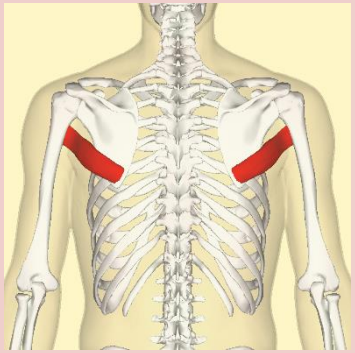
Horizontal Flexion	Horizontal Extension
Pectoralis Major	Posterior Deltoid (blue)

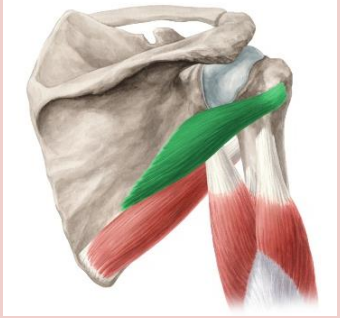


The Shoulder joint

Transverse Plane:

Medial Rotation	Lateral Rotation
Teres Major Subscapularis	Teres Minor Infraspinatous





The elbow joint

The elbow is a **hinge joint**, with the distal (far) end of the **humerus** articulating with the proximal (near) end of the **radius** and **ulna**.

Movement can take place in one plane only, allowing only flexion and extension

The elbow joint

Sagittal Plane:

Flexion	Extension
Biceps Brachii	Triceps Brachii

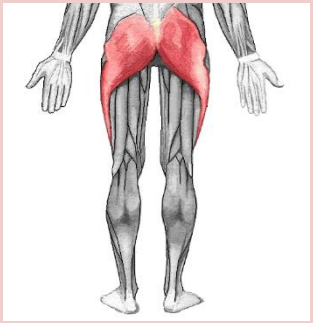
The wrist joint

The wrist is a **condyloid joint**, with the **radius, ulna** and **carpals** making up the joint.

Flexion	Extension
Wrist Flexors 	**Wrist Extensors** 

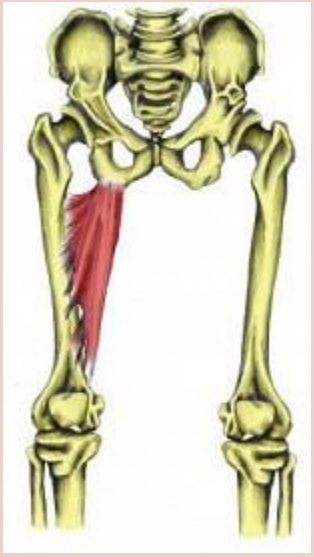
The Hip joint

The hip is a **ball-and-socket joint** where the head of the **femur** fits into the **pelvic girdle**.

Flexion	Extension
Action created by the **Iliopsoas**.  	**Gluteus Maximus.**  

The Hip joint

Adduction	Abduction
Adductor longus Adductor Brevis Adductor Magnus	Gluteus Maximus Gluteus Minimus Gluteus Medius



The Knee joint

The knee is classed as a **hinge joint** and allows **flexion** and **extension** only.

Flexion:
During the preparation for the action (backlift) the **biceps femoris, semitendinous and semimembranosus concentrically** contract.

Extension:
The downward kicking action involves the contraction of the **rectus femoris, vastus lateralis, vastus intermedius and vastus medialis.**

The Ankle joint

The ankle is a **hinge joint** where the articulating bones are the **tibia** and **fibula**. The main muscles that control movement in this joint are the **gastrocnemius**, **soleus** and the **tibialis anterior**.

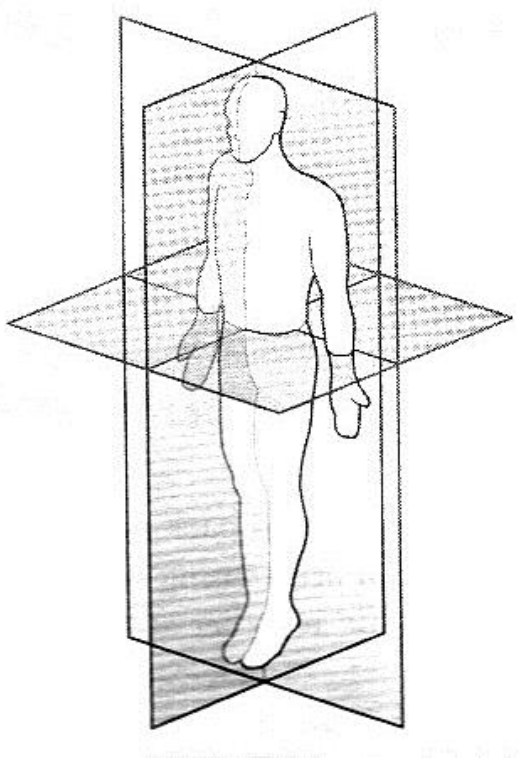
These muscles allow **plantarflexion** and **dorsiflexion** movement.

Planes of movement

To help explain movement, the body can be viewed as having a series of imaginary slices/glass panes running through it.

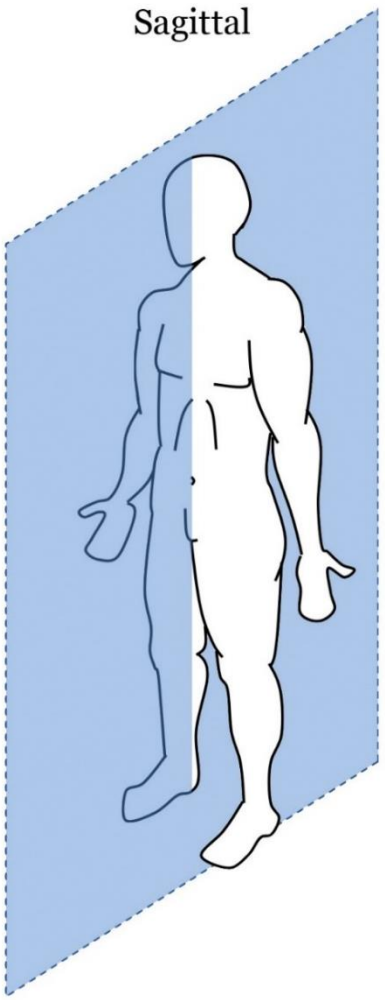
These are referred to as **planes of movement.**

For a movement to take place within a particular plane it must be parallel to that plane.



Planes

1.The **sagittal plane** is a vertical plane that divides the body into right and left sides.

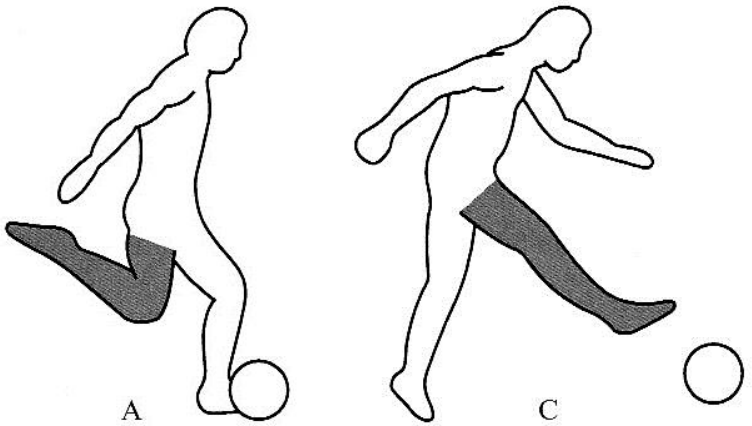


Think. Pair. Share – what joints in the body are capable of moving in the sagittal plane?

Sagittal Plane

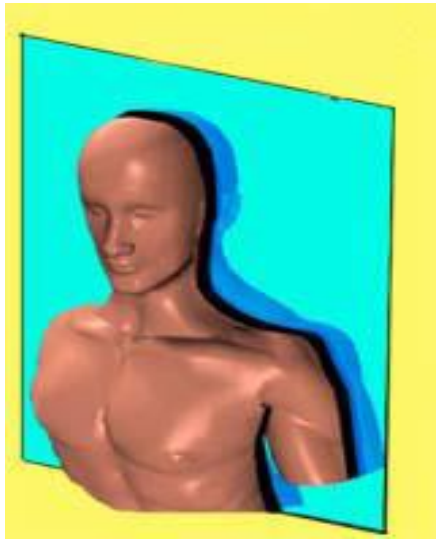
The hinge joint is responsible for these movements.

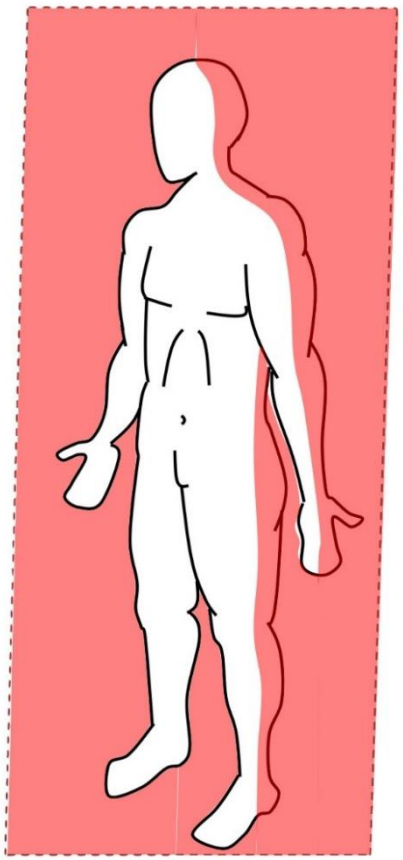
- Flexion and extension of the wrist, elbow, shoulder and knee.
- Dorsi flexion and plantar flexion at the ankle.



Planes

2.The **frontal plane** is also a vertical plane but this divides the body into front and back.

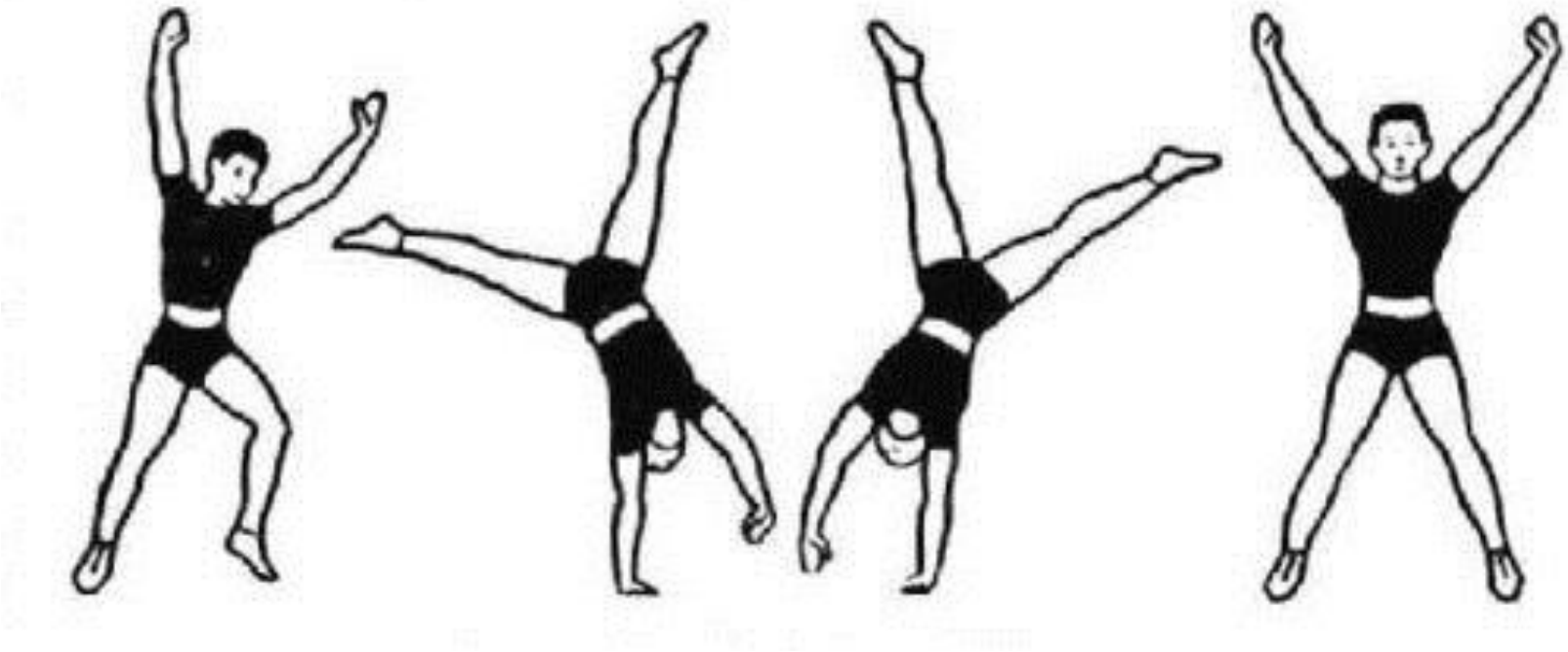




Think. Pair. Share – what joints in the body are capable of moving in the frontal plane?

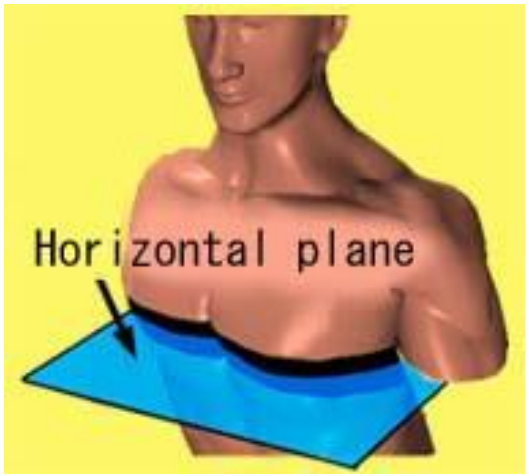
Frontal Plane

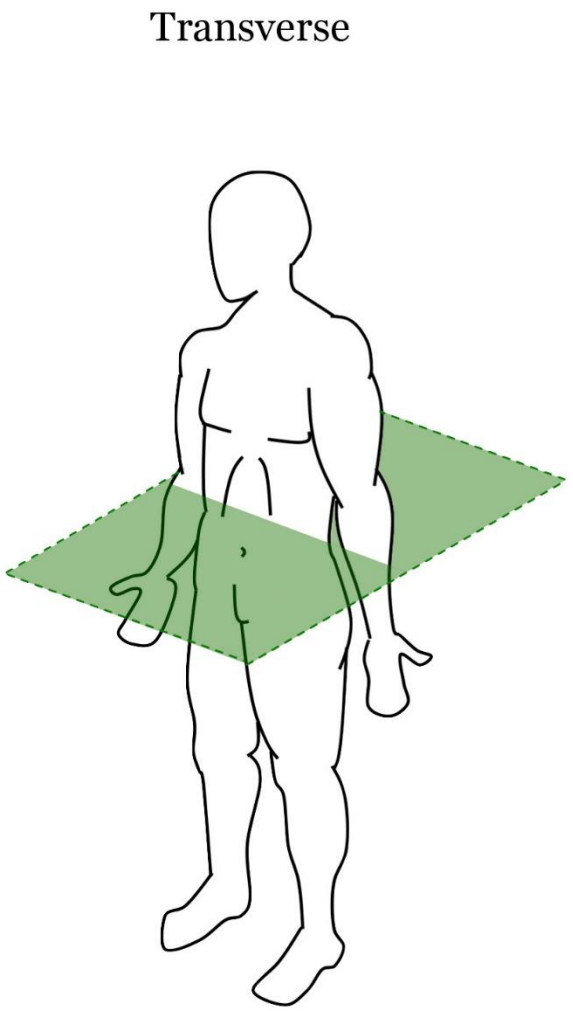
Adduction and **abduction** move articulating bones away or closer to the midline of the body.



Planes

3. The **transverse plane** is a horizontal plane that divides the body into upper and lower halves.





Think. Pair. Share – what joints in the body are capable of moving in the transverse plane?

Transverse Plane

Horizontal flexion and **horizontal extension** occur with the limb is **parallel** to the ground and the arm or leg moves away or closer to the midline of then body.

Planes

Shoulder: Flexion in the sagittal plane.

Think. Pair. Share – What movement has occurred at the shoulder and on what plane?

Planes

Flexion at the hip in the sagittal plane.

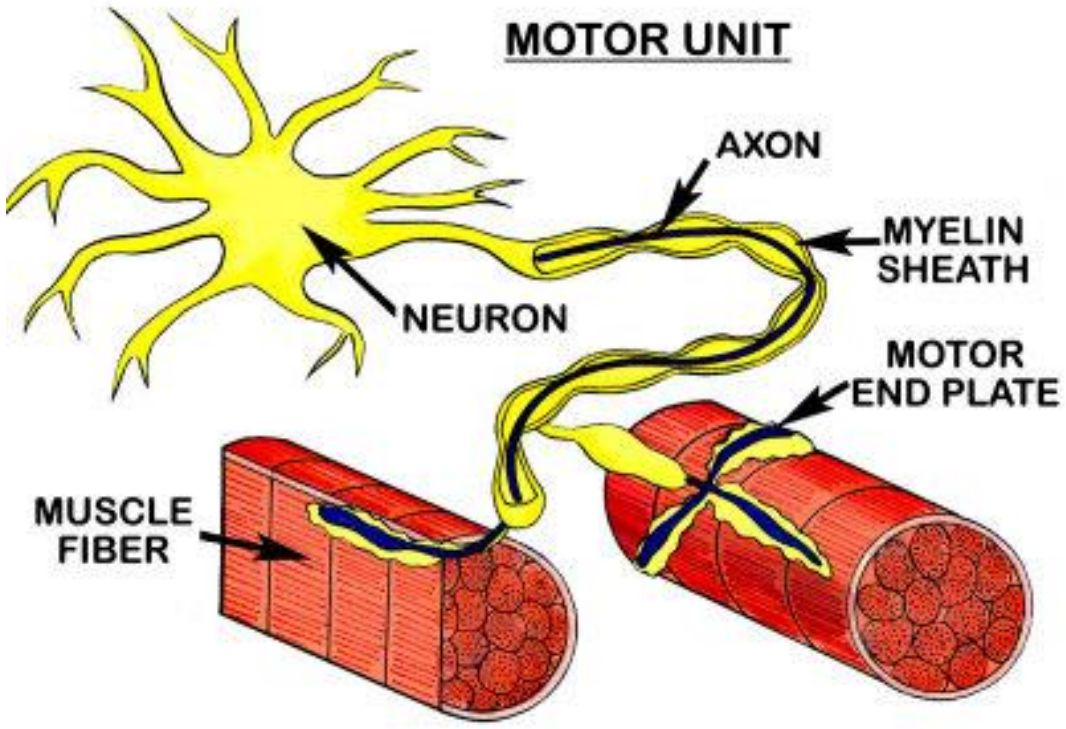
+

Abduction of the legs in the frontal plane.

Think. Pair. Share – What movement has occurred at the hip and on what plane?

The Motor Unit

Muscle contractions occur when an electrical impulse travels down the spinal cord, along motor neurones to the muscle fibres.

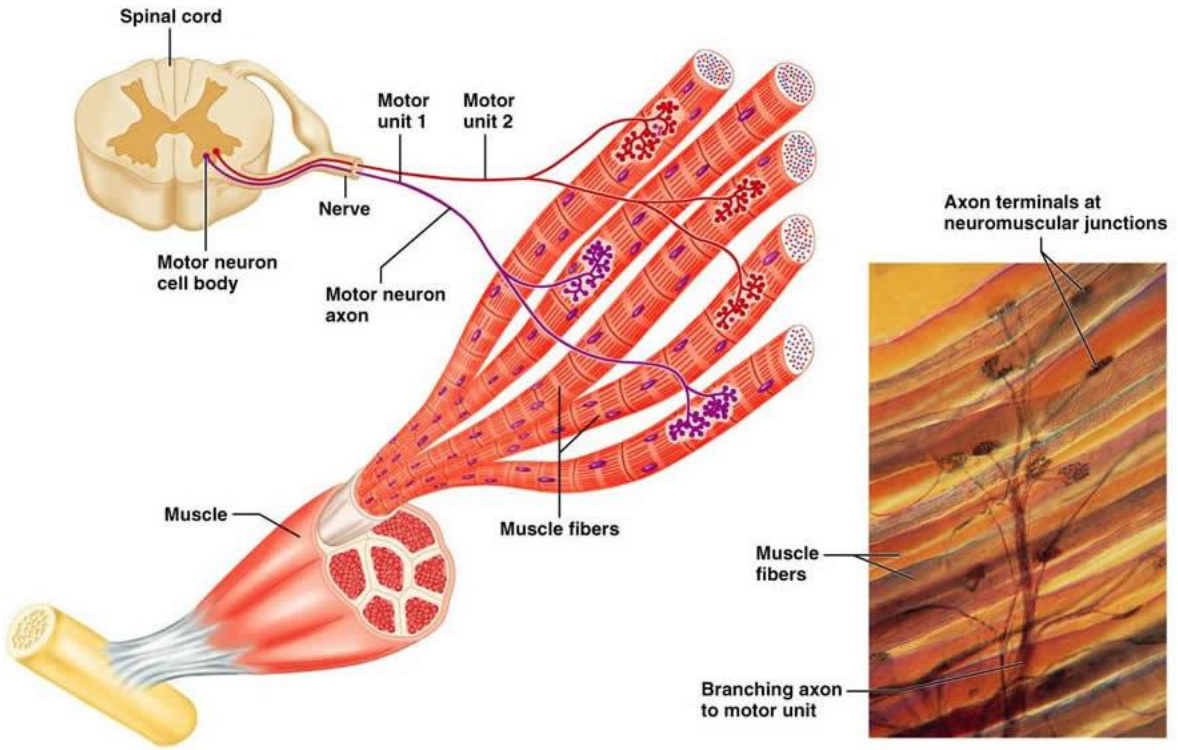


The cell body processes the information and sends an impulse down the axon. The motor neuron and its muscle fibres are called a **motor unit**.

The Motor Unit

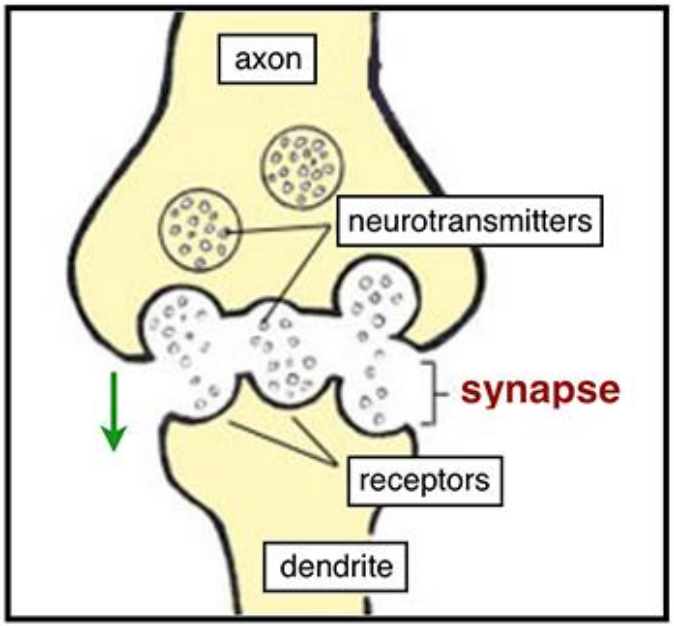
The **motor unit** must carry nerve impulses form the brain and spinal cord to the muscle fibres.

The nerve impulse travelling to the muscle fibre is an electrochemical process which requires **action potential**. This wave of electrical charge moves down the **axon** to the **motor end plate**.



The Motor Unit

As the impulse reaches the end of the **axon**, it triggers the release of **acetycholine** (a neurotransmitter) at the **neuromuscular junction**. This neurotransmitter is secreted into the synaptic cleft to assist the never impulse to cross the gap. If enough neurotransmitter is present muscle action potential is created and a wave of contraction occurs.



One motor neurone cannot stimulate the whole muscle.
Instead, a motor neurone will stimulate a number of fibres within that muscle.

Characteristics of a Motor Unit

The all-or-none law

The motor units exhibit an all-or-none response.

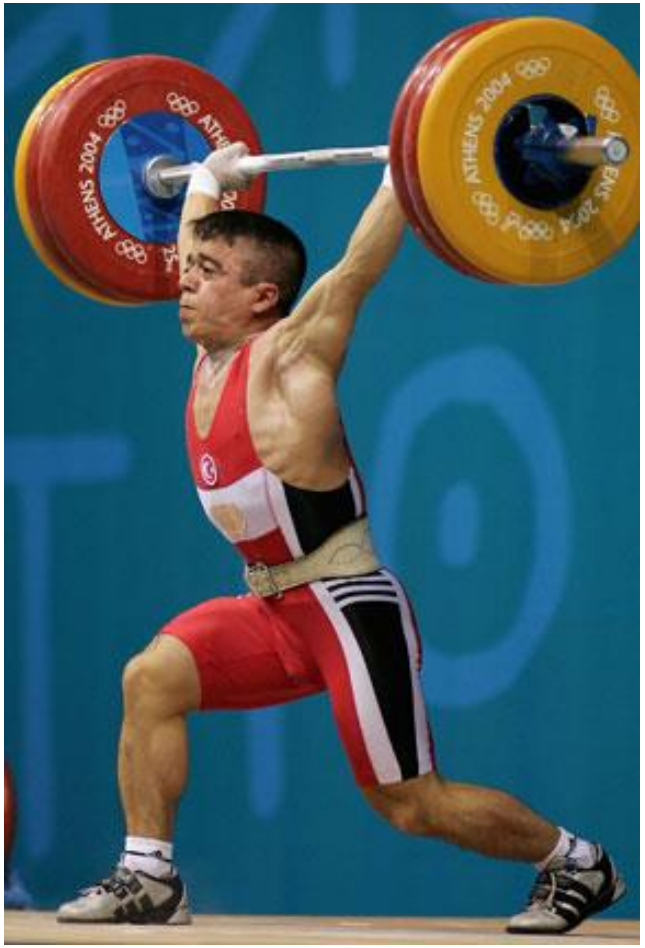
Think. Pair. Share – What is meant by the 'all-or-none' law? Link this to muscle recruitment.

Characteristics of a Motor Unit

A minimum amount of stimulation is required to start a muscle contraction.

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.

Muscle fibre types



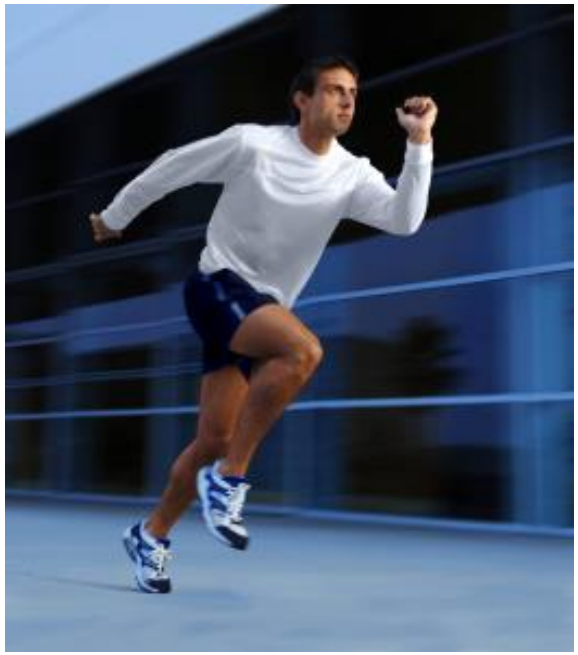
Watch me

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

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

It is possible to increase the size of muscle fibres through training. This increase in size (hypertrophy) is caused by an increase in the number and size of myofibrils per fibre.

Muscle fibre types

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

- Type 1 (slow oxidative or SO)
- Type 2a (fast oxidative glycolytic or FOG)
- Type 2b (or 2x) (fast glycolytic or FG)

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

SO muscle fibres are designed to store oxygen in myoglobin and process it in the mitochondria. This allows aerobic work to take place.

FG and FOG muscle fibres are designed to work under aerobic intensities with large stores of Phosphocreatine used for rapid energy production. However, fatigue is quick and therefore can only sustain contraction for short periods of time.

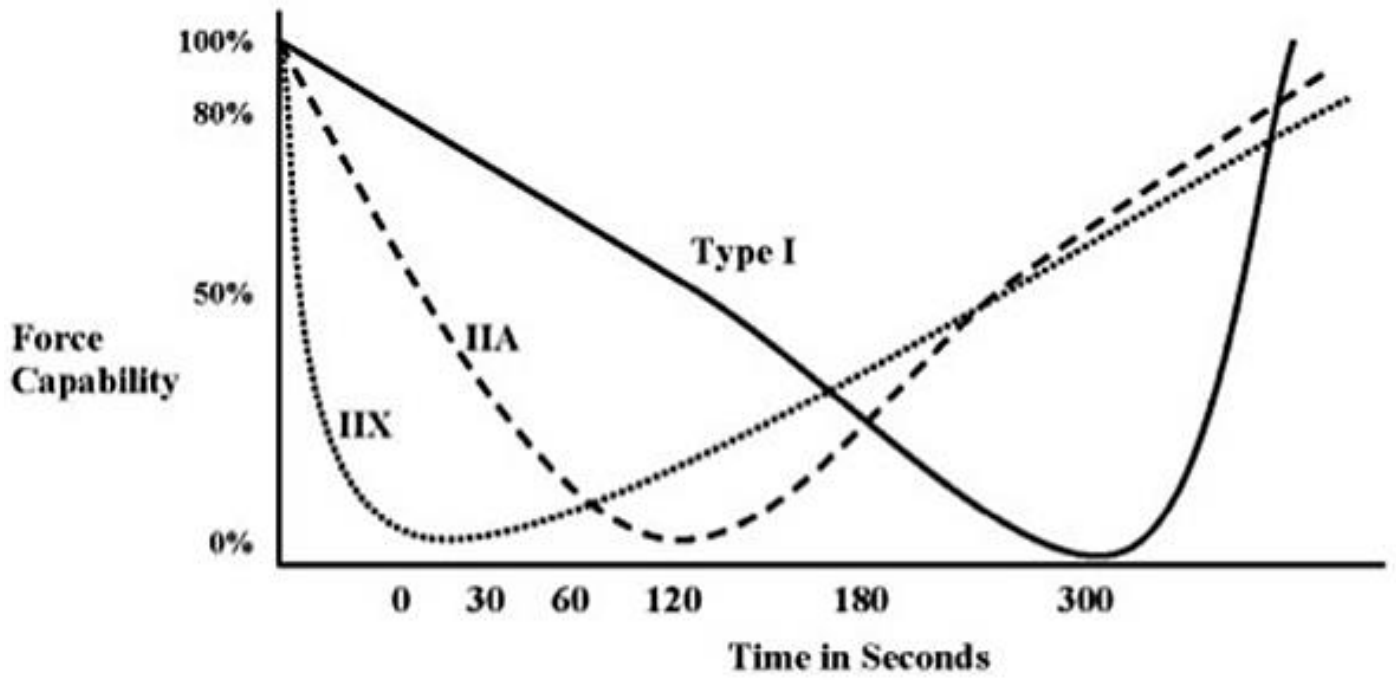
Muscle fibre types

Characteristics of muscles fibre types:

Characteristic	Type I	Type 11a	Type IIx
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

Slow oxidative muscle fibres are recruited and recover very quickly, within 90 seconds.

Aerobic training should therefore have limited rest periods.
i.e. 3 x 800m set with 90 seconds rest.

Muscle fibre types

Fast oxidative muscle fibres only provide 2-20 seconds of contraction. Both FO and FOG types take much longer to fully recover. Training should reflect this, *i.e. 2-6 repetitions with 3-4 minutes rest.*

Apply it!

What has stuck with you?

Describe the 3 planes of movement.

Explain the movement possible at the shoulder and articulating bones, muscle actions and main agonist?

Skeletal and muscular system

Highlight the difference between Isometric and Isotonic muscle contractions

Describe the role of motor units in the muscle contractions process.

Practice it!

Exam questions

1. Consider the following statements: [1 mark]

"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."

(a) (i) Which one of the following is true?

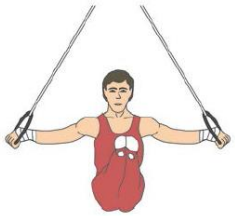
A. Both statements are true
B. The first statement is true, the second is false
C. The first statement is false, the second is true.
D. Both statements are false

Practice it!

Exam questions

2. 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 marks]

Table 1

Type of joint	Main agonist	Joint action

Practice it!

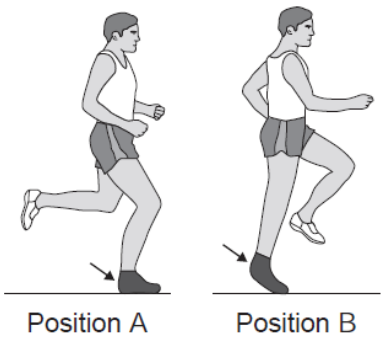
Exam questions

3. 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

4. In order for a muscle to contract, one or more motor units will be stimulated and will follow the 'all or none' law.

(a) Describe the structure of a motor unit. [1]

(b) What is the 'all or none' law? [1]

(c) What is the effect of stimulating more motor units? [1]

Practice it!

Marks Scheme:

1. C

2.

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

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

Practice it!

Marks Scheme:

4.

a. (consists of) a motor neurone and a number of muscle fibres

b. (When stimulated) all the fibres within a motor unit contract completely or not at all

c. Increased strength / force of contraction