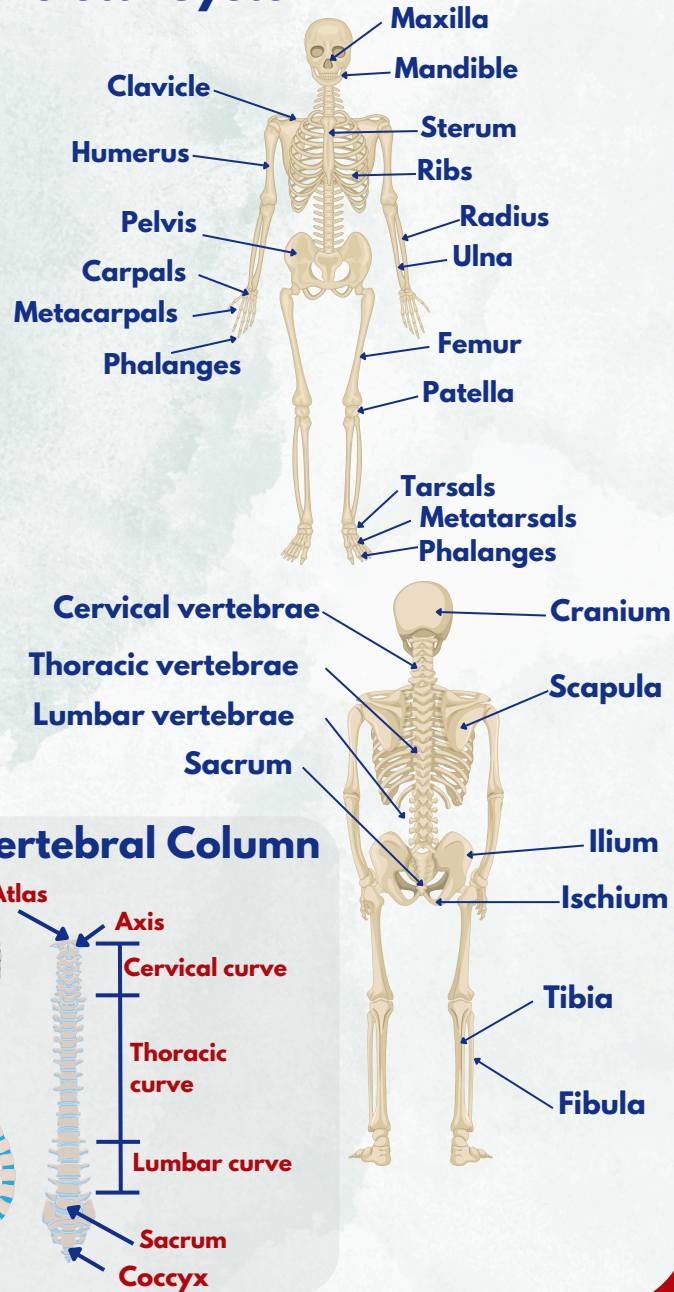


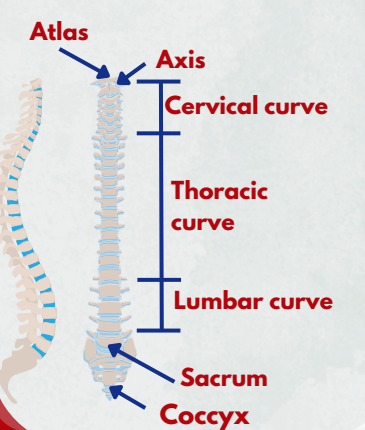
# The PE Classroom

## OCR A Level PE: Musculoskeletal System

### Skeletal System



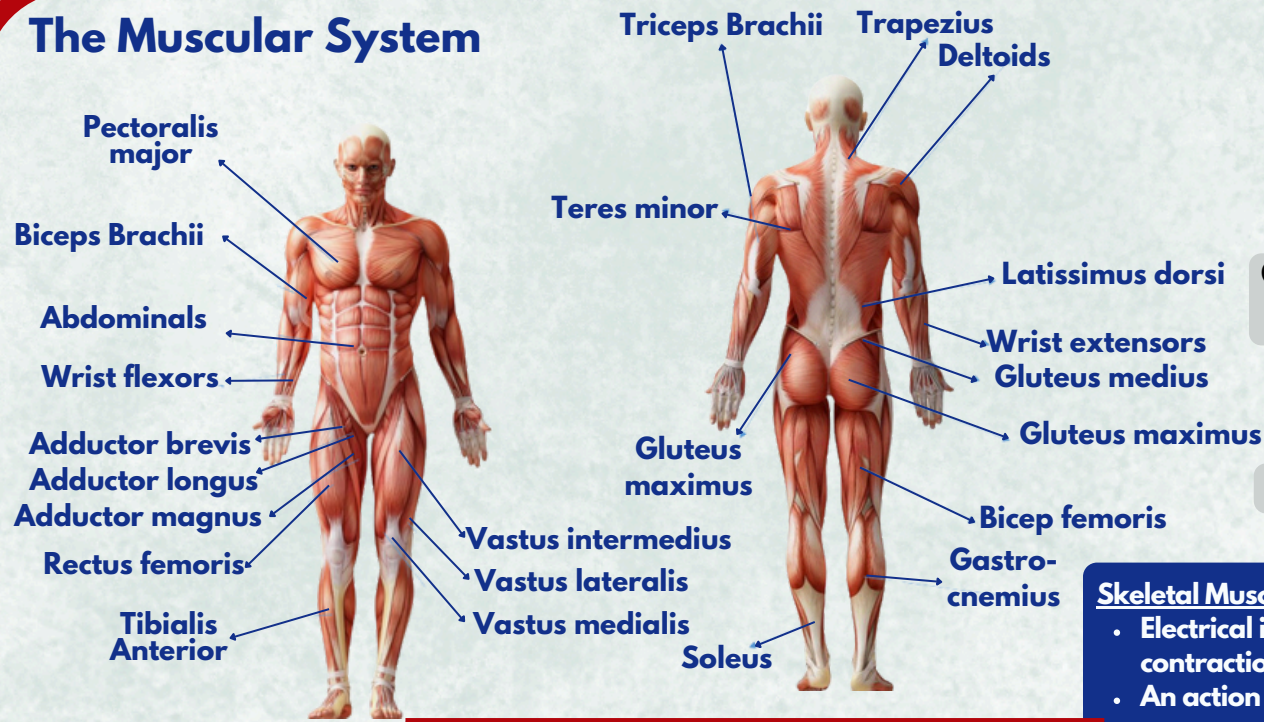
### Vertebral Column



### Articulating Joints

Shoulder Joint	• Humerus • Scapula
Hip Joint	• Pelvis • Femur
Knee Joint	• Femur • Patella • Tibia
Elbow Joint	• Humerus • Ulna • Radius
Ankle Joint	• Tibia • Talus • Fibula

### The Muscular System



Slow Oxidative (Type I)	Fast oxidative glycolytic (Type IIa)	Fast glycolytic (Type IIX)
Slow Twitch	Fast Twitch	Fast Twitch
Slow contractions	Fast contractions	Very fast contractions
Aerobic activity	Fatigue relatively quickly	Fatigue very quickly & fibres damaged
e.g. Marathon	e.g. 800m	e.g. 100m

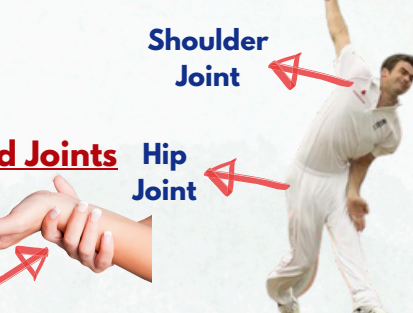
### Synovial Joints

- Where **two or more** bones meet
- Allow for **movement and rotation**

#### Hinge Joints



#### Ball & Socket Joints



**Flexion** - narrowing of the angle at a joint



**Adduction** - movement towards the body midline



**Extension** - widening of the angle at a joint



**Horizontal Adduction** - movement towards the body from a 90 degree position



**Hyperextension** - beyond 180 degrees



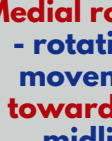
**Plantarflexion** - widening of the angle at the ankle joint



**Abduction** - movement away from the body midline



**Medial rotation** - rotational movement towards the midline



**Dorsiflexion** - narrowing of the angle at the ankle joint

**Lateral rotation** - rotational movement away from the midline

**Horizontal Abduction** - movement away the body from a 90 degree position



**Antagonistic Pairs** - As one muscle **CONTRACTS**, another muscle will **RELAX**:-

- Biceps & Triceps**
- Quadriceps & Hamstrings**
- Gastrocnemius & Tibialis Anterior**
- Hip Flexors & Gluteals**
- Pectorals & Deltoid**
- Abdominals & Latissimus Dorsi**

**Fixator** muscle **stabilises** one part of the body while another part moves

In an **isometric** muscle contraction, a muscle contracts but **does NOT change in length** (no movement)

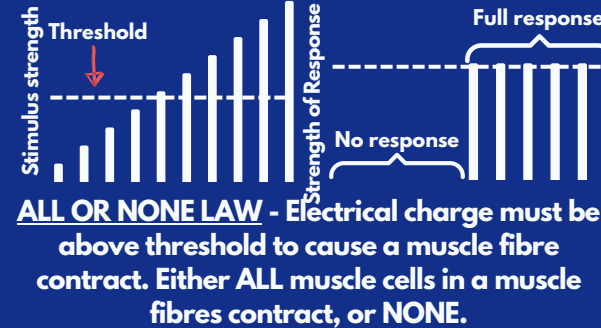
In an **isotonic** muscle contraction, the muscle **changes in length**

**Concentric** contraction - the muscle **shortens** and **generates force**

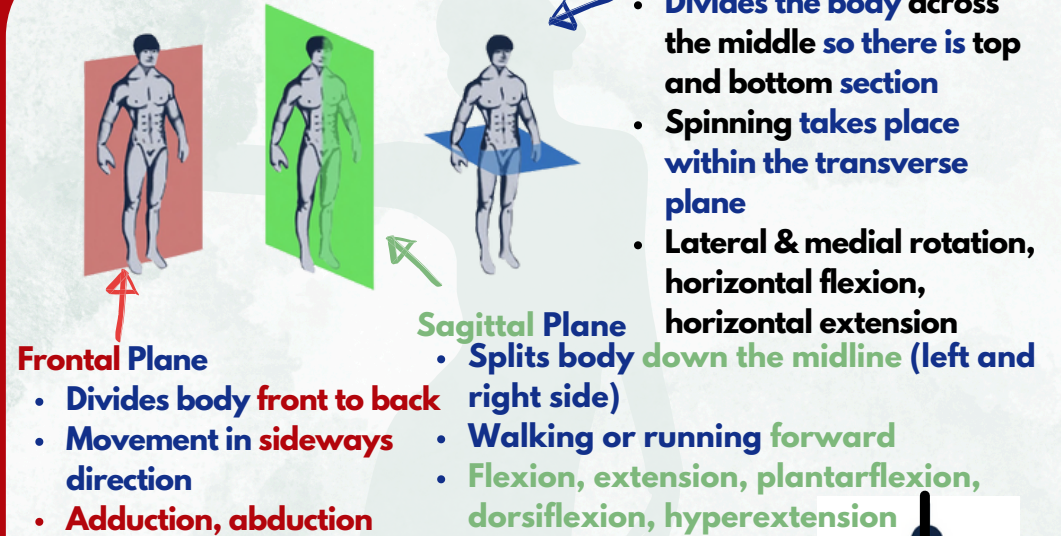
**Eccentric** contraction - the muscle **lengthens** due to a **greater opposing force**

### Skeletal Muscle Contraction

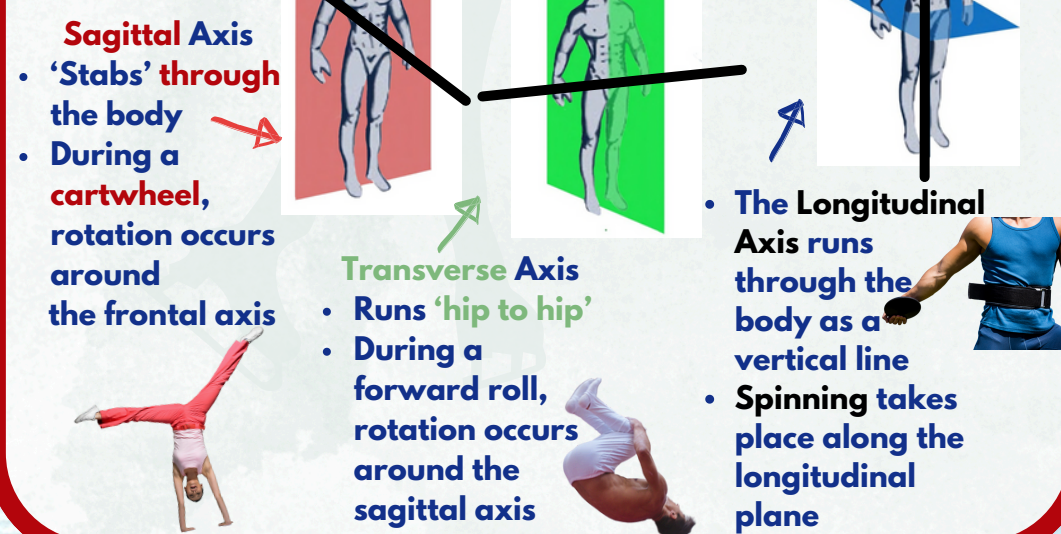
- Electrical impulses from the CNS stimulate contraction
- An action potential (+) conduct down motor neurones from CNS -> muscle fibres
- Neurotransmitter (acetylcholine) secreted into the synaptic cleft at the neuromuscular junction transmit the impulse across the gap (axon -> synaptic cleft -> muscle fibres)



### Planes of Movement

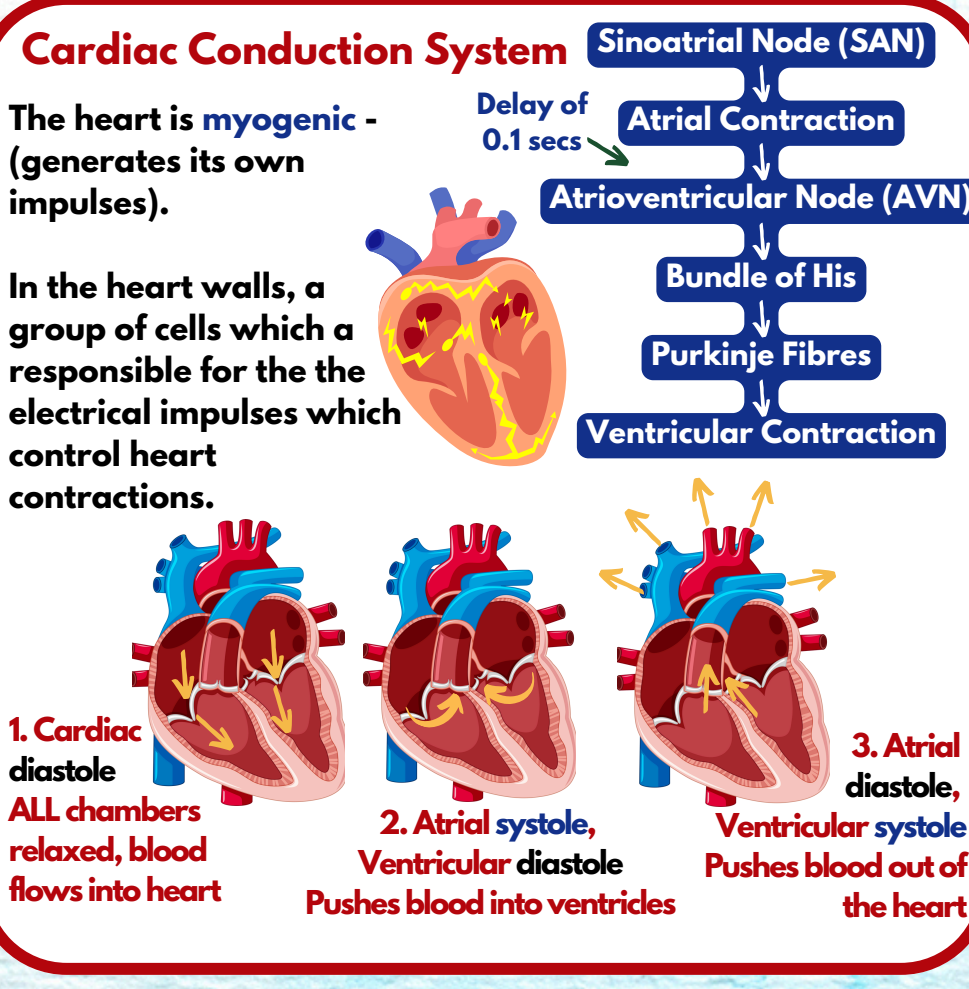
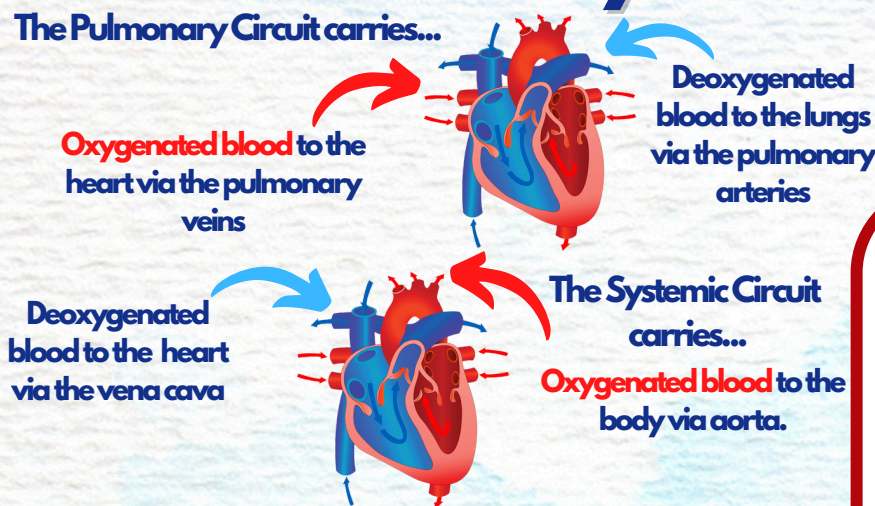
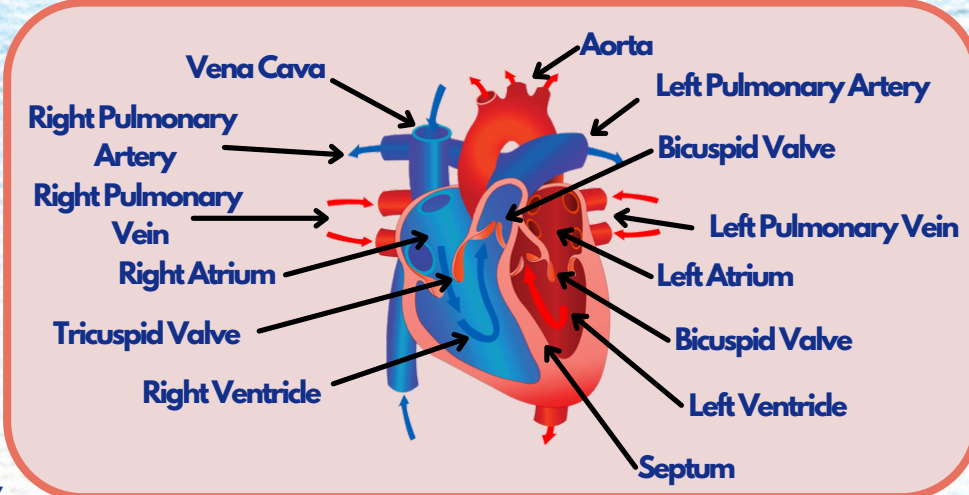


### Axes of Rotation

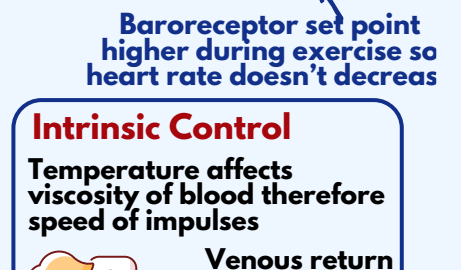
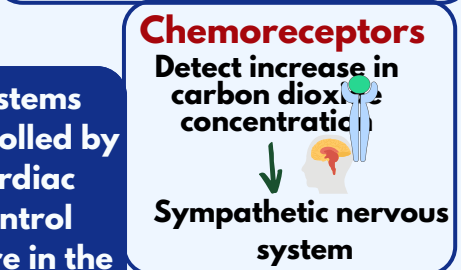
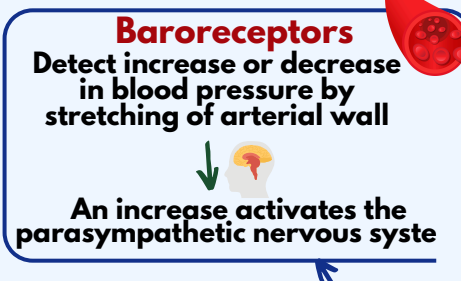
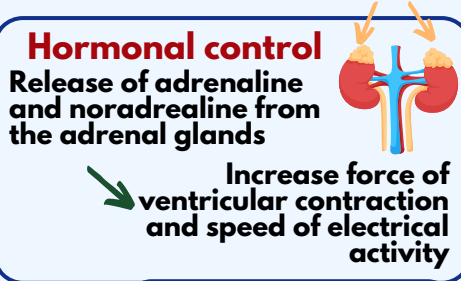
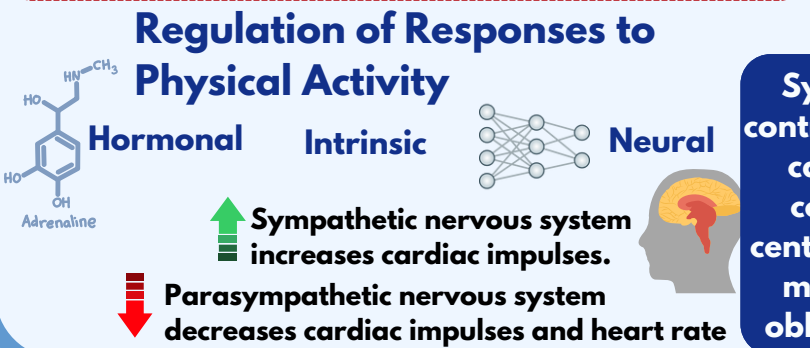
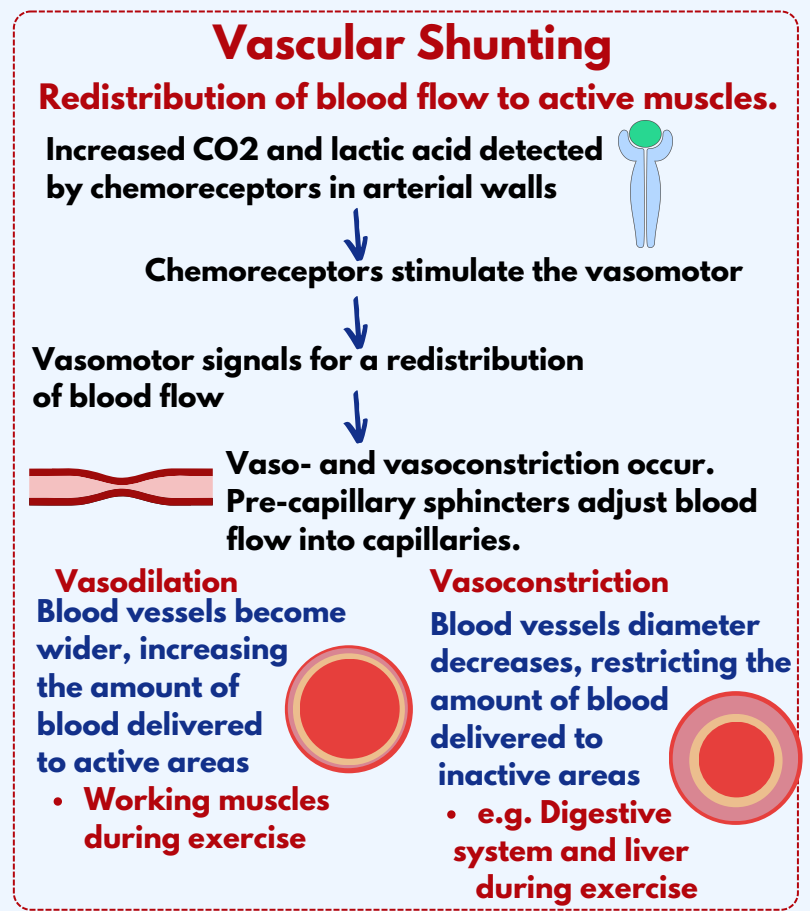


# The PE Classroom

## OCR A level PE: The Cardiovascular System



### Redistribution of Blood Flow



### Assessing 'Fitness'

**Stroke Volume (SV)**: Amount of blood ejected the left ventricles during one cardiac cycle. Depends on venous return and ventricular elasticity & contractility

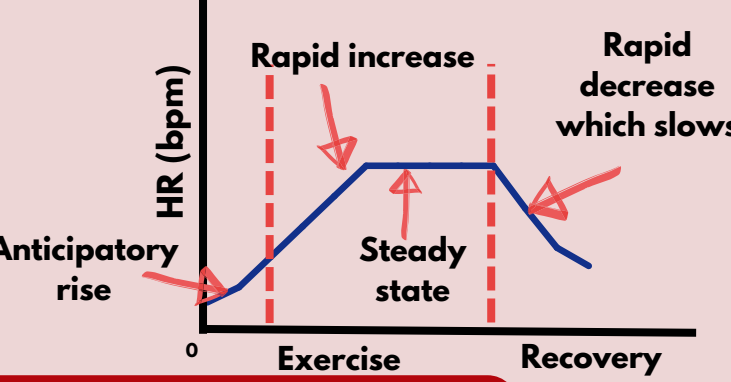
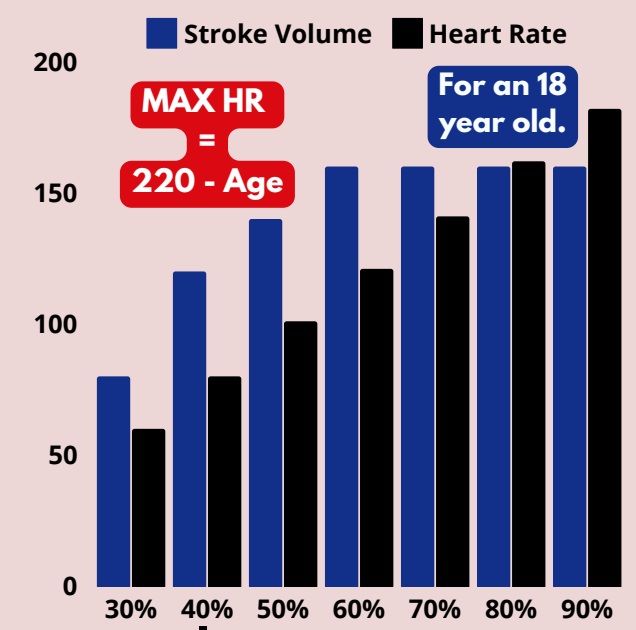
**Heart rate (HR)**: No. of cardiac cycles per minute

Higher stroke volume and cardiac output indicate higher levels of cardiovascular fitness

**Cardiac output (CO)**: Volume of blood pumped out by the heart ventricles per minute

**CO = HR x SV**

Stroke volume - measured in ml  
Cardiac output - measured in litres/min  
**REMEMBER to DIVIDE SV by 1000**



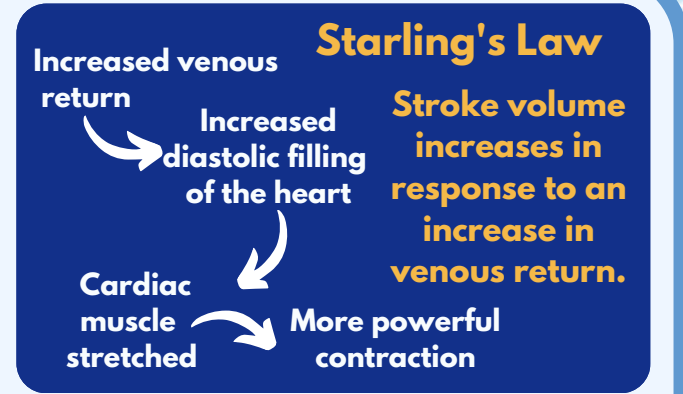
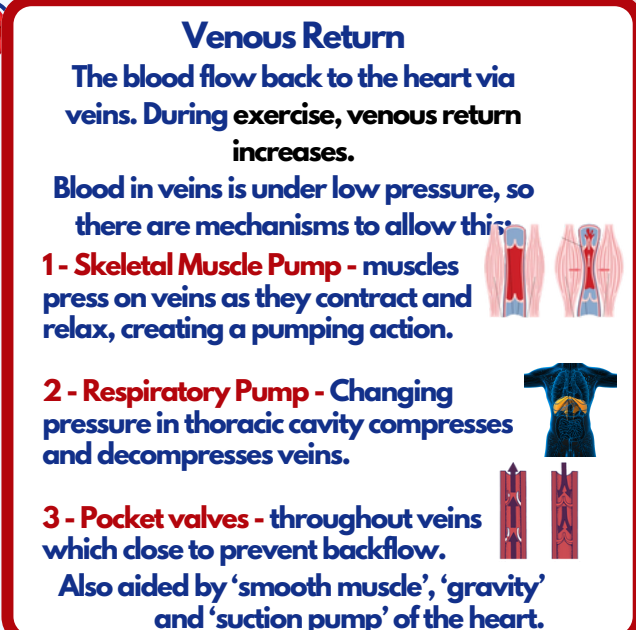
SV increases up to about 60% of max effort, when HR becomes too high for ventricles to fully fill

**BUT**  
HR and CO continue to increase up to max HR so oxygen supply continues to increase

**Anticipatory Rise**  
Increase in HR just before exercise  
Activated when a 'fight or flight' response is required.

↑ Sympathetic nervous system activity  
↑ heart rate, blood pressure and alertness.

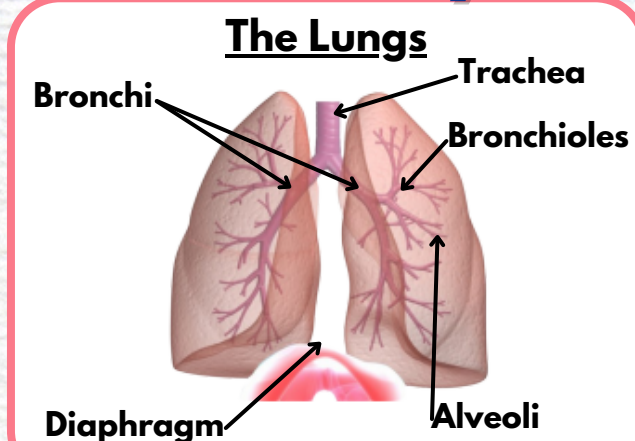
Sub-maximal exercise - up to 85% max HR  
Maximal exercise - 85-100% max HR



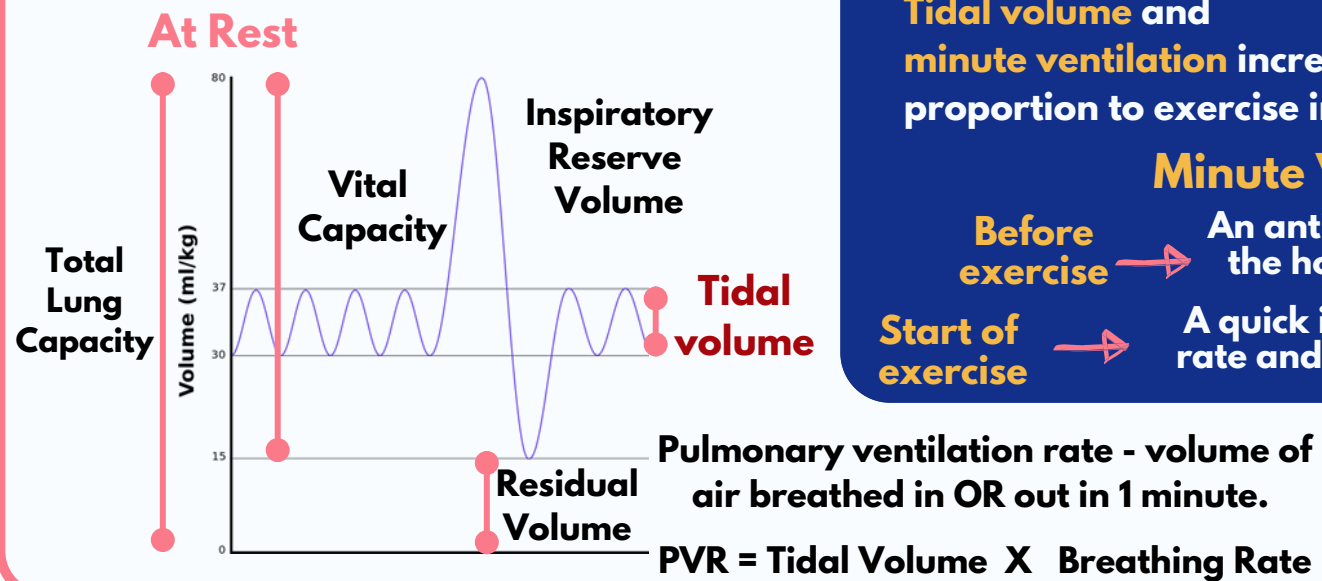


# The PE Classroom

## OCR A level PE: The Respiratory System



### Spirometer Trace -



**During Exercise** ↑

Tidal volume and minute ventilation increase in proportion to exercise intensity

**Minute Ventilation**

**Before exercise** → An anticipatory rise due to the hormone adrenaline

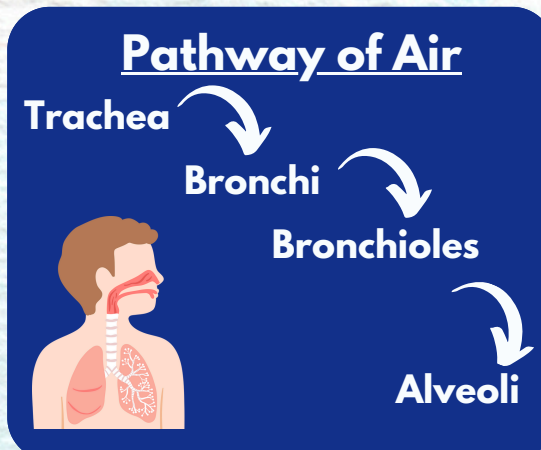
**Start of exercise** → A quick increase as breathing rate and tidal volume increase

**Sustained exercise intensity** → A steady state as oxygen supply meets the demands and waste is removed

**Start of recovery** → Initial rapid decrease to resting levels as oxygen demand decreases

**Minute ventilation** = No. breaths per minute × Tidal Volume

Volume of air breathed in and out per minute



**Inhalation** - Diaphragm contracts and flattens

**Exhalation** - Diaphragm relaxes into a dome-shaped

### Mechanics of Breathing During Exercise

**At rest** - As the rib cage expands, the lungs expand, decreasing the pressure inside the lungs, forcing air to enter.

The diaphragm and external intercostal muscles are used for expiration and inspiration.

**Greater expansion of ribcage increases the lung volume & pressure gradient**

**During exercise**, additional respiratory muscles provide a larger force of contraction.

**Sternocleidomastoid & Pectoralis Minor**

**Greater down and inward movement to decrease volume**

**Internal Intercostals & Rectus Abdominis**

**Proprioceptors**

- Sensory nerve endings in muscles and joints
- Information about movements and positioning

### Regulation of Pulmonary Ventilation

**Respiratory Control Centre (RCC)**

**At Rest**

- Inspiratory Centre (IC)**
  - Impulse via phrenic nerve to the diaphragm and external intercostals to stimulate contraction
- Expiratory Centre (RC)**
  - Inactive

**During Exercise**

- Inspiratory Centre (IC)**
  - Increased stimulation of diaphragm and external intercostal muscles
  - Stimulates additional inspiratory muscles: sternocleidomastoid and scalene increasing force of inhalation
- Expiratory Centre (RC)**
  - Stimulates internal intercostals, abdominals and Latissimus dorsi, creating a forced expiration

Sympathetic nervous system increases breathing rate.

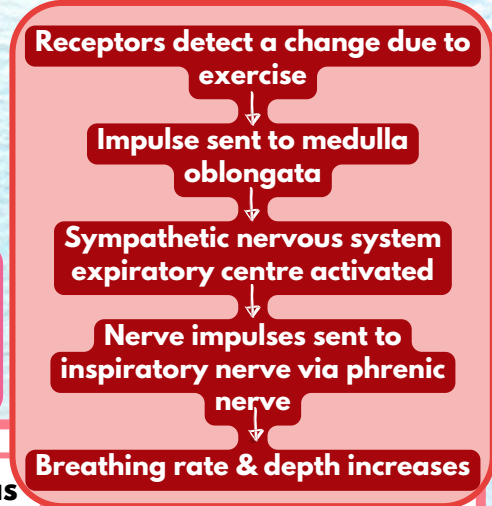
Parasympathetic nervous system decreases breathing rate.

**Chemoreceptors**

- Detect changes in blood acidity caused by CO<sub>2</sub> concentration change
- In carotid arteries

**Baroreceptors**

- Detect changes in blood pressure
- In the aortic arch & carotid sinus tissues, heart & pulmonary vessels



### Respiration

The process of taking in oxygen and removing carbon dioxide

**Internal Respiration** - exchange between capillary blood and respiring cells

**Cellular respiration** - metabolic reactions in the cell to obtain energy from glucose

**External Respiration** - exchange between lungs and blood

**Ventilation** - Inspiration and expiration of air

### Gaseous Exchange

Movement of oxygen from the air into the blood and the removal of carbon dioxide from the blood into the air.

**Alveoli**

- Good blood supply
- One cell thick
- Large surface area

**Partial Pressure** The pressure exerted by an individual gas when it exists within a mixture of gases.

**Diffusion down a concentration gradient**

How gases flow from area of high concentration to an area of low concentration. Steeper gradient = faster diffusion rate.

**At Lungs**

- Low pCO<sub>2</sub> in alveoli (40mmHg)
- High pO<sub>2</sub> in alveoli (100mmHg)
- High pCO<sub>2</sub> in blood vessel (46mmHg)
- Low pO<sub>2</sub> in blood vessel (40 mmHg)

**At Muscles**

- High pO<sub>2</sub> in the blood (100mmHg) and low pO<sub>2</sub> (5mmHg) in the muscles
- Oxygen moves from blood to muscles
- High pCO<sub>2</sub> in the muscles (46mmHg) and low pCO<sub>2</sub> in the blood (40mmHg)
- Oxygen moves from muscles to blood



# The PE Classroom

## OCR A level PE: Energy Systems

### Adenosine Triphosphate

**Breakdown**  
Adenosine - Phosphate - Phosphate - Phosphate

In muscle cells, the energy from this exothermic reaction can be used for muscular contraction.

**Resynthesis**  
Adenosine - Phosphate - Phosphate - Phosphate

ATP is produced from the ADP and P molecules in this endothermic reaction

**'Energy currency'**  
When chemical bonds are broken, energy is released:

**Exothermic Reaction (Gives off heat/energy)**  
ATP → ADP + P + Energy

**Endothermic Reaction (Requires heat/energy)**  
ADP + P + Energy → ATP

ATP stores in muscles cells are enough for 2-3 minutes of high intensity exercise.

ATP is re-synthesised in 3 main ways, the predominant way dependent on intensity and duration of activity.

### ATP-PC System

ATP = Adenosine Triphosphate  
PC = Phosphocreatine

Maximal activity, up to 10 seconds.

1. Anaerobic breakdown of PC into creatine and phosphate

ck - Creatine kinase released when ADP & P levels rise in sarcoplasm

Coupled reaction  
2. Breakdown of PC into free phosphate and energy synthesises 1 ATP

Energy → ATP

ADP + P → Energy

### Anaerobic Glycolytic System

When ATP/PC system is exhausted, glucose is the next source, but broken down without oxygen.

Glucose → Pyruvic Acid → Lactic Acid

PFK (Phosphofruktokinase) → 2 x ATP

LDH (Lactate Dehydrogenase) → Lactic Acid

1. Glycolysis  
2. Lactate Dehydrogenase breaks down pyruvic acid, lactic acid by-product

Lactic acid inhibits the release of enzymes by lowering pH.

Can be predominantly used for up to 3 minutes before fatigue occurs

### Fitness Levels

**VO2 max** - Maximum volume of oxygen transported per minute. Measures efficiency of the cardiorespiratory system. The higher VO2 max, the greater ability to exercise at higher intensities using aerobic energy systems, so avoid using anaerobic systems

**Lactate Accumulation** - the increase of lactate as a result of anaerobic activity.

**Lactate threshold** - the point during exercise at which lactic acid quickly accumulates in the blood.

**OBLA (onset of blood lactate accumulation)** - the point at which blood lactate levels go above 4 millimoles per litre.

**Buffering Capacity** - the ability of hydrogen carbonate ions to neutralise these effects of lactic acid.

ATP-PC	GLYCOLYTIC	AEROBIC
1 ATP produced per cycle	2 ATP produced per cycle	36-38 ATP produced per cycle
Type IIX fast twitch muscle fibres	Type IIa fast twitch muscle fibres	Type I slow twitch muscle fibres
Lasts up to 10 seconds	Lasts up to 3 minutes	Can last up to several hours
e.g. Shot put	e.g. 800m	e.g. Marathon running

### Intermittent exercise

When a sport alternates between lower and higher intensities, the predominate energy system used will change

Drive to a tackle - ATP-PC system

Standing in the wall - aerobic system

Lipase → Triglycerides → Glycerol + Free Fatty Acids

Free Fatty Acid (FFAs) Fuel Store

Is a huge fuel store - free fatty acids produces more acetyl-CoA than glucose, however 15% more oxygen is required.

### Aerobic Energy System

1. Glycolysis  
2. The Krebs Cycle  
3. The Electron Transport Chain

Up to 38 ATP are produced across the 3 stages.

**1. Glycolysis**  
Carbohydrates prepared for energy release by being broken down to pyruvic acid (pyruvate) Phosphofruktokinase Enzyme  
2 ATP resynthesised

**2. The Krebs Cycle**  
Pyruvic acid converted to acetyl coenzyme-A  
Acetyl coenzyme-A combined with oxaloacetic acid forms citric acid  
Further chemical reacted yield energy - 2 ATP  
Hydrogen atoms removed and transported to the cristae of mitochondria by carriers NAD and FAD  
CO2 by-product

**3. Electron Transport Chain**  
Hydrogen atoms move along the cristae and split into ions and electrons. Ions oxidised and released as water.  
H atoms carried by NAD → 30 ATP  
H atoms carried by FAD → 4 ATP  
36-38 ATP - 1 glucose molecule

### Energy continuum graph

A - ATP-PC/Glycolytic threshold  
The point at which PC stores are depleted and glycolytic system becomes predominant.

B - Glycolytic/aerobic threshold  
When there is sufficient oxygen and intensity reduction for the aerobic system to become predominant.

y axis - % energy supplied by each energy system  
x axis - time

### Factors that can affect the transfer to anaerobic systems

- Tactics and strategies
- Position of player
- Level of Competition
- Game structure
- Motivation / Pressure

### Interplay of energy systems during intermittent exercise

- Intensity of exercise
- Duration of exercise
- Recovery periods
- Fitness Levels

Predominant energy system → Fitness level

Tactics & Strategy → Role in team

Structure of game/race → Competition level

Recovery periods affected by...

Recovery periods (using suitable work:rest) give opportunity for PC & myoglobin oxygen stores to replenish, and for lactate and waste to be removed.

# OCR A level PE: Recovery and Environmental Effects on Systems



### Post-exercise oxygen consumption

The volume of oxygen consumed in recovery above resting rate.

- Muscle fibre restoration
- Breakdown (& remove) lactic acid
- Replenish glycogen stores
- Rehydration and electrolyte rebalance
- Resynthesise ATP/PC stores
- Resaturate myoglobin with oxygen

Present after any amount of exercise, but the intensity affects the size of the oxygen deficiency

### Exercise in the heat

- Thermoregulation maintains bore body temperature within +/- 1°C of 37°C
- Exercise in higher temperatures than normal causes the body to sweat - risk of dehydration

### Cardiovascular drift in hot conditions

- Excessive sweating to reduce core temperature
- Reduced blood plasma levels
- Increased blood viscosity
- Reduced venous return
- Reduced stroke volume
- Increased heart rate

### % O2 availability at altitude compared to sea level (100%)

- 1500m (medium) = 84%
- 2400m (high) = 76%
- 5500m (extreme) = 52%

### Hyperthermia

- Prolonged high intensity exercise
- High air humidity
- High air temperature

### Thermal Strain

Temperatures 25°C higher than normal reduces endurance performance by up to 12%

### Effect of Altitude on Body Systems

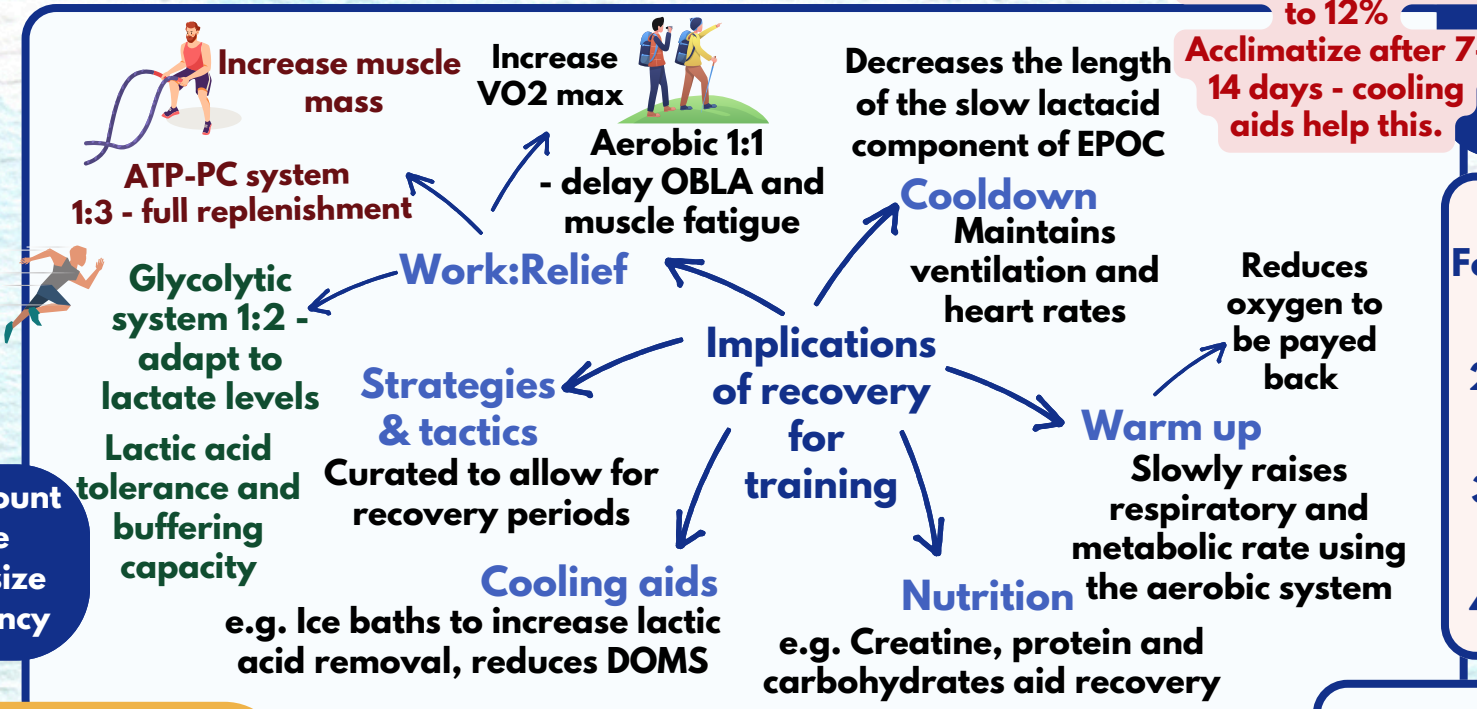
At altitude, there is a reduced: rate of diffusion at alveoli, oxygen saturation of haemoglobin, oxygen transportation to muscles, diffusion of oxygen at muscle cells

Other impacts:

- Increased breathing rate at rest and exercise
- Blood plasma volume decreased up to 25%
- Stroke volume decreases, increasing heart rate
- Maximum cardiac output decreases at high intensities
- Reduced metabolic processes in muscle cells

Reduction in VO2 max, reduced aerobic capacity. Training becomes harder. Anaerobic demands increase.

For every 1000m above 1500m, VO2 max drops by 8-11%



### Altitude Training

For endurance athletes:

- Erythropoietin released to increase red blood cell production
- More oxygen transported in blood, increased consumption in muscle cell.
- Breathing rate and ventilation stabilise (elevated compared to sea level)
- SV and CO reduced

Days of training required for full performance at altitude:

- 1000-2000m = 3-5 days
- 2000-3000m = 2 weeks
- 3000m+ = 2+ weeks

### Oxygen consumption during recovery

Section A - Oxygen Deficit - energy used during exercise which is obtained from anaerobic processes

Section B - Oxygen consumption during exercise derived from aerobic processes

Section C - Fast component of recovery post exercise used to replenish ATP/PC stores

Section D - Slow component of recovery post exercise used to remove lactic acid

C & D represent two phases of EPOC: fast and slow component

### Fast alactacid component

The volume of oxygen required to:

- Replenish blood and muscle oxygen
- Resynthesise ATP and PC stores

In 1 minute - oxygen reassociates with haemoglobin.

In 2-3 minutes - myoglobin stores are replenished.

ATP and PC stores are resynthesized 50% in 30 seconds, 100% in 3 minutes - during this time aerobic production provides the energy to resynthesize ATP and PC:

Energy + P → ADP → ATP

Energy + P + C → PC

### Slow lactacid component

- Lactic acid is removed
- Some glycogen is replenished
- Gradual decrease in ventilation
- Gradual decrease in heart rate
- Elevate core body temperature - Metabolic rate increases 13-15% per 1°C

Elevated ventilation and circulation continued to maximise oxygen delivery and waste removal.

5-8 litres of oxygen

Pyruvic acid 50-75% oxidised and re-enters the Krebs cycle

10-25% reconverted into glucose (gluconeogenesis) and glycogen (glyconeogenesis)

SMALL AMOUNT converted into protein, removed from body in sweat and urine

Pyruvic acid → Glucose

Pyruvic acid → Protein