Short term responses to exercise

Cardiac **dynamics** are the **physiological**, **neurological** and **hormonal** changes to exercise intensity. The type of physiological adaptations depends on the intensity and duration of exercise.

Cardiac output (Q): the volume of blood pumped by the heart per minute (ml/blood/min). It is the product of heart rate and stroke volume.

Heart rate (HR): the number of heart beats per minute (BPM).

Stroke volume (SV): the volume of blood, in millilitres (ml), pumped out of the heart per beat. Increasing either HR or SV increases cardiac output.

Cardiac output ml/min = heart rate (beats/min) × stroke volume (ml)

Cardiac cycle is the transport of blood to the lungs and the working muscles. It has **two** phases: the **relaxation phase (diastole)** and the **contraction phase (systole)**.

During **intense exercise**, Q can increase up to sevenfold. HR and SV increase proportionally with exercise intensity. We can continue increasing exercise intensity because of the continued increase in HR. This is difficult for a sedentary individual as they are not used to working at that intensity.

Venous return: the rate at which the blood returns to the heart. Exercising results in increased venous return due to increased demand.

Changes to blood pressure during exercise: most types of exercise cause a minimal change to the diastolic compared to the systolic pressure.

Ventilation values:

- **Tidal volume (TV):** the volume of air that is inhaled and exhaled with every breath (similar to SV).
- **Breathing frequency (BF):** number of breaths in a minute (similar to HR).
- **Minute ventilation (ME):** the volume of air breathed in or out every minute (similar to CO).

Minute ventilation ml/min = breathing frequency (beats/min) × tidal volume (ml)

MV will increase in proportion to the intensity of the exercise.

The usual **measure of maximal oxygen consumption** during exercise is known as **VO2**. **VO2 max** is the maximum rate of oxygen the body is able to use during exercise.

Neuro-muscular changes also occur during exercise. These reinforce the need for an effective warm-up to reduce the risk of injury to the muscular system and increase performance levels.

The primary purposes of the **cardiovascular** and **respiratory systems** are to deliver oxygen and remove waste from the working muscles.

The **heart** is a four-chambered dual-action pump. **Pulmonary circulation** is between the heart and the lungs. **Systemic circulation** carries oxygenated blood from the left side of the heart to the muscles and other tissues.

The **cardiovascular system** consists of the **heart**, **blood vessels** and **blood**. **Blood vessels** of the body: **arteries**, **arterioles**, **capillaries**, **venules** and **veins**.

Vasodilation: the widening of blood vessels to facilitate increased blood flow.

Vasoconstriction: the narrowing of **blood vessels** resulting in a reduction in blood flow and/or an increase in blood pressure.

As exercise intensity increases, blood flow is redistributed. This is known as the **vascular shunt**. Control of HR is carried out in the **cardiac control centre** (CCC) in the **medulla oblongata**; this is part of the **autonomic nervous system** (ANS). The ANS has **two** sub-divisions: the **Sympathetic Nervous System** (SNS), which speeds up HR via the cardiac accelerator nerve, and the **Parasympathetic Nervous System** (PNS), which slows HR through the vagus nerve.

As exercise increases in intensity, the SNS becomes more dominant and takes control of HR. The cardiac control centre (CCC) has **three** ways of regulating or controlling HR. These are **neural**, **hormonal** and **intrinsic**.

Neural control: The receptors that pick up the changes in the body are **proprioceptors** (Golgi tendon organs), **chemoreceptors** (found in muscle tissue, aorta and carotid arteries), **baroreceptors** (found in aorta and carotid arteries) and **thermoreceptors** (found in the skin, skeletal muscle and liver).

The contribution of physical activity to health and fitness

Leading an **active** and **healthy lifestyle** can have a wide range of **social**, **psychological** and **physical** benefits. All of these can lead to an **improved quality of life**.

Health can be defined as a sense of physical, mental and social well-being; therefore, it is more than simply being fit.

Not making positive lifestyle choices and leading a **sedentary lifestyle** can lead to a variety of consequences, such as lower life expectancy, deterioration in mental well-being and social issues.

Long term effects of exercise: musculoskeletal

After we exercise for a period of time, **adaptations** take place within the body. The main adaptations take place in the **musculoskeletal system** and the **cardio-respiratory/vascular systems**.

Physiological adaptations in the **musculoskeletal system** following a **12-week period** of **aerobic** training fall into two groups:

Muscles: a larger number of capillaries around muscles; a larger number of mitochondria; increased amounts of myoglobin; an increase in the efficiency of Type I muscles fibres; and the utilisation of Type IIa muscle fibres.

Bones and joints: extra deposits of calcium; an increase in the strength of tendons and ligaments and the flexibility/mobility of joints; and an increase in the amount of synovial fluid in the joint capsule.

A **16-week period** of **anaerobic** training using predominantly the **ATP-PC system** may achieve the following adaptations to the **musculoskeletal system**: an increase in the amount of force, power output, speed and strength of the performer; greater tolerance of lactic acid.

Long term effects of exercise: cardio-respiratory

Physiological adaptations in the **cardio-respiratory system** following a **12-week period** of **aerobic training**: increased capillarisation of the lungs; improved strength of the diaphragm and intercostal muscles; increased utilisation of the alveoli; increased tidal volume and minute ventilation.

Adaptations of **cardiovascular system**: cardiac hypertrophy; greater blood capacity in the ventricles; reduced resting heart rate; reduced systolic phase; increased blood pressure whilst exercising; a reduced resting blood pressure; increased cardiac output; strengthening of the smooth muscle in blood vessels; increased number of red blood cells and more haemoglobin; improved cardiovascular system.

Overall, the athlete can **work for longer in the aerobic zone** (taking longer to reach anaerobic threshold) as the **exercise intensity increases**. This reduces the **effects of fatigue** and the **build-up of waste products**.

Improvements to sporting performance: higher VO2 max; the ability to work aerobically for longer, raising the anaerobic threshold; reduced recovery times after intense exercise, meaning the body can replenish CP stores and glycogen at a faster rate; faster removal of lactic acid; faster resaturation of myoglobin stores.

Training and performance

Training is either **continuous** or **interval**. **Continuous training** improves the aerobic system by working continuously at the same intensity. **Interval training** is any form of training with a set recovery period built into the session (e.g. **weight training**, **circuit training**, and **plyometrics**).

Altitude training is a training strategy to enhance performance in endurance athletes. It assumes that due to decreased levels of O2 at altitude, the body will adapt to such conditions in a variety of ways.

Energy systems

Adenosine triphosphate (ATP) is the only energy source for all bodily functions and activities. When ATP is used, it must be replenished. The body can replenish ATP aerobically or anaerobically.

The **three** energy systems are the **ATP-PC system**, the **lactic acid system** and the **aerobic system**.

The three energy systems contribute to energy production simultaneously. It is important to consider the contribution of these systems as an **energy continuum**, rather than them working in isolation. The **predominant energy system** used during an activity is dependent on **three factors**:

1. Intensity of exercise
2. Duration of exercise
3. Fitness level of the performer

A higher level of aerobic fitness (VO2 max) means it will take longer to reach the **anaerobic threshold**. This is the point at which the performer gets more energy from the anaerobic systems rather than the aerobic one.

Fitness tests

Testing allows for the identification of strengths and weaknesses, the monitoring of progress and comparisons with other athletes.

Reliability: test results are consistent and repeated over tests and retests.

Validity: the tests actually measure what they are meant to.

Components of fitness: Aerobic capacity (CV endurance): to exercise for a sustained period of time, e.g. multistage fitness test.

Muscular endurance: exercising a specific muscle group over a period, e.g. one-minute press/sit up test.

Muscular strength: maximum force a muscle can generate against a resistance, e.g. handgrip dynamometer test.

Flexibility: the range of motion at a joint, e.g. sit and reach test.

Body composition: proportion of body weight (fat, muscle, bone, visceral).

Agility: ability to change direction quickly, e.g. Illinois agility test.

Speed: moving the body/body parts as quickly as possible between two points, e.g. 30m sprint test.

Power: a combination of strength and speed, e.g. vertical jump test.

Coordination: moving two or more body parts at the same time, e.g. alternative hand throw test.

Balance: the stability of the body's centre of mass above the base of support, e.g. standing stork test.

Reaction time: time taken to respond to a stimulus, e.g. ruler drop test.

Laboratory based tests: Maximal VO2 test measures aerobic power. The **Wingate test** measures anaerobic power and capacity.

Injury prevention and rehabilitation

Physiological benefits of an **effective warm up**: increased muscle temperature resulting in increased muscle fibre elasticity; increased heart rate and breathing frequency; reduced O2 debt; an increase in the nerve conduction velocity; and an increase in enzyme activity.

Physiological benefits of an **active cool down**: faster removal of lactic acid and CO2 from the blood and muscles; elevated HR, SV and Bf, maintaining blood flow; continued dilation of capillaries; decreased risk of delayed onset of muscle soreness (DOMS); continued elevation of metabolic activity; increased enzyme activity; maintained venous return; and the vascular shunt mechanism remaining active.

Other factors to consider prior to physical activity:

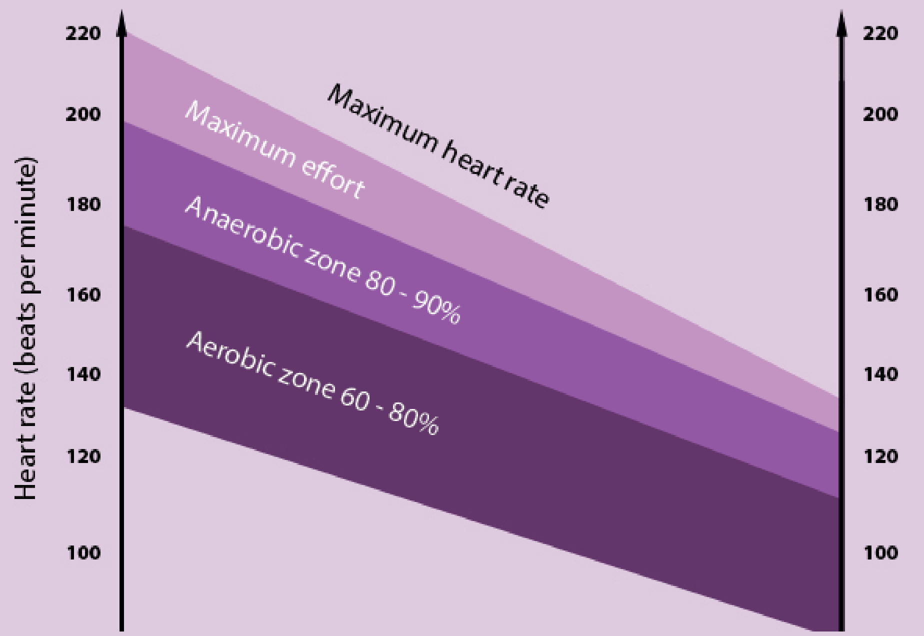
- A full understanding of the rules and etiquette of competition
- Specific protective equipment
- Experience, ability and, in some cases, size or weight
- Possible use of a Physical Activity Readiness Questionnaire (PAR-Q)
- Core stability, good posture and balance.

Minor injuries should be treated by immediately using the **PRICE** procedure (**protect** or **pressure**, **rest**, **ice**, **compression** and **elevation**).

Recovery can be **sped up** by using **ice baths**, **Kinesio tape**, **hypoxic tents**, **sports massage** and **electrotherapy**.

The principles and periodisation of training

These principles are **specificity**, **progressive overload or progression and overload**, **frequency**, **intensity**, **duration**, **reversibility** and **variance**. Heart rate training zones:

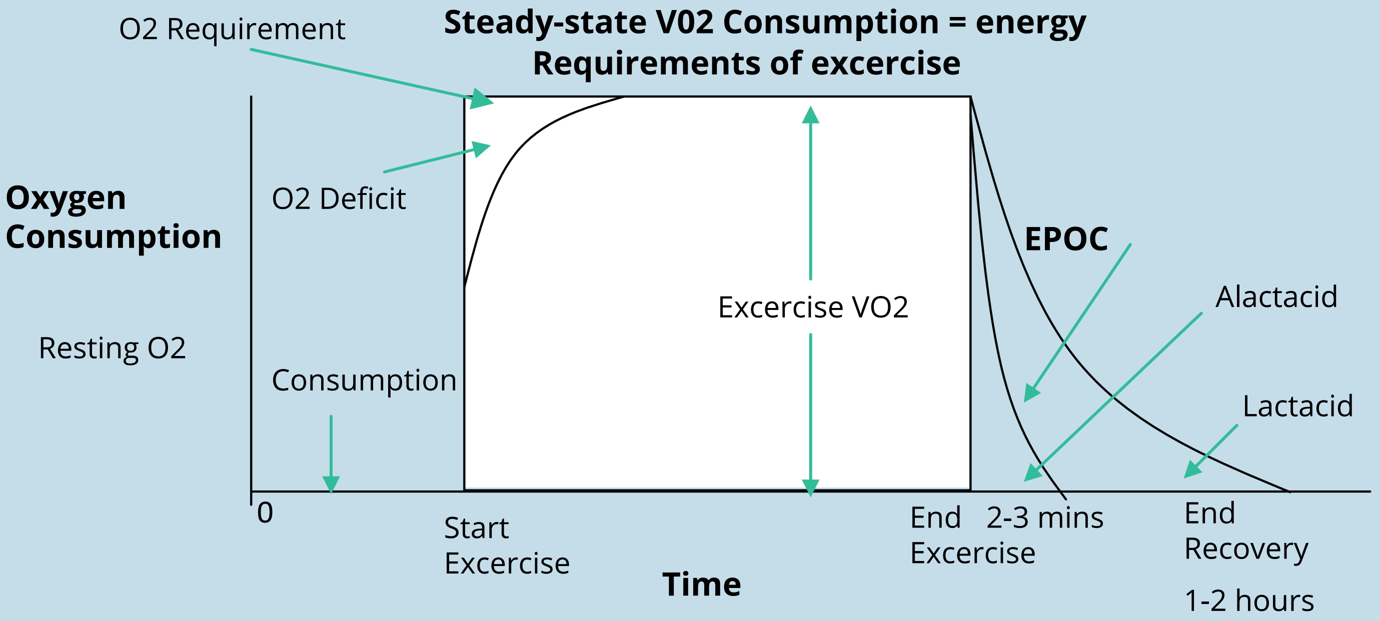


Fatigue and recovery

Fatigue can be due to a lack of energy, the effect of lactic acid, dehydration and the consequent reduction of plasma volume in the blood, and loss of electrolytes due to sweating.

An athlete needs to develop an **effective recovery process** to allow for the **replenishment of ATP, removal of lactic acid, replenishment of myoglobin with oxygen** and **replenishment of glycogen**.

1. Alactic Debt – initial recovery stage
2. Lactic Debt – the slower phase of recovery



Recovery can be sped up by **consuming a meal high in carbohydrates** within two hours of the end of the session, consuming **hypotonic** or **hypertonic drinks**, **warming up**, an **active cool down**, **using supplements**, taking **ice baths**, **massages** and the use of **compression clothing**.

The principles and periodisation of training

The training year can be split into **pre-season**, **in-season** and **off-season**. Training methods and types reflect the time of year. The aim of **periodisation** is to **peak** for a specific competition. The **preparation period (general)** is often **pre-season training**. The **competitive period** is often the **in-season**. The **transition period** is often the **off-season**.

Diet and nutrition

Recommended daily amounts for a **balanced diet:**

- 50–65% carbohydrates
- 10–20% proteins
- 20–30% fats

Carbohydrates and **fats** are a source of energy. **Proteins** allow body tissues to grow and repair. A balanced diet must also include **vitamins**, **minerals**, **roughage** and **water**. When identifying appropriate carbohydrate sources, knowledge of the **glycaemic index (GI)** is needed to improve health, performance and recovery.

Carbohydrates are the main source of energy for exercise at moderate to high intensity, with fat providing energy for exercise at a lower intensity.

Following specific training, the energy systems will become more efficient, allowing exercise duration to increase at higher intensity.

Carbohydrate loading is a dietary process that increases the storage of glycogen. It is primarily employed prior to an event by endurance athletes.

Hydration is maintaining the correct levels of water in the body, and therefore blood plasma, to allow the body to function normally. If water levels drop, the body is in a state of **dehydration**. This has a significant negative effect on performance. Dehydration **increases blood viscosity**, which in turn **decreases the speed of blood flow to the muscles, increases breathing frequency and heart rate, decreases blood pressure, decreases both the speed with which glucose is supplied to the muscles and lactic acid is removed, impairs muscle function** and **impairs temperature control**.

The most common **supplements** are **protein**, **caffeine** and **creatine**.

Doping refers to athletes taking illegal substances to improve their performances. Commonly used illegal substances are **anabolic steroids, stimulants, diuretics, erythropoietin (EPO), beta blockers, human growth hormones (HGH)** and **blood doping**.