Biomechanical principles

Newton's three laws of motion:

Newton's 1st Law: A winger will continue to run in a straight line to cross the ball unless the opposition comes across to tackle them.

Newton's 2nd Law: If a rugby player, taking a penalty, applies a force to the ball it will move in the direction that this force is applied, and acceleration of the ball will be in proportion to the force applied.

Newton's 3rd Law: In the start blocks of athletes, a force is applied to the blocks by the athlete, at the same time an equal force and opposite force comes back from the blocks resulting in the athlete moving forward out of the blocks.

- Momentum allows us to understand how mass and velocity influence movement of athletes.
- Impulse allows us to explain how force and time can cause the athlete to start moving or change direction.
- Force time graphs are used to demonstrate impulse.
- Balance and stability can be understood through knowledge of a person's centre of mass.
- Stability is increased by making the base larger and lowering the centre of mass.
- Linear motion allows us to understand how quickly the athlete or object is travelling and in which direction.
- Angular motion relates to rotating movements at joints. A cyclist will produce angular movement at the legs, pushing the peddles to achieve linear motion.
- Moment of Inertia is the body's resistance to motion.
- The flight path (trajectory) of an object is influenced by gravity and air resistance. Key factors that determine the path of a projectile are angle, height and velocity.
- The Bernoulli principle refers to changes in fluid (water and air) speeds, due to changes in pressure.
- The Magnus Effect is the Bernoulli principle applied to spinning objects. The side of the object that is spinning in the direction of the air will result in a high velocity air flow and therefore low pressure.
- Fluid mechanics looks at the movement through air and liquid, applying principles of increasing and decreasing drag through streamlining and altering laminar flow.

Diet, nutrition and performance

- Carbo-loading and the importance of depletion, tapering and repletion/loading.
- The methods to deplete glycogen stores, e.g. training, tapering of training and loading phases (use of appropriate GI foods in these processes).
- The use and misuse of supplements and ergogenic aids to training: protein (whey and casein), creatine, caffeine.

Supplementation in sport

Sports supplementations are also called ergogenic aids.

- Proteins are required for growth and repair.
- Caffeine's impact is the maintenance of alertness in the brain. Research suggests there is a positive impact on sports that are high intensity, strength based or include multiple sprints, and caffeine can aid recovery.
- Creatine is naturally occurring but there are no long-term studies into the physiological impact of the supplementation. Similarly, the improvements in strength and power may also be placebo (psychological rather than physiological).

Carbo-loading

Carbo-loading is a process of increasing carbohydrate consumption and storage of glycogen prior to an endurance event. There are numerous ways to carbo-load but all follow a similar principle; the Shearman technique has three stages.

1. Depletion stage

This stage reduces muscle glycogen stores. The training intensity continues or in some instances increases but the carbohydrate intake is reduced. The theory is that the body will store more carbohydrate when its available.

2. Tapering stage

Training is reduced during this stage, while carbohydrate consumption remains the same. Preparation for the event and replenishment of glycogen stores happens during this stage.

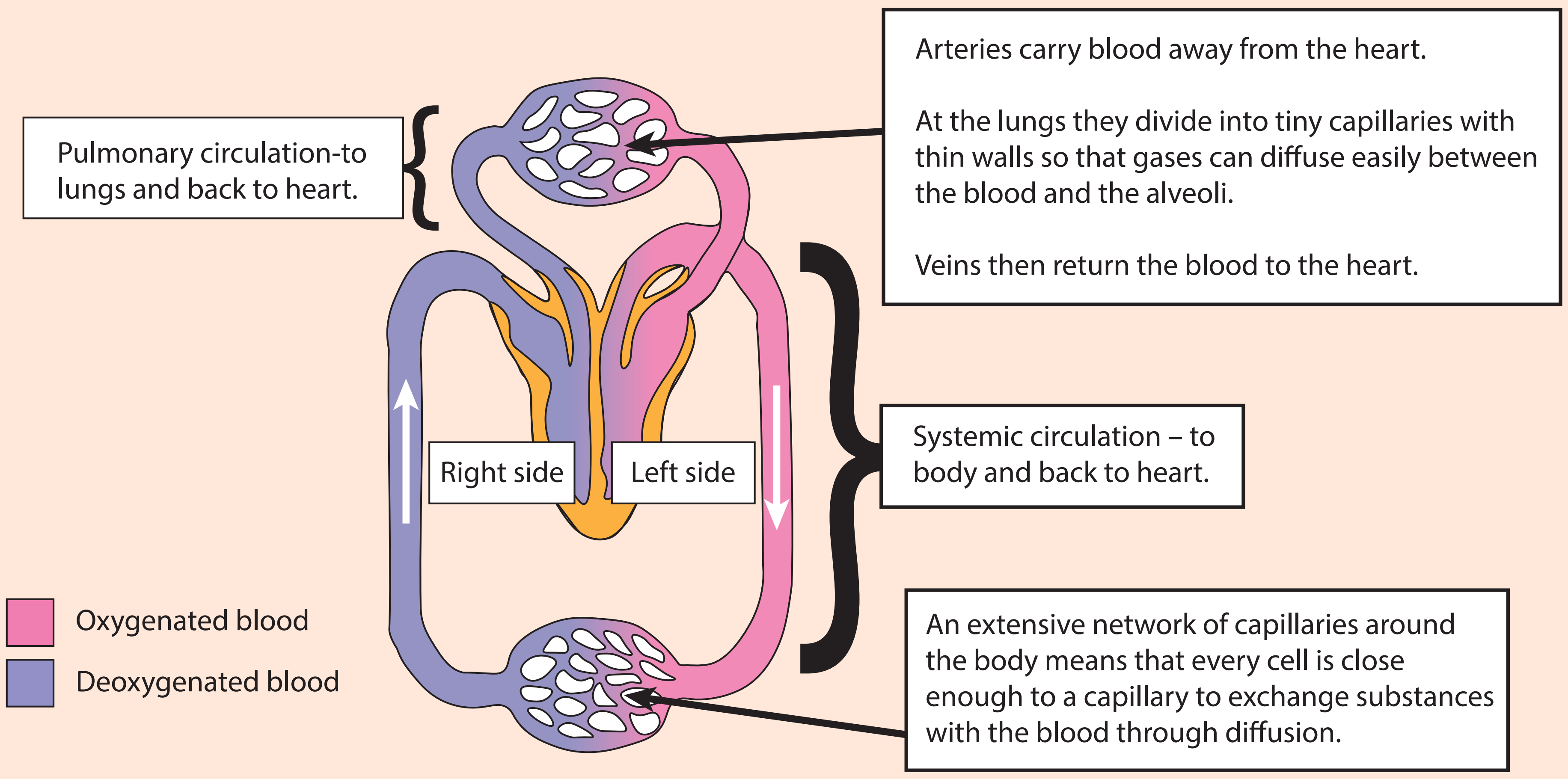
3. Loading stage

The intensity decreases to almost no training in this stage and there is an increase in consumption of carbohydrates. This allows the body to overload the system with glycogen, which should allow more glycogen to be stored than normal. This process is called super compensation.

Short-term responses to exercise

Cardio-vascular system

- There are two circulatory systems; pulmonary and systemic.
- The cardiac cycle consists of two phases; diastole (relaxation phase) and systole (contraction phase).
- Venous return is the volume of blood returning to the heart.
- Cardiac values change from rest to when exercising at different intensities (Q=HRxSV). At rest Q=5 l/min compared with up to 35 l/min when exercising.
- During exercise, blood is redistributed to the muscles (blood shunting) by vasomotor control (vasodilation and vasoconstriction).
- Blood pressure increases from 120/80mmHg at rest to 180/85mmHg (low intensity) and up to 240/160mmHg (high intensity).
- Systolic pressure tends to increase significantly compared with diastolic pressure.
- Control of heart rate is carried out in the Cardiac Control Centre (CCC) found in the Medulla Oblongata of the brain; this is part of the Autonomic Nervous System (ANS). The (ANS) has two sub-divisions, the Sympathetic Nervous System (SNS) and the Parasympathetic Nervous System (PNS).
- CCC has three ways of regulating or controlling heart rate: neural (various receptors), hormonal (adrenaline/ noradrenaline) and intrinsic (Starlings Law).



Cardio-respiratory system

- Major functions of the respiratory system: provide oxygen (O2) to muscle and removal of carbon dioxide (CO2) by gaseous exchange and diffusion.
- Diffusion: move from an area of high concentration to an area of low concentration until equilibrium is reached.
- Inspire and expire: the mechanics of breathing influenced by the diaphragm and intercostal muscles.
- The rate of inspiration and expiration is controlled by the respiratory control centre (RCC) found within the Medulla Oblongata in the brain.
- The respiratory values vary depending upon intensity and duration of exercise (ME=TVxBf).
- Breathing rate is controlled by:
  - chemoreceptors (detect chemical changes)
  - proprioceptors (detect movement)
  - thermoreceptors (detect temperature change).

Long-term responses to exercise

Aerobic physiological adaptations

An improved cardiovascular system has real health benefits, like reducing the potential impact of hypertension (high blood pressure), CHD and arthrosclerosis.

Overall, the athlete is able to 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 unit of measurement of aerobic fitness).
- Work aerobically for longer raising the anaerobic threshold, reducing the onset of blood lactate (OBLA) and conserving glycogen and CP stores.
- Reduced recovery times after intense exercise.
- Faster recovery means the body can replenish CP stores and glycogen, and remove lactic acid at a faster rate.
- Myoglobin stores will be re-saturated at a faster rate because of increased oxygen uptake.

Anaerobic physiological adaptation

Even though there are specific adaptations from anaerobic exercise, research suggests that there is a significant benefits to the adaptations from aerobic exercise.

Training at a high intensity for a short duration using predominantly the ATP-PC system, power and strength training may achieve the following adaptations:

- muscle hypertrophy (increase in size of the muscles)
- increased creatine phosphate and glycogen stores in the muscles
- increased bone density and tendon thickening and strengthening
- development of type IIb muscle fibres
- neural system is improved i.e. the firing patterns speed up, reducing response time.

Training at a high intensity for a slightly longer duration, predominantly using the anaerobic system, could produce a greater tolerance to lactic acid (also known as buffering capacity of the muscles); training includes interval sprints.