Chronic Adaptations

Long term adaptations to regular training.

SAID

- The principle of ***specific adaptation to imposed demand*** suggests that when the body is placed under some form of stress, it starts to make adaptations which allow it to get better at withstanding that form of stress in the future.

- The body is always trying to get better at exactly what you practise.

Limitations to chronic adaptations

1. Overload – right amount of overload needs to be applied to ensure the athlete continues to improve and not overtrain or plateau

2. Specificity – the body only makes adaptations to the specific training used

3. Frequency and Duration – for aerobic adaptations, training has to take place a minimum of 3 times a week for at least 6 weeks (12+). Anaerobic adaptations, training three times a week for at least 6 weeks (8)

Aerobic adaptations

Leads to a more efficient delivery of oxygen to the working muscles, which improves performance during aerobic activity.

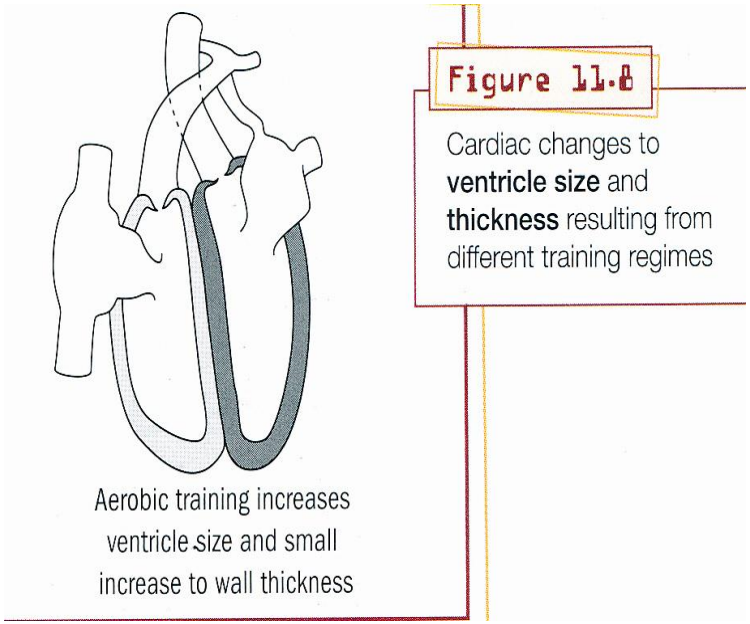
Aerobic adaptations

- A more efficient aerobic system will enable an athlete to not work as hard at the same intensity.
- Allows them to work harder for longer without succumbing to the fatiguing by-products of the anaerobic systems (LIP
- Continuous, Fartlek, Circuit and Long Interval are best methods for developing the body aerobically.

Cardiovascular Adaptations

Heart Size

- Develop a larger left ventricle
- Can hold more oxygenated blood in their heart, which means they will have a larger stroke volume



Stroke Volume

- Because the heart can hold more blood in the left ventricle, more blood can then be pumped out into the body per beat
  - 71ml per beat vs. 100ml per beat
  - 113ml per beat vs. 179 ml per beat
- SV higher at rest, during submaximal and maximal exercise in a trained person
- More oxygenated blood is pumped to the working muscles with each beat

Heart Rate

- Regular training results in the following:
  - Lower resting heart rate
  - Lower sub-maximal heart rate
  - slower increase in heart rate during exercise
  - Faster return to resting heart rate after exercise

The heart does not have to beat as often to pump the same amount of blood – the heart becomes more efficient

Cardiac Output: Q

- At rest Q is the same for a trained and untrained athlete 5L
- Trained athlete will not have to work as hard to get the same amount of blood to the working muscles.
- Higher Q allows an athlete to work at a higher intensity more efficiently.

Advantages of Q

- They can work at a higher intensity and still be working aerobically
- They can work longer at the same intensity, as the aerobic system is more efficient

- Due to the increase in SV there is an increase in Q.
- More blood being pumped to the working muscles

Blood Flow

- Blood flow is redirected to the working muscles.
- Allows for more oxygen to be transported and used by the working muscles

Blood Volume

- Plasma volume rises up to 1L after exercise
- Means there is an increase in RBC count
- Haemoglobin carries O2 in the RBC and also increases, which means the oxygen carrying capacity is increased

- Plasma also helps to remove metabolic by products and carbon dioxide – leading to a more effective removal of waste products

A-V02 difference

- In a trained athlete, more oxygen is absorbed from the blood into the muscles during submaximal and maximal exercise

- More oxygen can be extracted from the blood to the working muscles, leading to an increase in breakdown of fats and glycogen in the muscle

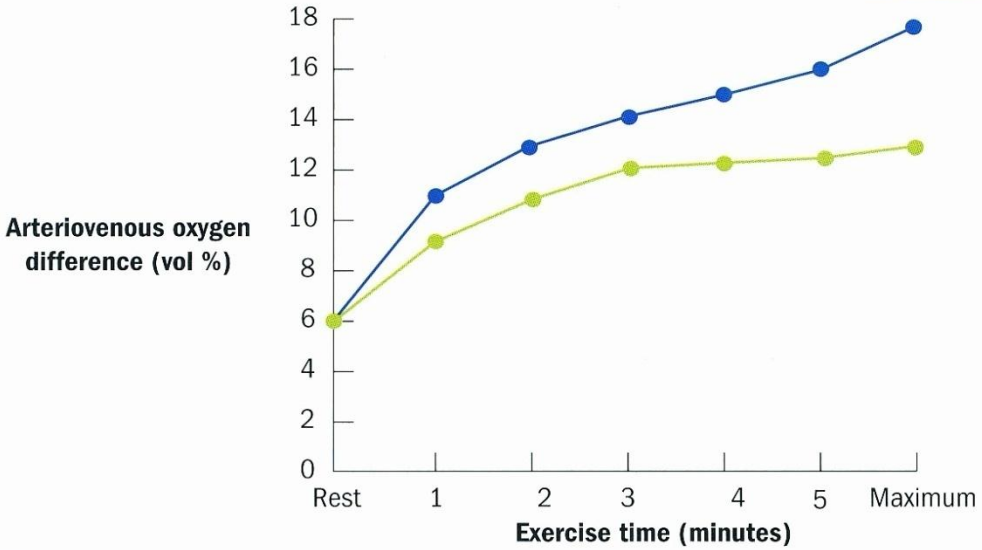
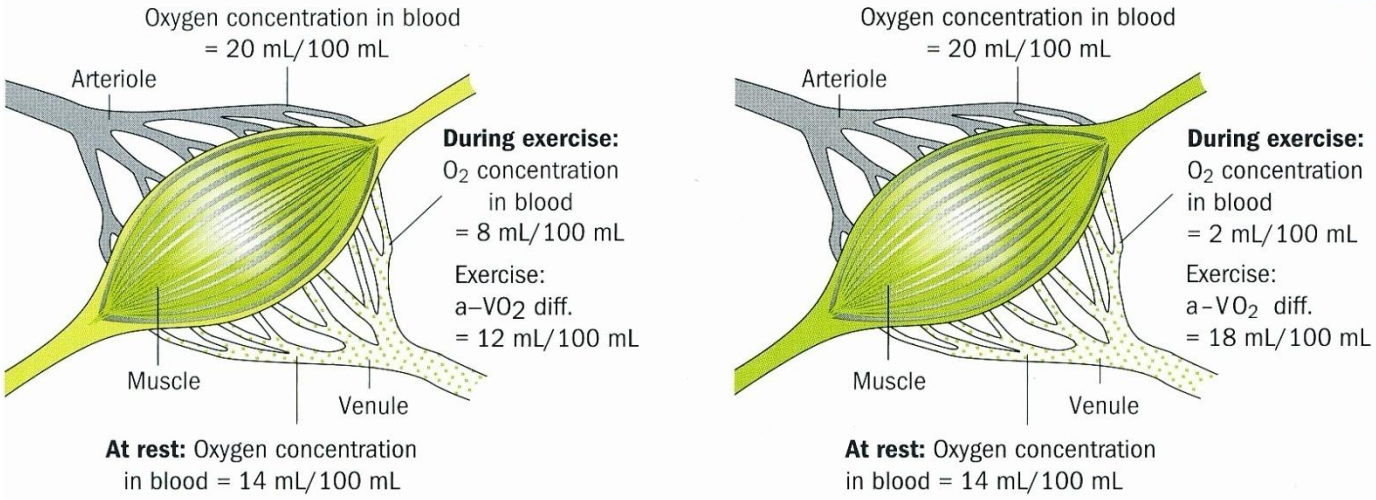


Figure 11.13

Aerobic training contributes to improved oxygen extraction from blood and increases a–VO_2 diff.



Adapted from Davis, Kimmet & Auty 1991

Figure 11.14

The arteriovenous oxygen difference increases in response to exercise and aerobic training.

Blood Pressure

- Decrease during rest and submaximal exercise
- Hypertension
- Increased capillarisation and improved elasticity of blood vessels lead to lower resting BP
- Benefits are health-related as high blood pressure is a major risk factor for cardiovascular disease

Questions

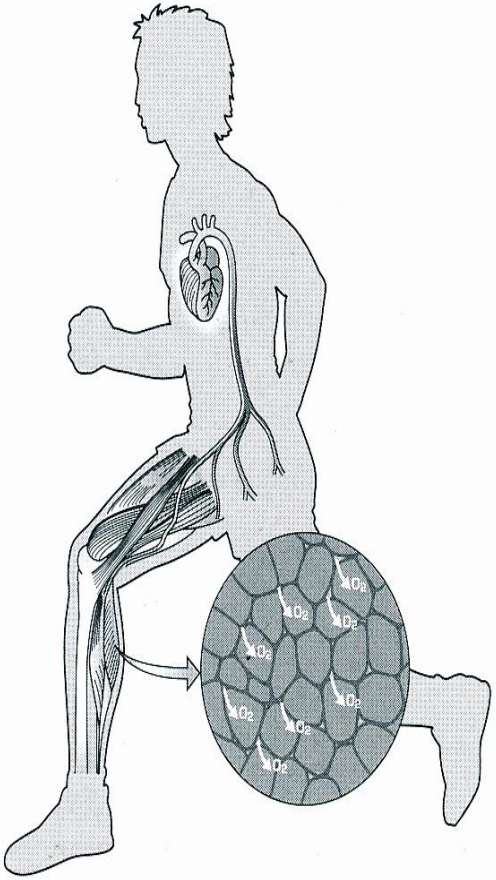
- Complete the thinking through questions on page 303

Summary of aerobic training – cardiovascular adaptations

- **Heart**
  - Increase ventricle size
  - Increase SV
  - Increase Q
  - Decrease rest & sub-maximal heart rates
  - Decrease steady state heart rate
  - Decrease recovery heart rates
- **Blood vessels**
  - Increase capillary density to heart muscle
  - Increase blood flow 20% away from organs to working muscles
  - Increase capillary density at muscles (mainly ST)
  - Increase HDL
  - Decrease LDL
- **Blood**
  - Increase blood volume
  - Increase plasma levels
  - Increase RBC count
  - Increase haemoglobin
  - Increase myoglobin
  - Increase OBLA
  - Decrease blood pressure

Figure 11.7

Cardiovascular adaptations resulting from aerobic training, which bring about improved oxygen delivery to working muscles



↑ Plasma volume

↑ Haemoglobin

↑ Total blood volume

↑ Ventricle size

↑ Venous return

↑ Myocardial contractility

↑ Maximum stroke volume

↑ Maximum cardiac output

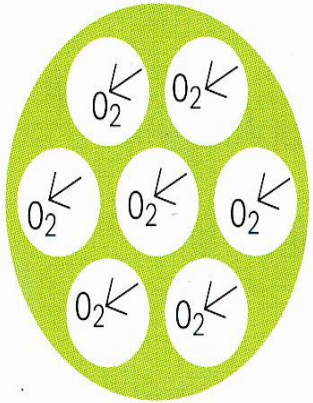
Increased effectiveness of cardiac output distribution

Increased peripheral blood flow

Increased blood flow to working muscle

↑ Capillarisation

↑ Arteriovenous oxygen difference



Adapted from McArdle, Katch & Katch 2001

Respiratory adaptations

»

Tidal Volume

- Amount of air inspired and expired in one breath increases after aerobic training at maximal levels, meaning more oxygen can be extracted from the air per breath.

Respiratory Rate

- At resting and submaximal levels, the RR decreased because lung function is improved and more oxygen can be extracted from one breath
- Meaning the athlete doesn't have to breath as frequently

- Same amount of oxygen can be taken from air with fewer breaths

Minute Ventilation

- At rest trained and untrained will be the same
- During maximal activity the trained athlete has an advantage as they can inspire more air and consequently take in more oxygen per breath than the untrained athlete.
- Trained have higher MV
- With the increase in TV and decrease in RR, more oxygen can be extracted from the air and then transported to the working muscles

Lung Diffusion

- The ability of the blood to attract oxygen from the alveoli in the lungs also increases
- This allows more oxygen to be extracted per breath from the lungs into the bloodstream

Oxygen Uptake

- O2 Uptake increases due to increase in Q, MV, A-VO2 diff, capillarisation, number of RBC and lung diffusion.

- It takes longer before reaching the point at which oxygen delivery cannot keep up with oxygen demand, resulting in the athlete being able to work at higher intensities for longer without the anaerobic glycolysis system becoming dominant.

Increased anaerobic or lactate threshold

- Improved oxygen delivery and utilisation in the muscles, results in a higher lactate threshold.
- The AG system is not utilised as much until higher exercise intensities are reached.
- LA and hydrogen ion accumulation will be delayed.
- The athlete can work harder and for longer periods.

Questions

- Complete the thinking through questions on page 305

Muscular

Capillary Density

- Number of capillaries around the muscles.
- Allows more oxygen to be taken up by muscles as more blood is present near the muscle

- More blood flow around the working muscles, leading to an increase in oxygen uptake

Mitochondria

- Power site of cells
- Food fuel is combined with oxygen to produce ATP.
- Size and number of mitochondria increase
- More sites are available to produce ATP, leading to more power

Myoglobin

- Protein
- Storage site for oxygen in muscle
- Amount of myoglobin increases resulting in more sites of oxygen storage in the muscles

Oxidative Enzymes

- Help breakdown food fuels

- Increase stores of triglycerides in muscles
- Increase stores of glycogen in muscles

- More enzymes available to speed up the breakdown of food fuels

Muscle Fibre Types

- Type 1, slow twitch
- Get larger
- Type 2 (partially oxidative) fibres can take on characteristics of Type 1 fibres

- Larger slow twitch fibres allow the body to work for longer periods of time

ATP

- Due to increase in muscle size, the muscle can store more ATP
- More energy to break down

Questions

- Complete the thinking through questions on page 309

Questions

1. Explain the term ‘chronic adaptation’
2. Define SAID principle
3. Calculate an athletes Q if SV is 85ml/min and their HR is 56bpm at rest and 196bpm at maximal levels
4. Explain how chronic adaptations such as increased Q, MV, A-VO2 diff, capillarisation, RBC and lung diffusion lead to an increase in VO2 Max
5. What are the advantages to an athlete if they have more efficient aerobic system? Justify your answer by referring to at least two different chronic adaptations

Anaerobic Adaptations

Lead to stronger muscles, which improves performance during speed and strength activities.

Plyometric, resistance, circuit and short to intermediate interval training are best methods

Muscular

Muscular Hypertrophy

- When an athlete is exercising a muscle, there is an increase in the nerve impulses that cause the muscle to contract.

- This alone results in strength gains without any noticeable changes in size

Muscular Hypertrophy

- With continued exercise there is a complex interaction of nervous system responses, resulting in an increase in protein synthesis over months the muscle cells grow larger and stronger

- Larger muscles mean the body can create more force in a contraction

Glycogen Stores

- Glycogen stores in the muscles increase
- More glycogen means a greater opportunity to create energy

ATP

- Increase in muscle size increases the amount of ATP that can be stored
- More energy to break down

CP or PC

- More CP stores in the muscle means a greater opportunity to create energy

Glycolytic Enzymes

- Enzymes that break down glycogen increase
- More enzymes are available to speed up the break down of food fuels

Heart size

- Thickness of the left ventricle wall increase
- More forceful heart beat leads to quicker removal of waste products

Motor Unit Recruitment

- Increase in ability to recruit motor units to produce more forceful contractions

Speed of Contractions

- Increase in the speed of contractions
- Increase the number of contractions, making the athlete faster

Strength of ligaments and tendons

- Increase strength of tendons and ligaments
- Increases that ability of the muscle to withstand force, meaning less chance of injury

Questions

1. What training methods lead to anaerobic changes at the muscular level?
2. Explain the process of muscle hypertrophy
3. How does an increase in food fuels (glycogen and CP) lead to an increase in anaerobic performance?
4. Explain the differences in the heart muscle after anaerobic training compared to aerobic training? How do the changes help an athlete in both cases?
5. What are the advantages to an athlete if they have more efficient anaerobic glycolysis and ATP-PC systems? Justify your answer by referring to at least two different chronic adaptations

Questions

- Complete the thinking through questions on page 314
- Chapter Review questions page 315 & 316

Summary

- SAID principle suggests that our body will adapt to specific stress put on it
- There are three limitations to adaptations: overload, specificity, and frequency
- Aerobic adaptations can occur to three different systems: cardiovascular, respiratory and muscular
- Aerobic adaptations all lead to a more efficient delivery of oxygen to the working muscles

Summary

- An efficient aerobic system improves an endurance athlete's performance by allowing them to work at a higher intensity for a longer period of time
- Anaerobic training leads to adaptations that help prolong the use of the anaerobic systems
- Everything increases apart from Blood Pressure, Heart Rate and Respiratory Rate.

Extension questions

- Discuss the three main areas that affect chronic adaptations to training
- Name the training methods used that develop: both aerobic adaptation and anaerobic adaptations
- For the following athletes, identify the adaptations and suggest the adaptations that might occur.
  - Soccer goal keeper
  - Cross country skier
  - Iron man
  - Basketball
  - Pole vault

Extension questions

- Identify three types of athletes who would more likely experience cardiovascular adaptations to training
  - Explain why these adaptations would occur
- Discuss the relationship between HR, SV, and Q
- Explain why HR decreases at rest and during sub-maximal workloads but not during maximal workloads
- Discuss why trained athletes are able to absorb more oxygen from their bloodstream than untrained individuals

Extension questions

- Explain how the mitochondria and myoglobin in the muscle cell improves aerobic performance