CHAPTER 5: *Training methods and aerobic training*

Practice questions - text book pages 91 - 92

1) Mary is a 20 year old college student. What is her theoretical maximum heart rate?
   a. 195.
   b. 100.
   c. 205.
   d. 200.

Answer: d.
Explanation:
- *Maximum heart rate = 220 - age.*

2) Which of the following cannot be considered as a metabolic adaptation to endurance training?
   a. increased maximal oxygen uptake.
   b. increased maximal rate of fat oxidation.
   c. increased adrenaline response to exercise.
   d. lower respiratory exchange ratio (RER) during submaximal exercise.

Answer: c.
Explanation:
- *Increased adrenaline response is in proportion to the intensity of the exercise, whereas a. b. and c. are metabolic adaptations that result from endurance training.*

3) The overload principle applied to the development of:
   a. cardiovascular endurance.
   b. flexibility.
   c. strength.
   d. all of these.

Answer: d.
Explanation:
- *The overload principle is defined as 'training activities that are harder, more intense and/or lengthier than the normal physical activity undertaken by an individual and so can be applied to cardiovascular endurance, flexibility and strength'.*

4) Immediately following high intensity interval training HIIT) the performer should:
   a. sit down and rest.
   b. take a shower.
   c. continue to do low intensity exercise.
   d. breathe deeply for five minutes.

Answer: c.
Explanation:
- *The process of continuing low level exercise (c.) immediately after the high intensity exercise continues to provide oxygen to skeletal muscle.*
- *This enhances oxidation of lactic acid and ensures that less lactic acid remains in the muscle tissue. Choices a. b. and c. are easily eliminated.*

5) Cardiovascular activity can result in the following benefit to the heart
   a. increase in cardiac output.
   b. increase in resting heart rate.
   c. increase in blood pressure.
   d. decrease in heart size.

Answer: a.
Explanation:
- *The reason why a. is the correct answer is because the long-term effect of cardiovascular activity on the heart is to make the heart bigger and stronger by increasing ventricular muscle mass and a stronger elastic recoil of the myocardium – resulting in cardiac hypertrophy. Hence there is an increase cardiac output with an associated decrease in stroke volume and resting heat rate.*
- *Whereas, choices b. c. and d. are all appropriate to a lack of cardiovascular activity associated with a sedentary lifestyle.*

6) a) Define the term $\dot{V}O_{2max}$ and describe two main factors which limit $\dot{V}O_{2max}$. 3 marks

Answer:

- *$\dot{V}O_{2max}$ is defined as the maximum rate of oxygen uptake when a performer is undertaking exercise at maximal effort.*
- *$\dot{V}O_{2max}$ is measured in milllitres per minute per kilogramme of body mass.*

Factors which limit $\dot{V}O_{2max}$:

- *Aerobic fitness of the individual performer.*
- *Age of the performer.*
- *Type of sport undertaken, for example a predominantly anaerobic performer (weight lifter, thrower) would have a lower $\dot{V}O_{2max}$ than a 5000m runner, however fit.*

b) Describe a field test used to estimate a person's $\dot{V}O_{2max}$. 3 marks

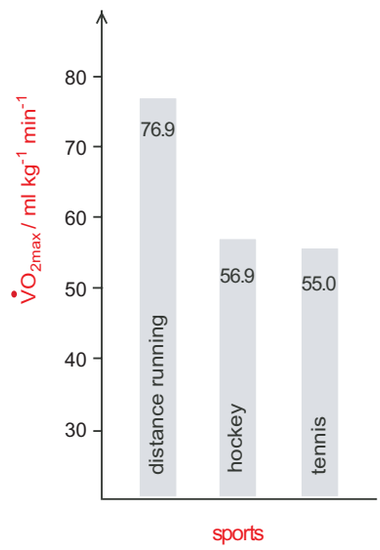
Answer:

Note that this question is asking for a predicted $\dot{V}O_{2max}$ test of which there are many possible answers, such as the Queen's College Step test, PWC-170 test, Multi-Stage Shuttle Run test and the Yo-Yo Intermittent test.

- *Multi-stage Shuttle Run test:*
- *Subject runs for 10 metres in time with an increasingly rapid timed bleep, until subject can no longer maintain pace.*
- *Predicted $\dot{V}O_{2max}$ depends on stage reached.*

7) a) Figure 5.21 shows variation in $\dot{V}O_{2max}$ between three different sports. Suggest reasons for variations in $\dot{V}O_{2max}$ between these three sports. 3 marks

figure 5.21 – $\dot{V}O_{2max}$ for different sports



Answer

Heredity:

- *Variations in $\dot{V}O_{2max}$ could be related to % fibre type since a higher % of slow twitch fibres.*
- *Will contribute to increased aerobic endurance.*

Specificity of training:

- *Physiological adaptations in response to training.*
- *For example, a distance runner will stress the aerobic system in training.*
- *Whereas the hockey and tennis players will need to stress anaerobic and aerobic systems.*
- *Hence the aerobic physiological adaptive response will be less when compared with the distance runner.*

b) Explain the potential physiological advantages for endurance athletes having a high $\dot{V}O_{2max}$. 2 marks

Answer

- *A high $\dot{V}O_{2max}$ is associated with increased O_2 delivery to active muscle.*
- *Or increased O_2 extraction by active muscle tissues (increased $a\text{-}\bar{v}O_{2diff}$).*
- *Which means that the relative $\dot{V}O_{2max}$ at a given submaximal workload is less.*
- *Due to the increased $\dot{V}O_{2max}$.*
- *And the ability to sustain and work at a higher aerobic work rate is enhanced.*

c) What other factors contribute to an individual's $\dot{V}O_{2max}$? 3 marks

Answer

- *The main physiological factors are the limitations of the cardiovascular and pulmonary systems.*
- *Lung volume and the relative surface area of alveoli will affect gaseous exchange and hence $\dot{V}O_{2max}$.*
- *Heart size, particularly the size of the left ventricle, is a factor that will affect stroke volume and cardiac output and hence the circulation rate of oxyhaemoglobin.*
- *The involuntary tone of arterial blood vessels is a factor that will affect blood pressure and blood velocity in the transportation of oxygen to active muscle tissues.*
- *The number of red blood cells, mitochondria and percentage of slow twitch muscle fibres in muscle tissue are factors that affect the ability to transport and extract oxygen and therefore contribute to individual's $\dot{V}O_{2max}$,*
- *It is found that $\dot{V}O_{2max}$ decreases as the percentage of body fat increases.*

8) $\dot{V}O_{2max}$ is the best indicator of cardiovascular endurance capacity and increases substantially in response to long-term endurance training.
Define the term $\dot{V}O_{2max}$ and identify its units of measurement
Through what mechanisms does this improvement occur? 8 marks

Answer

2 marks for definition of $\dot{V}O_{2max}$ and units of measurement:

- *$\dot{V}O_{2max}$ represents the greatest rate of oxygen used/consumed by an individual per unit of time.*
- *$\dot{V}O_{2max}$ is measured in ($cm^3\ kg^{-1}\ min^{-1}$) or $ml\ kg^{-1}\ min^{-1}$.*

6 marks for mechanisms for improvement of $\dot{V}O_{2max}$:

- *Lungs:*
  - *Ventilatory efficiency is achieved by the strengthening of respiratory muscles.*
  - *Hence bigger total lung volumes.*
  - *More alveoli are utilised due to improved capillarisation of outer regions of lung tissue.*
  - *Increased cardiac output (via increased stroke volume) slightly increases the pulmonary driving pressure in the lung/alveoli transport system.*
  - *This creates a bigger distortion of the red blood cells (red corpuscles).*
  - *And thus a much more rapid diffusion and uptake of oxygen to the haemoglobin in red blood cells - known as ventilation-perfusion ratio.*
  - *Hence increased gaseous exchange and $\dot{V}O_{2max}$.*
- *Vascular system:*
  - *Increase in blood volume due to increases in plasma volume and number of red blood cells.*
  - *Means more oxygen can be transported to active muscle tissues.*
- *Muscle cells:*
  - *Increase muscle capillary density.*
  - *Increase muscle myoglobin content.*
  - *Increases in number and size of slow twitch fibres.*
  - *In addition to the type1 1b being converted to type1 1a.*
  - *Increase in mitochondria and therefore increases in oxidative enzymes, such as pyruvate dehydrogenase.*
  - *Hence increase in the respiratory capacity of slow twitch fibres by increasing $a\text{-}\bar{v}O_{2diff}$.*

9) a) Identify two valid and reliable submaximal tests that measure endurance or stamina. Why are submaximal tests often favoured over maximal tests? 4 marks

Answer:

Tests:

- *PWC-170 test.*
- *Queen's College Step test.*
- *Harvard Step test.*

Submaximal tests are often favoured over maximal tests because:

- *There is less stress on the performer.*
- *Greater reliability of results.*

b) Explain why fitness testing is necessary for both the coach and the athlete. 3 marks

Answer

- *Provide objective measures about the individual's current state of fitness/health.*
- *Highlights strengths and weaknesses.*
- *Evaluates effects of a training programme.*
- *Motivates individual to reach optimal test scores.*
- *Adds variety to training programme.*

10) Using practical examples from the cardiovascular systems explain the difference between a short-term response and a long-term adaptation to exercise. 4 marks

Answer

- *Example: Heart rate response to exercise:*

Short-term response:

- *This is an immediate response produced in the body occurring during the physical activity.*
- *Heart rate increases linearly to workload.*

Long-term adaptation:

- *This is a physiological change produced in the body as a result of physical activity, to cope better with the physical activity.*
- *Resting heart rate reduces over a period of several months as a result of aerobic endurance training.*

11) Identify the long-term adaptations an elite performer would expect to occur to the structure and the functioning of the cardiovascular system, as a result of an intense aerobic training programme. 10 marks

Answer

6 marks for cardiac adaptations:

- *The heart muscle becomes bigger and stronger - called cardiac hypertrophy (mainly left ventricle).*
- *Stronger elastic recoil of myocardium.*
- *Therefore bigger stroke volume (SV) associated with decrease in resting heart rate (bradycardia).*
- *Blood plasma volume increases, which in turn increases the size of the left ventricular chamber.*
- *More blood volume enters the left ventricle per beat (increased pre-load) increasing the stretch of the ventricular walls by the Frank-Starling mechanism.*
- *Reduced systemic vascular resistance (decreased after-load) increases volume of blood pumped from the left ventricle per beat.*
- *The net effect is up to 20% bigger stroke volume and greater oxygen delivery to muscles.*

- *Blood vessels in the heart evolve so that the blood flow to the heart decreases because the heart muscle itself is more efficient.*
- *Following physical activity, heart rate recovery is quicker.*
- *Cardiac output at maximal levels of exercise increases considerably in response to the increase in $\dot{V}O_{2max}$.*
- *Cardiac output at rest and at submaximal levels of exercise remains unchanged or decreases slightly after endurance training.*
- *Hence there is a decrease in resting heart rate (HR) and an increase in HR during maximal workloads.*

6 marks for vascular adaptations:

- *Capillary system in muscle bed is utilised better and developed.*
- *Increased capillarisation of trained muscle.*
- *Improved dilation of existing capillaries due to increased blood volume.*

- *Total number of red blood cells increases by 10%.*
- *Therefore more haemoglobin is available for oxygen transport.*

- *Diversion of a larger portion of cardiac output to the active muscle – known as the enhanced vascular shunt.*
- *Hence increased vasodilation of blood vessels such as arterioles and precapillary sphincters.*

- *Increase in blood volume is attributed to increases in both plasma volume and number of red blood cell cells.*

- *Results in a reduction in fluid friction drag as blood flows through vessels, which can improve circulation and oxygen availability.*

- *Increased elasticity and thickness of smooth muscle of arterial walls.*
- *Makes arterial walls tougher and therefore less likely to stretch under pressure.*
- *Hence blood pressure is maintained, which therefore continues to force blood through the capillary network.*

12) Jodie Swallow is a top class female British Triathlete, and has a resting heart rate of 36 beats per minute. Give reasons why such an athlete might have a low resting heart rate. 4 marks

Answer

- *Due to bradycardia or slow heart beat.*
- *Effects of an aerobic endurance-based triathlete training programme is to produce cardiac hypertrophy i.e. heart becomes bigger and stronger (mainly left ventricle).*
- *Producing an increase in stroke volume (SV).*
- *And decrease in resting heart rate (HR_{rest}).*
- *A reduced resting heart rate allows for an increase in diastolic filling time or pre-load.*
- *The net effect is that the heart does not have to pump as frequently for the same given resting oxygen consumption.*

13) Describe and account for some of the long-term effects of regular aerobic training methods on respiratory volumes. 6 marks

Answer

3 marks for long-term effects:

- *Vital capacity (VC) increases slightly.*
- *At the same time residual volume (RV) shows a slight decrease.*
- *Tidal volume (TV) is unchanged at rest and at submaximal levels of exercise.*
- *Tidal volume increases towards maximal levels of exercise.*
- *Minute ventilation ($\dot{V}E$) resting value remains unchanged.*
- *Minute ventilation maximal values increase dramatically, as a result of substantial increases in frequency of breathing (f) and a smaller increase in tidal volume (TV).*

3 marks for account for long-term effects:

- *Changes in fitness levels such as improvements in cardiovascular and muscular fitness.*
- *And efficiency of the breathing mechanisms.*
- *Ventilatory efficiency is achieved by the strengthening of respiratory muscles.*
- *Improved alveolar ventilation to pulmonary blood flow (known as ventilation-perfusion ratio).*
- *And hence bigger total lung volume.*
- *As a result the rate (f) and depth of breathing (TV) is reduced at rest.*
- *Due to lower pulmonary ventilation for a given O_2 uptake.*
- *And increased too much larger values (compared with the untrained person) during exercise.*

14) Describe four changes that occur in muscle cells as a result of an endurance-based training programme. 4 marks

Answer

- *Slow twitch fibres (type 1) become larger.*
- *In addition to the type 11b being converted to type 11a.*
- *Thus increasing the aerobic capacity of slow twitch and type 11a muscle fibres.*
- *Increase in myoglobin content.*
- *Increases number and size of mitochondria.*
- *Increases in oxidative enzymes such as pyruvate dehydrogenase.*
- *Therefore increase in activity of Kreb's cycle.*
- *Increase in $a\text{-}\bar{v}O_{2diff}$.*
- *Increase in glycogen/triglyceride stores.*
- *Fat stores (triglycerides) are mobilised earlier within the exercise period, hence glycogen sparing occurs.*
- *This adaptation reduces the respiratory exchange ratio, which reflects fuel food usage.*

15) A Level. Your PE group has been asked to devise a running training schedule for an elite 1500m runner. Using your knowledge of both intermittent and continuous training methods show how you could use this information to produce both aerobic and anaerobic adaptations. Justify the content of your training programme for an elite 1500m runner, with regard to the expected respiratory adaptations. 20 marks

Answer

3 marks for intermittent training:

- *Is also known as **interval** training and can be manipulated by using the following variables:*
- *Duration of the exercise period.*
- *Intensity of the exercise period.*
- *Number of repetitions (reps) within a set.*
- *Number of sets within a session.*
- *Duration of the rest interval (rest relief) or recovery.*

5 marks for our 1500 m athlete would benefit from the following track interval sessions:

- ***Lactate acid intervals** increase lactate tolerance.*
- *Working between medium to high intensity effort i.e. 60-80% of maximum effort).*
- *Lasting between 30-90 seconds.*
- *For example, 3 sets x (8 reps x 200m) with 30 seconds rest relief between reps and 5 minutes rest relief between sets.*
- *Frequency of sessions at least 3 times per week to benefit from anaerobic adaptations.*

- ***Aerobic intervals** increase aerobic capacity or $\dot{V}O_{2max}$.*
- *Working at low intensity effort i.e. below 50% of maximum effort.*
- *For example, 6 reps x 2000m with 3 minutes recovery.*

5 marks for continuous training:

- *Involves continuous activity in which there is no rest or break.*
- *Is normally associated with developing aerobic capacity ($\dot{V}O_{2max}$).*
- *Recommended intensity should be between 60-75% of maximum heart (HR_{max}).*
- *For example, **session 1**: 45 minute steady run at 65% of HR_{max}, **session 2**: 3 km run – 1st km steady at 60% of HR_{max}, 2nd km 70% HR_{max} and 3rd km 75% HR_{max}.*
- *Frequency of sessions at least 3 times per week to benefit from aerobic adaptations.*

2 marks for expected respiratory adaptations resulting from the interval and continuous sessions would be:

- *Improved strengthening of respiratory muscles would enable athlete to train for longer.*
- *Increased pulmonary blood flow, particularly to upper lobes of lungs, and hence greater utilisation of alveoli would increase gaseous exchange and $\dot{V}O_{2max}$.*

5 marks for the major training adaptations noted during maximal or high intensity sessions are:

- *During a maximal training session, such as during the lactate interval session, long-term adaptations would result from increased breathing rates and increased gaseous exchange.*
- *Resulting in a large increase in minute ventilation.*
- *These adaptations would enable the athlete to increase intensity of training session by delaying the onset of blood lactate accumulation (OBLA) because more oxygen would be available for tissue site respiration.*

- *During submaximal workloads, such as during the 45 minute run, breathing rate and $\dot{V}O_{2max}$ would be less because of greater efficiency of respiratory musculature.*
- *Greater O_2 uptake and increase in lung volumes such as tidal volume.*

- *The $a\text{-}\bar{v}O_{2diff}$ would increase with training, reflecting greater oxygen extraction by the tissues and more effective blood distribution to the active tissues.*
- *Frequency of training sessions would ensure that the respiratory system was stressed sufficiently to ensure that the above adaptations occurred.*

16) Describe a method of monitoring exercise intensity and give an advantage and disadvantage for the method you have selected. 5 marks

Answer

3 marks for description of method:

- *Exercise intensity can be monitored on the basis of training heart rate (THR).*
- *THR can be determined using the Karvonen method.*
- *Which takes a given percentage of maximal heart rate reserve and adds it to resting heart rate.*
- *With this method, the percentage maximum heart rate reserve used corresponds to the same percentage of $\dot{V}O_{2max}$ when a person is exercising at moderate to high intensities.*

One mark for advantage:

- *THR allows for a progressive increase in rate of training.*
- *With improvements in fitness to maintain the same heart rate.*

One mark for disadvantage:

- *Could get errors when establishing HR_{rest}.*
- *HR_{max} value relies on a general equation i.e 200 - age.*
- *May not be the case for highly trained athletes.*
- *Who could achieve higher values due to long-term training adaptations.*

Or

3 marks for description of method:

- *Exercise intensity can also be measured on the basis of the Metabolic equivalent system (MET). The amount of oxygen the body consumes is directional proportional to the energy expended during physical activity.*
- *This system assumes that the body uses approximately 3.5ml kg^{-1} min^{-1} at rest.*
- *This resting metabolic rate (as in sitting at rest) is referred as 1.0 MET.*
- *Activity intensities can be classified by their oxygen requirements as multiples of the resting metabolic rate.*

One mark for advantage:

- *MET is useful as a guideline for training.*

One mark for disadvantage:

- *Although the MET system is a useful guideline for training, it fails to account for changes in environmental conditions.*
- *Or changes in physical conditioning.*
- *Difficulty when assessing how hard a person is working in order to establish MET values.*

17) A group of students wish to create an aerobic weight training programme. Suggest how they could calculate working intensities that would give them optimal strength endurance gains. Illustrate your answer with examples. 8 marks

Answer

2 marks for 2 of:

- *1RM*
- *Working intensities can be measured as a proportion of a performer's one repetition maximum or 1RM.*
- *1RM represents the highest successful lift*
- *that can be achieved for one complete repetition of an exercise*
- *having failed at the final lift.*

6 marks for 6 of:

- *Once the 1RM's values are known the students then calculates a percentage of the 1RM in order to create an aerobic weight's training programme.*
- *In this case, training done at less than 50% of 1RM with high repetitions would **stress** the aerobic energy system.*
- *For example a student achieves a 1RM of 50 kg on bench press. This 1RM value can then be used to calculate a working intensity for optimal strength endurance gain chosen at 40% of 1RM.*
- *Bench press session: 3 sets (20 kg x 20 repetitons) short recovery of 60 seconds between sets.*
- *This method can be used to create an interval weight training programme for a variety of exercises that would aerobically stress major muscle groups.*
- *With strength gains achieved as a result of regular systematic training, it is important to retest 1RM values at regular intervals (say once a month) so that percentage training values can be adjusted accordingly.*

18) Continuous training is one of the least used methods of training by top performers. Identify the main characteristics of continuous training and suggest how this can benefit a performer. 4 marks

Answer

- *Continuous training consists of 'Long Slow' training - i.e low intensity and long duration.*
- *With even pace/tempo/work intensity at around 60-70% of maximum heart rate.*
- *This would be an aerobic workout.*
- *Which builds aerobic benefits such as an improved CVR (cardiovascular response) - see answer to Chapter 5 question 2 above.*
- *Suitable for technique training.*
- *Suitable for recovery sessions.*

19) Fartlek training is a type of training that is used to develop aerobic capacity. What does the term Fartlek mean? Answer by outlining the training principles used to create a typical Fartlek training session. 3 marks

Answer

- *Fartlek means 'speed play'.*
- *Whereby pace is varied from sprinting to jogging.*
- *In a combined from of continuous and interval training.*
- *Normally performed in the countryside over a variety of terrains.*
- *For 45 minutes or longer.*

20) What is meant by the term high intensity interval training (HIIT)? How can this type of training be of benefit to an untrained sedentary individual? 6 marks

Answer:

- *HIIT involves repeated bouts of high intensity training followed by a varied recovery time.*
- *Duration of work periods may range from 5 seconds to 8 minutes long.*
- *Performed at an intensity of between 80% to 95% of HRmax.*
- *Recovery periods are performed at an intensity of between 40% to 50% of HRmax.*
- *Exercise continues with alternating work and a 1:1 rest relief ratio.*
- *HIIT benefits both aerobic and anaerobic fitness, cardiovascular health such as lowering blood pressure, cholesterol profiles and body fat whilst increasing muscle mass.*