PE.AP7 Long-Term Effects of Exercise: Training Adaptations

Total Marks

AQA 8582 · Calculators not allowed · about 50 minutes

Name: _______________________________ Date: ____ / ____ / ______

Answer ALL questions. Show all your working.

1 After several months of regular aerobic training, what typically happens to a performer's resting heart rate?

- ☐ A) It increases
- ☐ B) It decreases
- ☐ C) It stays exactly the same
- ☐ D) It becomes irregular

(Total for Question 1 is 1 mark)

---

2 Long-term (many months of) aerobic and resistance training causes lasting adaptations across the body's systems.

(a) State one long-term adaptation of the cardiovascular system to training. **(1)**

(b) State one long-term adaptation of the respiratory system to training. **(1)**

(c) State one long-term adaptation of the muscular system to training. **(1)**

(d) State one long-term adaptation of the skeletal system to training. **(1)**

(Total for Question 2 is 4 marks)

---

3 Explain what cardiac hypertrophy is, and how it leads to an increase in stroke volume.

(Total for Question 3 is 2 marks)

4 A cyclist's resting heart rate falls from 72 bpm to 54 bpm over a two-year period of consistent training. Explain why this fall in resting heart rate occurs.

(Total for Question 4 is 2 marks)

---

5 Long-term aerobic training also increases the number of capillaries surrounding the alveoli in the lungs, not just around the muscles. Explain how this respiratory adaptation improves gaseous exchange.

(Total for Question 5 is 2 marks)

---

6 A swimmer's vital capacity increases noticeably over a two-year training programme. Explain how long-term training can cause this increase.

(Total for Question 6 is 2 marks)

---

7 A bodybuilder follows a resistance training programme for a year, causing their muscles to noticeably increase in size.

(a) State the term used for this increase in muscle size. **(1)**

(b) Explain how repeated resistance training causes this increase in muscle size. **(2)**

(Total for Question 7 is 3 marks)

---

8 Long-term aerobic training increases the number and size of mitochondria within muscle cells. Explain how this adaptation benefits an endurance performer.

(Total for Question 8 is 2 marks)

9 Long-term aerobic training also increases the amount of myoglobin stored within muscle cells. State what myoglobin's function is, and explain how having more of it benefits a trained performer.

(Total for Question 9 is 2 marks)

---

10 Long-term training also increases the amount of glycogen a muscle can store. Explain how this benefits a performer during prolonged exercise.

(Total for Question 10 is 2 marks)

---

11 A gymnast follows a long-term training programme involving repeated high-impact landings. Explain how this can lead to an increase in bone density over time.

(Total for Question 11 is 2 marks)

---

12 Explain how long-term training can increase the strength of tendons and ligaments, and how this benefits a performer.

(Total for Question 12 is 2 marks)

13 A rower follows a structured training programme for three years, progressing from club level to national competition.

Evaluate how long-term training adaptations across the cardiovascular, respiratory, muscular and skeletal systems combine to improve the rower's performance over this period.

(Total for Question 13 is 6 marks)

14 Table 1 gives descriptions of long-term training adaptations, with the term missing.

Table 1

Part	Description of adaptation
(a)	The heart muscle, particularly the left ventricle wall, enlarges and thickens
(b)	Resting heart rate falls below the typical untrained range
(c)	The number of capillaries around the muscles and alveoli increases
(d)	Muscle fibres increase in size (cross-sectional area)
(e)	Bones become denser and stronger in response to repeated loading

(a) Name the adaptation described in row (a) of Table 1. **(1)**

(b) Name the adaptation described in row (b) of Table 1. **(1)**

(c) Name the adaptation described in row (c) of Table 1. **(1)**

(d) Name the adaptation described in row (d) of Table 1. **(1)**

(e) Name the adaptation described in row (e) of Table 1. **(1)**

(Total for Question 14 is 5 marks)

---

15 Using resting heart rate as an example, state one difference between a short-term effect of exercise and a long-term effect of exercise.

(Total for Question 15 is 2 marks)

16 Although a trained endurance athlete's resting heart rate is lower than an untrained person's, their maximal cardiac output during hard exercise is actually higher. Explain why this is the case.

(Total for Question 16 is 2 marks)

---

17 Explain how muscle hypertrophy from a resistance training programme would help a weightlifter perform better in competition.

(Total for Question 17 is 2 marks)

---

18 Explain why a single, one-off exercise session does not cause long-term adaptations such as cardiac hypertrophy or muscle hypertrophy, but a structured training programme lasting several months does.

(Total for Question 18 is 2 marks)

---

19 Explain one way increased bone density specifically benefits a gymnast who repeatedly performs high-impact landings throughout their career.

(Total for Question 19 is 3 marks)

---

20 A marathon runner stops training completely for six months due to injury. Explain what is likely to happen to their long-term training adaptations, such as cardiac hypertrophy and increased stroke volume, during this time.

(Total for Question 20 is 2 marks)

Mark scheme · PE.AP7 Long-Term Effects of Exercise: Training Adaptations

Question 1

- **B1** B (it decreases)
- **Answer: B (it decreases)**

Question 2

- (a) **B1** any one of: cardiac hypertrophy / increased stroke volume / decreased resting heart rate (bradycardia) / capillarisation
- **(a) Answer: For example, cardiac hypertrophy (the heart muscle enlarges).**
- (b) **B1** any one of: increased vital capacity / stronger respiratory muscles / increased capillarisation around the alveoli
- **(b) Answer: For example, an increase in vital capacity.**
- (c) **B1** any one of: muscle hypertrophy / increased number and size of mitochondria / increased myoglobin stores / increased glycogen stores
- **(c) Answer: For example, muscle hypertrophy (an increase in muscle size).**
- (d) **B1** any one of: increased bone density / stronger tendons and ligaments
- **(d) Answer: For example, increased bone density.**

Question 3

- **B1** cardiac hypertrophy is the enlarging/thickening of the heart muscle, particularly the wall of the left ventricle, as a result of long-term training, oe
- **B1** a larger, stronger heart muscle can contract more powerfully, pumping out a greater volume of blood with each beat, which is an increased stroke volume, oe
- **Answer: Cardiac hypertrophy is the enlarging and thickening of the heart muscle, particularly the wall of the left ventricle, as a result of long-term training; a larger, stronger heart can contract more powerfully, pumping out a greater volume of blood with each beat, which is an increased stroke volume.**

Question 4

- **B1** long-term training has increased the cyclist's stroke volume, oe
- **B1** because more blood is now pumped out with each beat, fewer beats per minute are needed to maintain the same resting cardiac output, so resting heart rate falls, oe
- **Answer: Long-term training has increased the cyclist's stroke volume; because more blood is now pumped out with each beat, fewer beats per minute are needed to maintain the same resting cardiac output, so resting heart rate falls.**

Question 5

- **B1** more capillaries around the alveoli means more blood is in contact with the alveoli at any one time, oe
- **B1** this increases the surface area/rate at which oxygen can diffuse into the blood and carbon dioxide can diffuse out, making gaseous exchange more efficient, oe
- **Answer: More capillaries around the alveoli means more blood is in contact with the alveoli at any one time, which increases the surface area and rate at which oxygen can diffuse into the blood and carbon dioxide can diffuse out, making gaseous exchange more efficient.**

Question 6

- **B1** long-term training strengthens the respiratory muscles (the diaphragm and intercostal muscles), oe
- **B1** stronger respiratory muscles allow a greater expansion and compression of the thoracic cavity, increasing the maximum volume of air that can be forcibly breathed in and out, which is vital capacity, oe
- **Answer: Long-term training strengthens the respiratory muscles (the diaphragm and intercostal muscles); stronger respiratory muscles allow a greater expansion and compression of the thoracic cavity, increasing the maximum volume of air that can be forcibly breathed in and out, which is vital capacity.**

Question 7

- (a) **B1** (muscle) hypertrophy
- **(a) Answer: Muscle hypertrophy**
- (b) **B1** resistance training repeatedly places a high load/stress on the muscle fibres, causing microscopic damage/breakdown, oe
- (b) **B1** during recovery, the muscle fibres repair and rebuild slightly thicker/larger than before, so their cross-sectional area increases over repeated cycles of training and recovery, oe
- **(b) Answer: Resistance training repeatedly places a high load on the muscle fibres, causing microscopic damage; during recovery, the fibres repair and rebuild slightly thicker than before, so over repeated cycles of training and recovery their cross-sectional area increases.**

Question 8

- **B1** mitochondria are the site of aerobic energy production within the cell, oe
- **B1** more/larger mitochondria increase the muscle's capacity to produce energy aerobically, allowing more energy to be produced using oxygen before relying on the anaerobic system, delaying fatigue, oe
- **Answer: Mitochondria are the site of aerobic energy production within the cell; more and larger mitochondria increase the muscle's capacity to produce energy aerobically, allowing more energy to be produced using oxygen before the performer needs to rely on the anaerobic system, delaying fatigue.**

Question 9

- **B1** myoglobin stores oxygen within the muscle cell itself, oe
- **B1** having more myoglobin means the muscle can store and have a readily available supply of oxygen close to where it is needed for aerobic energy production, oe
- **Answer: Myoglobin stores oxygen within the muscle cell itself; having more myoglobin means the muscle has a greater readily available supply of oxygen close to where it is needed for aerobic energy production.**

Question 10

- **B1** glycogen is the muscle's stored form of glucose, used as fuel by both the lactic acid and aerobic systems, oe
- **B1** a larger glycogen store means more fuel is available before the muscle runs low, delaying fatigue during prolonged exercise, oe
- **Answer: Glycogen is the muscle's stored form of glucose, used as fuel by both the lactic acid and aerobic energy systems; a larger glycogen store means more fuel is available before the muscle runs low, delaying fatigue during prolonged exercise.**

Question 11

- **B1** repeated impact/weight-bearing forces place mechanical stress on the bones, oe
- **B1** in response, the bones gradually lay down more bone tissue/mineral, becoming denser and stronger over time to better withstand this repeated stress, oe
- **Answer: Repeated impact and weight-bearing forces place mechanical stress on the bones; in response, the bones gradually lay down more bone tissue and mineral, becoming denser and stronger over time to better withstand this repeated stress.**

Question 12

- **B1** repeated loading of the tendons and ligaments during training causes them to gradually adapt and become thicker/stronger over time, oe
- **B1** stronger tendons and ligaments can withstand greater forces and provide more joint stability, reducing the risk of injuries such as strains and sprains, oe
- **Answer: Repeated loading of the tendons and ligaments during training causes them to gradually adapt and become thicker and stronger over time; stronger tendons and ligaments can withstand greater forces and provide more joint stability, reducing the risk of injuries such as strains and sprains.**

Question 13

- **Level 3** (5-6): A detailed and coherent evaluation that explains at least four long-term adaptations from different body systems (e.g. cardiac hypertrophy, increased stroke volume, capillarisation, increased vital capacity, muscle hypertrophy, increased mitochondria, increased bone/tendon strength) and clearly links each to improved rowing performance, using accurate terminology throughout.
- **Level 2** (3-4): At least two or three long-term adaptations are explained with reasonable accuracy, with some link made to improved performance, but development may be limited or restricted to one or two systems.
- **Level 1** (1-2): One or two relevant points about long-term training adaptations are made, with little explanation or clear link to performance.
- **Level 0** (0): No relevant content.
- **Indicative content:**
  - Cardiac hypertrophy and increased stroke volume increase the rower's cardiac output during maximal effort, delivering more oxygen to the working muscles.
  - A lower resting heart rate (bradycardia) shows the heart has become more efficient, needing fewer beats to maintain the same resting cardiac output.
  - Capillarisation around both the muscles and the alveoli improves the exchange of oxygen and carbon dioxide, supporting a higher rate of aerobic energy production.
  - An increased vital capacity, from stronger respiratory muscles, allows the rower to take in more air with each breath during a race.
  - Muscle hypertrophy in the legs, back and arms increases the force the rower can generate with each stroke.
  - An increased number and size of mitochondria, and increased myoglobin and glycogen stores in the muscles, all increase the muscle's capacity to produce energy aerobically over the several minutes a rowing race lasts.
  - Increased bone density and stronger tendons and ligaments help the rower withstand the repeated high forces of training and racing with a reduced risk of injury, allowing more consistent long-term training.
  - A balanced evaluation might conclude that no single adaptation explains the improvement alone: the cardiovascular and respiratory adaptations increase how much oxygen can be delivered, the muscular adaptations increase how effectively that oxygen (and stored fuel) can be used to generate force, and the skeletal adaptations allow the rower to sustain the training load needed to develop and maintain all of the above over three years.

Question 14

- (a) **B1** cardiac hypertrophy
- **(a) Answer: Cardiac hypertrophy**
- (b) **B1** bradycardia
- **(b) Answer: Bradycardia**
- (c) **B1** capillarisation
- **(c) Answer: Capillarisation**
- (d) **B1** (muscle) hypertrophy
- **(d) Answer: Muscle hypertrophy**
- (e) **B1** increased bone density
- **(e) Answer: Increased bone density**

Question 15

- **B1** a short-term effect is a temporary change that happens during a single exercise session (heart rate rises during exercise) and then returns to normal once exercise stops, oe
- **B1** a long-term effect is a lasting change that develops over weeks or months of repeated training (resting heart rate becomes permanently lower) and remains even when the person is not currently exercising, oe
- **Answer: A short-term effect (e.g. heart rate rising during a single session) is a temporary change that returns to normal once exercise stops, whereas a long-term effect (e.g. a permanently lower resting heart rate) is a lasting change that develops over weeks or months of repeated training and remains even when the person is not currently exercising.**

Question 16

- **B1** long-term training has significantly increased the athlete's stroke volume, oe
- **B1** because cardiac output = stroke volume x heart rate, this much larger stroke volume means that even at a similar maximum heart rate to an untrained person, the trained athlete's maximal cardiac output is higher, oe
- **Answer: Long-term training has significantly increased the athlete's stroke volume; because cardiac output = stroke volume x heart rate, this much larger stroke volume means that even at a similar maximum heart rate to an untrained person, the trained athlete's maximal cardiac output is higher.**

Question 17

- **B1** hypertrophy increases the cross-sectional area of the muscle fibres, oe
- **B1** a larger cross-sectional area allows the muscle to generate a greater maximal force, allowing the weightlifter to lift heavier loads, oe
- **Answer: Hypertrophy increases the cross-sectional area of the muscle fibres, and a larger cross-sectional area allows the muscle to generate a greater maximal force, allowing the weightlifter to lift heavier loads.**

Question 18

- **B1** a single session only produces short-term effects (such as a temporary rise in heart rate), which reverse once the exercise stops, oe
- **B1** long-term adaptations require the body to be repeatedly stressed/overloaded over weeks and months, so it gradually adapts and rebuilds its tissues to cope with this repeated demand, which cannot happen from a single session, oe
- **Answer: A single session only produces short-term effects, such as a temporary rise in heart rate, which reverse once the exercise stops; long-term adaptations require the body to be repeatedly stressed over weeks and months, so it gradually adapts and rebuilds its tissues to cope with this repeated demand, which cannot happen from just one session.**

Question 19

- **B1** denser bones are stronger and can withstand greater forces before being damaged, oe
- **B1** this reduces the gymnast's risk of stress fractures or other bone injuries from the repeated high-impact forces of landings over a long career, oe
- **B1** allowing the gymnast to train and compete more consistently over time, without as many injury-enforced breaks, oe
- **Answer: Denser bones are stronger and can withstand greater forces before being damaged, which reduces the gymnast's risk of stress fractures or other bone injuries from the repeated high-impact forces of landings over a long career, allowing them to train and compete more consistently without as many injury-enforced breaks.**

Question 20

- **B1** without the repeated training stimulus, these adaptations will gradually reverse (detraining), oe
- **B1** for example, the heart muscle will gradually reduce in size and stroke volume will fall back towards untrained levels the longer training is stopped, oe
- **Answer: Without the repeated training stimulus, these adaptations will gradually reverse (a process called detraining); for example, the heart muscle will gradually reduce in size and stroke volume will fall back towards untrained levels the longer training is stopped.**