CHAPTER 2: *Environmental effects on body systems*

Practice questions - text book pages 45 to 46

1) Which one of the following will be encountered after an individual is acclimatized to high altitude?
   a. blood pH is higher than normal.
   b. there is an increase in red cell count.
   c. cardiac output at rest is higher than that at sea.
   d. periodic breathing may occur, especially during sleep.

Answer: *b.*

2) Which one of the following is not an aerobic adaptive response to altitude training?
   a. improved working capacity of muscles.
   b. increased muscle myoglobin.
   c. increased utilisation of fast twitch motor units.
   d. increased haemoglobin concentration.

Answer: *c.*

3) Which hormone is responsible for maintaining water and electrolyte balance in the human body?
   a. aldosterone.
   b. insulin.
   c. glycagon.
   d. human growth hormone.

Answer: *a.*

4) A heat-acclimatized athlete and an untrained subject are exercising in the same room and at the same absolute power output. Which one of the following statements is true?
   a. to help prevent dehydration, the athlete allows her core temperature to increase to a greater extent than the untrained subject before she begins sweating.
   b. skin blood flow will increase earlier in the untrained subject than in the athlete.
   c. sweating and increased skin blood flow will occur earlier in the athlete than in the untrained subject.
   d. none of the above.

Answer: *c.*

5) Which one of the following does not lead to an increase in body's core temperature?
   a. a reduction in plasma volume.
   b. a decrease in sympathetic nervous activity.
   c. a decrease in the amount of cutaneous blood flow.
   d. an increase in cardiac output.

Answer: *d.*

6) Altitude training is used by some marathon runners as part of their physiological preparation for sea level racing. Discuss whether altitude training is always beneficial to marathon runners. 8 marks

Answer:

4 marks for four of beneficial effects:

- *Reduced pO_2 at altitude/less oxygen in air/available/lower O_2 concentration.*
- *Body produces more erythropoietin which stimulates the increase of cell production.*
- *And a reduction in plasma volume.*
- *These two factors increase the haemoglobin concentration in the blood flowing to active tissue.*
- *And hence the oxygen carrying capacity of the blood.*
- *In addition to increases muscle myoglobin, mitochondria and oxidative enzymes.*
- *Greater stamina/cardio-respiratory endurance/aerobic capacity/increased $\dot{V}O_{2max}$/aerobic respiration.*
- *Athlete needs to work out optimal time to compete when returning to sea level – usually within 2 to 14 days, after which individual's adaptations return to sea-level norms.*

4 marks for four of: Initial effects of altitude are:

- *Reduced pO_2 means that athlete is unable to train as hard as previously/at sea level.*
- *Altitude sickness/dehydration/too cold.*
- *Loss of fitness/quicker to exhaustion while at altitude/detraining effect.*
- *Therefore aerobic performance deteriorates.*
- *Requires several weeks/months to be effective.*
- *Psychological problems of lifestyle/isolated/expensive/interferes with normal.*

7) a) Describe the conditions at altitude that could limit performance. 3 marks

Answer:

- *Altitude causes hypobaric conditions or a reduction in barometric pressure.*
- *Resulting in decreased partial pressure of oxygen (pO_2) throughout the body.*
- *Reducing the oxygenation of haemoglobin.*
- *Air temperature decreases as altitude increases.*
- *Solar radiation is more intense.*
- *Thus limiting human activity when compared with sea level performance.*

b) An elite group of endurance athletes spend three weeks training at 2400 metres. What major physiological responses and adaptations would they expect during this period of acclimatisation? 8 marks

Answer:

4 marks for four of immediate physiological responses:

- *Pulmonary:*
  - *Hyperventilation occurs immediately.*
  - *As body fluids become more alkaline.*
  - *Due to reduced CO_2 (H_2CO_3) with hyperventilation.*
  - *Corrected by the kidneys, which excretes a more alkaline urine solution.*
- *Cardiovascular:*
  - *Increased submaximal heart rate.*
  - *Increased submaximal cardiac output.*
  - *Stroke volume remains the same or lowers slightly.*
  - *Maximum cardiac output remains the same or lowers slightly.*

4 marks for four of longer term physiological adaptations following 3 weeks of altitude training:

- *Cardiovascular:*
  - *Stroke volume lowers.*
  - *Maximum cardiac output lowers.*
  - *Decreased plasma volume.*
  - *Increased haematocrit (the percentage of blood volume occupied by red blood cells).*
  - *Increased haemoglobin concentration.*
  - *Increased total number of red blood cells.*
  - *Possible increased capillarisation of skeletal muscle.*
- *Cellular changes:*
  - *Increased mitochondria.*
  - *Increased oxidative enzymes such as pyruvic dehydrogenase.*
- *Net effect is to improve the aerobic working capacity of muscles to compensate for the reduced pO_2.*
- *And to improve the capacity of the oxygen transport system.*
- *To purge the oxygen debt.*

8) Discuss immediate and longer-term physiological adjustment to altitude exposure. 10 marks

Answer

4 marks for four of immediate physiological responses:

- *Pulmonary:*
  - *Hyperventilation occurs immediately.*
  - *As body fluids become more alkaline.*
  - *Due to reduced CO_2 (H_2CO_3) with hyperventilation.*
  - *Corrected by the kidneys, which excretes a more alkaline urine solution.*
- *Cardiovascular:*
  - *Increased submaximal heart rate.*
  - *Increased submaximal cardiac output.*
  - *Stroke volume remains the same or lowers slightly.*
  - *Maximum cardiac output remains the same or lowers slightly.*

6 marks for six of longer term physiological adaptations following altitude training:

- *Cardiovascular:*
  - *Stroke volume lowers.*
  - *Maximum cardiac output lowers.*
  - *Decreased plasma volume.*
  - *Increased haematocrit (the percentage of blood volume occupied by red blood cells).*
  - *Increased haemoglobin concentration.*
  - *Increased total number of red blood cells.*
  - *Possible increased capillarisation of skeletal muscle.*
- *Cellular changes:*
  - *Increased mitochondria.*
  - *Increased oxidative enzymes such as pyruvic dehydrogenase.*

- *Net effect is to improve the aerobic working capacity of muscles to compensate for the reduced pO_2.*
- *And to improve the capacity of the oxygen transport system.*
- *To purge the oxygen deficit.*

9) Discuss whether altitude training produces greater improvement than sea-level training on a sea-level exercise programme. 8 marks

Answer:

8 marks for eight of:

- *Altitude training is necessary for athletes who hope to compete and or exercise optimally at altitude, such as climbing Everest.*
- *There is some debate around the idea that altitude training is superior to sea-level training for sea-level competitions.*

- *Altitude training does not benefit to anaerobic performance as sprinting and jumping.*
- *This is because altitude training only produces cardiovascular and respiratory aerobic adaptations, such as increased erythrocyte production and improved oxygen diffusion.*
- *As opposed to anaerobic adaptations such as increases in speed/power.*

- *To achieve aerobic physiological adaptations, that would benefit sea level performances, the athlete must consider:*
  - *The length of time to spend at altitude, known as an acclimatisation schedule.*

- *An elite endurance athlete would normally have a minimum of 2 training blocks within his or her periodised year.*
  - *One long training block of between 4-6 weeks during the preparation training phase.*
  - *A shorter block of between 2-3 weeks just prior to a major competition.*
- *During the second visit the body adapts more quickly.*
- *Select an optimal height required to achieve aerobic physiological adaptations.*
- *This is normally between 2400 and 2600 metres.*
- *On arrival at attitude, short-term symptoms include headaches, dizziness and increased breathing at heart rates.*
- *Monitor training intensities and recovery times.*

- *During the acclimatisation process, athletes begin training less intensely – at slower speeds than they would utilise at sea level.*
- *Training more slowly is definitely not the way to improve performance.*
- *Repeated testing, such as blood sampling will indicate changes in red blood count.*
- *Choose when to return to sea level in preparation for a major competition, such as a world 10,000 metres event.*
- *The optimal is time is within 2-14 days of return at sea level.*
- *Altitude training also gives athletes a mental edge over their opponents.*
- *All these factors must be considered by the athlete and coach since each athlete will respond differently.*

- *Elite Kenyans have dominated world class endurance events.*
- *They were born at altitude and thus have long-term physiological adaptations associated with growing up at altitude.*
- *Moving from sea level to altitude for training blocks won't produce the same positive cardiovascular and muscular alterations.*
- *And so athletes who were born and grew up at sea level will always be at a disadvantage, compared with athletes who have lived at altitude all their lives.*

- *Another strategy is to live at altitude but to train at sea level, as Chinese women distance runners and Finnish cross country skiers have done.*
- *Living at altitude, in hypobaric chambers, dopes the blood naturally, and training at sea level permits the highest-quality training.*
- *Some studies have shown that to train consistently at faster than race pace on a sea level exercise programme can increase both anaerobic and aerobic physiological adaptations that result in supporting good performances.*
- *A sea level exercise training programme enables the athlete to stay at home without the psychological stress associated with being away from family members.*
- *Ultimately the only way an athlete can assess whether he or she can benefit from altitude training is to try it out.*

10) a) Define what is meant by the term acclimatisation. 1 mark

Answer:
- *Acclimatisation is the process in which an individual adjusts to a change in its environment.*

b) Discuss the importance of acclimatisation when exercising in a hot environment. 4 marks

Answer:
- *Initial activity sessions in a hot environment should be light in intensity and last no longer than 60 minutes.*
- *Needed to increase in body core and skin temperatures, as well as stimulate sweating.*
- *If the exercise programme is too severe, the athlete will suffer from dehydration and so it is important that fluid loss is matched with fluid intake.*
- *Thereafter, activity sessions can increase systematically to achieve normal training duration and intensity.*

c) Identify three short-term physiological adaptive changes that improve heat tolerance, following a period of heat acclimatisation. 3 marks

Answer:
3 marks from three of:
- *Improved cutaneous blood flow.*
- *Effective distribution of cardiac output.*
- *Lowered threshold for start of sweating.*
- *More effective distribution of sweat over skin surface.*
- *Increased sweat output.*
- *Lower skin and core temperatures and heart rate for standard exercise.*
- *Less reliance on CHO catabolism during exercise.*

11) The cardiovascular adjustment to heat stress is a phenomenon termed cardiovascular drift. Explain how the cardiovascular drift helps maintain a nearly constant cardiac output during submaximal activity, lasting more than 15 minutes in hot conditions. 5 marks

Answer:
- *The effects of exercise produces progressive water loss through sweating and a fluid shift from plasma to tissues.*
- *The cardiovascular drift is associated with a small increase in core temperature.*
- *A rise in core temperature also causes blood distribution to the periphery for body cooling.*
- *At the same time, the progressive decrease in plasma volume decreases central venous cardiac pressure (CVCP).*
- *Note CVCP reflects the amount of blood returning to the heart, known as venous return.*
- *Resulting in a decrease in end-diastolic volume to subsequently reduce the heart's stroke volume.*
- *A reduced stroke volume initiates a compensatory heart rate increase to maintain a nearly constant cardiac output as the activity progresses.*

12) Discuss the role of the thermoregulatory centre in maintaining the core temperature of the body. 3 marks

Answer:
3 marks for three of:
- *The thermoregulatory centre is situated in the hypothalamus.*
- *It consists of a hot and a cold centre.*
- *Its job is to maintain the body's core temperature at around 37°C.*
- *Body temperature varies with temperature fluctuations in the environment.*
- *And as a result of the effects of physical activity.*
- *Sensory feedback alerts the hot or cold centres to respond to temperature changes.*
- *By balancing heat production in the body with heat loss to the environment (thermoregulation).*

13) a) What are the major avenues for loss of body heat energy? Which of these four pathways is important for controlling body temperature at rest, and during exercise? 6 marks

Answer:

4 marks for the major avenues:

- *Radiation.*
- *Conduction.*
- *Convection.*
- *Evaporation.*

1 mark for which of these four pathways is most important:

- *Radiation is the primary method for discharging the resting body's excess heat.*

1 mark for during exercise:

- *Evaporation is the primary method for heat dissipation during exercise.*

b) What happens to the body temperature during exercise and why? 4 marks

Answer:

- *Increased skeletal muscle activity increases the core temperature.*
- *By increasing metabolic heat production.*
- *Increased sweat gland production decreases the core temperature.*
- *By increasing evaporative sweat loss.*

14) How does the body regulate temperature when an elite athlete is training in a warm climate? 3 marks

Answer:

- *Autonomic nerves from the hot centre of the hypothalamus cause:*
  - *Vasodilation of smooth muscle in the skin arterioles.*
  - *Directing blood to the skin for heat transfer out of the body.*
  - *Decreased muscle tone.*
  - *And increased sweating.*

15) What are the physiological effects of dehydration on an athlete and how does this affect exercise performance? 4 marks

Answer:

- *Fluid loss decreases plasma volume.*
- *This decreases blood pressure.*
- *Which in turn reduces blood flow to muscles and skin.*
- *In an effort to overcome this, heart rate increases and stroke volume decreases.*
- *To maintain a nearly constant cardiac output (known as the cardiovascular drift).*
- *Because less blood reaches the skin, heat dissipation is hindered.*
- *And the body retains more heat.*
- *And so body temperature increases.*
- *These physiological changes will decrease exercise performance.*
- *Dehydration promotes renal retention of water and sodium.*
- *Which makes the athlete thirsty.*
- *If the athlete does not rehydrate there will be continued circulatory distress.*

16) List four environmental factors that limit the ability of an athlete to continue to exercise in hot conditions. 4 marks

Answer:

- *Air temperature.*
- *Humidity.*
- *Air velocity.*
- *Amount of thermal radiation.*

17) Describe how an athlete is able to control his or her body temperature during a marathon race. 4 marks

Answer:

- *Replace body fluids to prevent dehydration and over heating.*
- *Wear suitable clothing such as mesh running vest.*
- *That allows air to circulate.*
- *Hence body is cooled by evaporation of sweat, convection and radiation.*
- *Use sponge stations to cool down body parts.*

18) Why is humidity an important factor when an athlete is performing at high temperatures? Why are wind and cloud cover important? 4 marks

Answer:

2 marks for humidity:

- *Water vapour in the air plays a major role in evaporative heat loss.*
- *Hence high humidity limits sweat evaporation and heat loss.*

2 marks for wind and cloud cover:

- *Wind increases heat loss by convection.*
- *Known as the windchill factor.*
- *Cloud cover reduces heat gain by solar radiation.*

19)a) Quantify fluid loss during hot-weather exercise, and indicate the consequences of dehydration on human physiology and performance. 6 marks

Answer:

1 mark for:

- *Fluid loss during hot-weather exercise can be between 1.0 to 1.5 litres hr^{-1} depending on the surrounding temperature and humidity.*

Consequences of dehydration, 5 marks for five of:

- *When plasma volume decreases as dehydration progresses.*
- *Peripheral blood flow and sweating rate also decrease to make the body's control of thermoregulation progressively more difficult which potentially can lead to heat stroke.*
- *Performance fatigue occurs from reduced plasma volume.*
- *Which in turn increases heart rate, electrolyte imbalance, perception of effort and core temperature.*

Symptoms include at least two of the following:

- *Heavy sweating.*
- *Thirst.*
- *Paleness.*
- *Muscle cramps.*
- *Dry tongue and thirst.*
- *Tiredness.*
- *Weakness.*
- *Dizziness.*
- *Headache.*
- *Nausea or vomiting.*
- *Fainting.*

b) How is body water balance maintained during prolonged aerobic exercise in hot weather? 3 marks

Answer:

- *Water balance depends on the electrolyte balance.*
- *But the need to replace lost body fluid is greater than the need to replace lost electrolytes.*
- *Because sweat is very dilute.*
- *It is important to drink water at regular intervals during prolonged aerobic exercise.*
- *To reduce the risk of dehydration.*
- *And optimise cardiovascular and thermoregulatory functions.*

c) What are the potential benefits of using sports drinks? 3 marks

Answer:

- *Sports drinks are designed to supplement energy, fluid and protein needs of the athlete.*
- *When taken during exercise the carbohydrate concentration of a sport drink should not exceed 7% to maximise both sugar and fluid intake and absorption.*
- *This is known as a isotonic sport drink because the dilute level of glucose is the same level of concentration as in the blood.*
- *An isotonic sport drink is an important source of energy during exercise.*
- *And reduces the risk of dehydration.*
- *During recovery, hypertonic drinks contain much higher levels of glucose – up to 20%.*
- *This highly concentrated drink is used to replenish depleted glycogen stores.*
- *And should be drunk as soon as the exercise period has been completed.*

20) Long-distance runners may experience difficulties with their temperature regulation during performance. Why may an increase in body temperature cause a problem and how is it regulated during performance? 6 marks

Answer:

3 marks for three of:

- *Exercise/muscle contraction generates heat.*
- *High core temperature.*
- *Increased blood viscosity/blood gets thicker.*
- *Metabolic processes slowed down.*
- *Cannot transfer metabolic heat generated by muscles quickly enough/unableto sweat efficiently.*
- *Denaturisation of enzymes/enzymes don't function/work properly.*
- *Loss of electrolytes/dehydration.*

Regulation

3 marks for three of:

- *Thermoregulatory centre/medulla/hypothalamus.*
- *Heat loss through sweating/evaporation.*
- *Vasodilation/opening of skin capillaries/blood closer to skin.*
- *Heat loss through radiation.*
- *Head loss through conduction/convection.*
- *Rehydration.*
- *Training adaptations.*