Temperature Regulation During Exercise

Chapter 4

Temperature Regulation

• Human body range must stay within a narrow range of temperatures.
  – Normal is about 37°C or 98.6°F
• Muscle contraction has an efficiency of about 30-33%.
  – Which means a lot of energy is released as heat.
• Endurance performance is affected by
  – The ability to get rid of excess heat in a hot environment.
  – The ability to retain heat in a cold environment.

Heat Exchange During Exercise

Heat Balance

• The goal of temperature regulation is to maintain a constant core-body temperature ( ).
  – Heat loss must match heat gain.
• A function of the is to transport heat.
  – During exercise where heat must be lost, blood flow is increased to the skin.
    • Promotes heat loss to the environment.
  – During exercise where heat must be retained, blood flow is directed away from the skin.

Temperature Regulation

• Controlled by the
  – Works like a thermostat

Heat Transfer

• Energy can be transformed from one form to another.
• Terms like “ ” and “Heat Loss” are descriptors of
  – Transformation of energy from one form to another.
    • Chemical to heat
  – Transfer of energy from one object to another.
    • Heat gradient: Heat will flow from objects with high temperature to objects with low temperature.
Heat Production

• The body produces heat through
  – Normal _____________ processes
    • Not very large production of heat
  – Voluntary _______________ (exercise)
    • Heat results from contraction
  – Involuntary muscle contraction (e.g., shivering)
    • Shivering can increase heat production as much as ____________ resting.

Heat Loss (usually)

• Mechanisms of heat loss from the body:
  – ______________
    • Heat loss to the environment in the form of infrared rays.
      • No physical contact.
  – Conduction
    • Heat flow from cooler object to hotter object where objects are in contact.
    • A form of conductive heat loss.
      • Heat is transmitted to air or water molecules and moved away from heat source (e.g., fan).
  – Evaporation
    • Change from liquid form to vapor.
      • Heat is transferred to the skin via water. When water has reached sufficient heat, it is converted to a gas (water vapor).

Factors that Affect Heat Balance

• Exercise intensity

Factors that Affect Heat Balance

• Wind
  – Heat loss by ______________
    • Must consider relative wind speed
      • Head wind vs. tail wind
  • High temperatures
    – If exercise is in an environment equal to or greater than body temperature, heat cannot be lost via ______________.
      • Heat can be gained by the body in this type of environment.
    • ______________ is an important mechanism of heat loss in hot environments.
      • If humidity is high, sweat does not vaporize but drips off body without producing a cooling effect.

Factors that Affect Heat Balance

• Low temperatures
  – The concern in low temperature environments is when the rate of heat loss exceeds the rate of heat production.
    • ______________
      • Low body temperature
      • The body is better designed to lose heat energy vs. retain heat energy.
        • Clothing is important
Factors that Affect Heat Balance

• Cloud cover
  – The amount of ____________________ which the athlete is exposed to is greatest when there is no cloud cover.

• Clothing
  – As an ____________
    • Traps a layer of air between skin and clothing.
    • Air is a poor conductor of heat (i.e., insulator).
    • Wear sufficient clothing to keep warm but not so much that you start to sweat.
    • Insulating properties of clothing are generally lost when they become wet.
  – To promote heat loss
    • Should not interfere with evaporation
      – Mesh singlet, breathable fabric for shorts and shirts

• Heat ________________
  – Performance can be impaired if the athlete is not acclimatized to heat.
  – Heat acclimatization begins after the first exposure and is fully developed in ______________.
    • The optimum acclimatization program is to exercise daily at intensities greater than ________________.
      – Individual variability
        • Stimulus for acclimatization is raising the core temperature.
        • Characterized by earlier onset of sweating, increase in sweat capacity, reduced losses of sodium and chloride.
  – Heat acclimatization is retained for a few days up until about a week after returning to cooler climates
    • Complete loss of acclimatization ______________.

Factors that Affect Heat Balance

• Dehydration
  – Loss of fluid from body due to:
    • Ingestion of water during exercise enhances the ability to sustain the same exercise intensity for longer duration.
    • Including carbohydrate in the drink is better than water alone (prevents hypoglycemia; possible placebo effect).
    • Fluid ingestion decreases the perception of effort.
    • Fluid ingestion ad libitum is as beneficial as higher rates of forced ingestion.

Dehydration

• Several studies (Adolph, 1947; Pugh et al., 1967; Wyndham and Strydom, 1969) demonstrated that:
  – Endurance athletes ____________ during competition.
    • Voluntary dehydration
  – Top finishers were ____________ and had high rectal temperature.
    • But there were no dangers to athletes who were dehydrated.
  • Two interpretations:
    – Fluid intake should be promoted.
      • Prevent heatstroke (failure of the heat-regulating mechanisms in the body).
    – To be a top endurance athlete you need to be able to tolerate levels of dehydration.

• Is dehydration a cause of fatigue?
  – Noakes reviews some of the early work on dehydration during exercise in the heat.
  – Even when given free access to adequate fluids, subjects drank less than they lost in sweat or urine.
  – Progressive dehydration was associated with premature fatigue.
  – Subjects stopped exercise when they lost about 7-10% body weight.
  – Dehydration did not reduce sweat or urine rate during exercise.
  – Rectal temperature and heart rate rose linearly with level of dehydration.
  – There were no immediate health risks associated with levels of dehydration (7-10%). Only at high levels of dehydration (15-20%) was there a risk of serious organ failure (e.g., kidney).
    • Ingestion of fluid prolonged exercise (preventing dehydration).
    • The impact of dehydration: stopping exercise.
  • There is no empirical evidence that endurance performance will be optimized if fluid is ingested at the same rate that it is lost during exercise.
    • McConnel et al. (1979) reported that replacing 100% sweat lost during exercise did not improve performance more than did replacing only 50% of that loss.
  • Exercise in the heat is limited by ______________.
    • Ingesting fluid is an important mechanism to keep body temperature controlled.
    • There may be a trade off to ingesting too much fluid (e.g., hyponatremia, excess weight, gastrointestinal problems).