

Chapter
12

Temperature Regulation

Objectives

1. Define the term *homeotherm*.
2. Present an overview of heat balance during exercise.
3. Discuss the concept of "core temperature."
4. List the principal means of involuntarily increasing heat production.
5. Define four processes by which the body can lose heat during exercise.
6. Discuss the role of hypothalamus as the body's thermostat.

Objectives

7. Explain the thermal events that occur during exercise in both a cool/moderate and hot/humid environment.
8. List physiological adaptations that occur during acclimatization to heat.
9. Describe the physiological responses to a cold environment.
10. Discuss the physiological changes that occur in response to cold acclimatization.

An Overview of Heat Balance

An Overview of Heat Balance

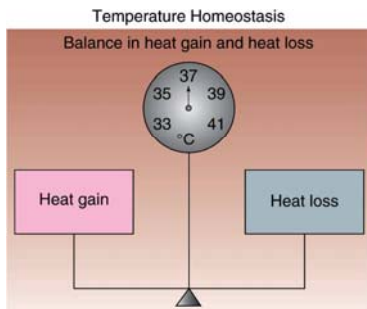


Figure 12.1

Summary

Temperature Measurement During Exercise

- Deep-body (core) temperature

- Skin temperature

Heat Production

- Voluntary

- Involuntary

Heat Production

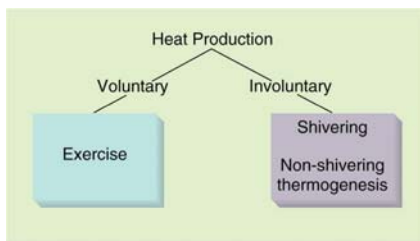


Figure 12.2

Heat Loss

- Radiation
- Conduction
- Convection

Heat Loss

- Evaporation

Heat Exchange Mechanisms during Exercise

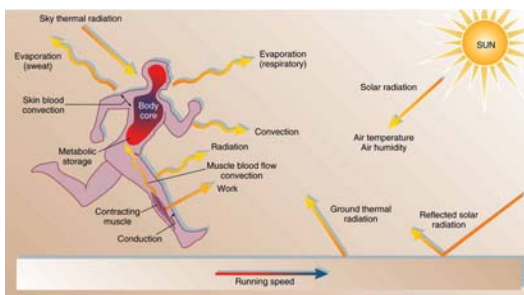


Figure 12.3

Heat Storage in the Body during
Exercise

Summary

Summary

The Body's Thermostat—Hypothalamus

Physiological Responses to "Heat Load"

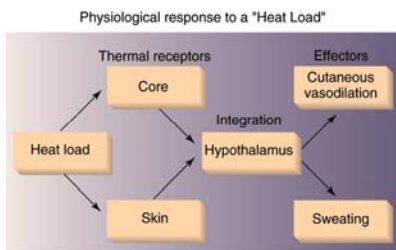


Figure 12.4

Physiological Responses to Cold Stress

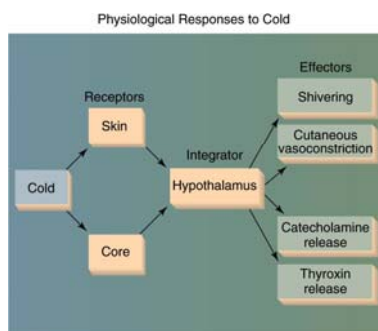


Figure 12.5

Shift in Hypothalamic Set Point Due to Fever

Summary

- The body's thermostat is located in the hypothalamus.
- The anterior hypothalamus is responsible for reacting to \uparrow s in core temperature, while the posterior hypothalamus governs the body's responses to a \downarrow in temperature.
- An \uparrow in core temperature results in the anterior hypothalamus initiating a series of physiological actions aimed at increasing heat loss. These actions include: (1) the commencement of sweating & (2) an \uparrow in skin bld flow.

In Summary

- Cold exposure results in the posterior hypothalamus promoting physiological Δ s that \uparrow body heat production (shivering) & reduce heat loss (cutaneous vasoconstriction).

Thermal Events during Exercise

- As exercise intensity ↑s:

- As ambient temperature ↑s:

Δs in Metabolic Energy Production & Heat Loss during Exercise

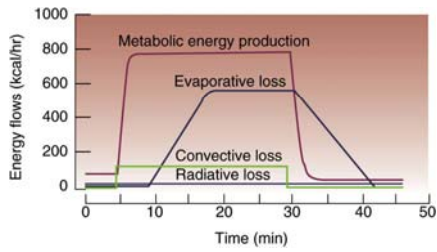


Figure 12.6

Body Temperature during Arm & Leg Exercise

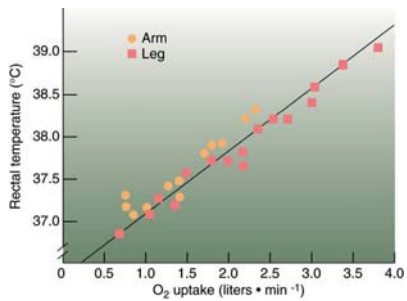


Figure 12.7

Thermal Events during Exercise

Heat Exchange At Rest & During Exercise

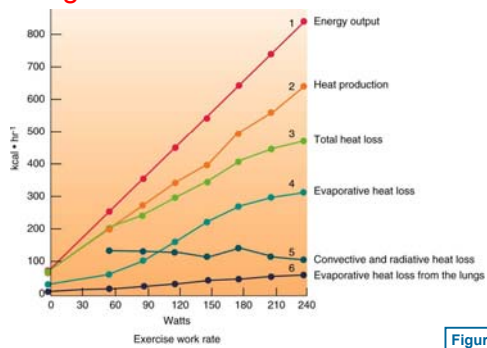


Figure 12.9

In Summary

- During constant intensity exercise, the \uparrow in body temperature is directly related to the exercise intensity.
- Body heat production \uparrow s in proportion to exercise intensity.

Heat Index

- Measure of body's perception of how hot it feels
- Example:
 - Air temperature = 80°F, relative humidity = 80%
 - Heat index = 89°F
- High relative humidity reduces evaporative heat loss

Relationship of Relative Humidity (%), Temperature, & Heat Index



Exercise in the Heat

Core Temperature & Sweat Rate during Exercise in a Hot/Humid Env't

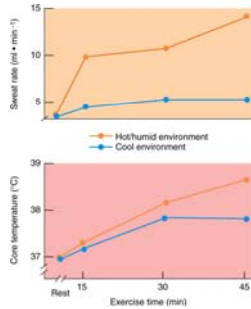


Figure 12.11

Clinical Applications 12.1 Exercise-Related Heat Injuries Can Be Prevented

The Winning Edge 12.1 Prevention of Dehydration during Exercise

Exercise Performance in a Hot Env't

Research Focus 12.1
Exercise in the Heat Accelerates
Muscle Fatigue

Gender & Age Differences in
Thermoregulation

Heat Acclimatization

Primary Adaptations of Heat Acclimatization

TABLE 12.2 A Summary of the Primary Adaptations That Occur as a Result of Heat Acclimatization

1. Increased plasma volume
2. Earlier onset of sweating
3. Higher sweat rate
4. Reduced sodium chloride loss in sweat
5. Reduced skin blood flow
6. Increased heat shock proteins in tissues

In Summary

- During prolonged exercise in a moderate environment, core temperature will ↑ gradually above the normal resting value & will reach a plateau at approximately thirty to forty-five minutes.
- During exercise in a hot/humid environment, core temperature does not reach a plateau, but will continue to rise. Long-term exercise in this type of environment ↑s the risk of heat injury.
- Heat acclimatization results in: (1) an ↑ in plasma volume, (2) an earlier onset of sweating, (3) a higher sweat rate, (4) a reduction in the amount of electrolytes lost in sweat, (5) a reduction in skin bld flow, & (6) ↑d levels of heat shock protein in tissues.

Exercise in a Cold Env't

In Summary

- Exercise in a cold environment enhances an athlete's ability to lose heat & therefore greatly reduces the chance of heat injury.
- Cold acclimatization results in three physiological adaptations: (1) improved ability to sleep in cold environments, (2) ↑d nonshivering thermogenesis, & (3) a higher intermittent bld flow to the hands & feet. The overall goal of these adaptations is to ↑ heat production & maintain core temperature, which will make the individual more comfortable during cold exposure.

Study Questions

1. Define the following terms: (1) *homeotherm*, (2) *hyperthermia*, & (3) *hypothermia*.
2. Why does a significant ↑ in core temperature represent a threat to life?
3. Explain the comment that the term *body temperature* is a misnomer.
4. How is body temperature measured during exercise?
5. Briefly discuss the role of the hypothalamus in temperature regulation. How do the anterior hypothalamus & posterior hypothalamus differ in function?

Study Questions

6. List & define the four mechanisms of heat loss. Which of these avenues plays the most important part during exercise in a hot/dry environment?
7. Discuss the two general categories of heat production in people.
8. What hormones are involved in biochemical heat production?
9. Briefly outline the thermal events that occur during prolonged exercise in a moderate environment. Include in your discussion information about Δs in core temperature, skin bld flow, sweating, & skin temperature.

Study Questions

10. Calculate the amount of evaporation that must occur to remove 400 kcal of heat from the body.
11. How much heat would be removed from the skin if 520 ml of sweat evaporated during a thirty-minute period?
12. List & discuss the physiological adaptations that occur during heat acclimatization.
13. How might exercise in a cold environment affect dexterity in such skills as throwing & catching?
14. Discuss the physiological Δs that occur in response to chronic exposure to cold.
