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Exercising in the Heat and Sun

Abstract

Because of the many health benefits of physical activity, it is recommended that Americans engage in moderate-intensity exercise on a regular basis.[35] However, exercising in a hot environment places an increased strain on the body and increases the risk for heat-related illness or injury. Understanding how the body responds and adapts to being physically active in the heat is critical to ensuring safe and effective exercise. The purpose of this review is to discuss (1) how exercising in the heat and sun can be a major challenge to body temperature regulation, (2) physiological and behavioral adaptations to combat the threat of the potential illness or injury related to exercising in a hot environment, and (3) populations and predisposing factors that may be associated with an increased risk for heat-related problems. While the term "exercise" is used throughout this review, it is important to note that the information provided is relevant for anyone who is physically active in the heat, whether exposure to a hot environment occurs during sports competition, recreational exercise, work, or summer vacation.

Introduction: Challenges to Exercising in the Heat and Sun

Body Core Temperature and Hyperthermia

To preserve optimal physiological function, human body core temperature is usually regulated within a relatively narrow range (35-39°C or 95-102.2°F).[2] During resting thermoneutral (mild environmental temperature) conditions, body core temperature (set point = 37°C or 98.6°F) is maintained by an equal rate of body heat gain and heat loss. However, when the rate of heat gain is greater than the rate of heat loss, body core temperature will increase above set point, and in extreme situations, rise to dangerously high levels (> 40°C or 104°F). The primary means by which the body gains heat is from the environment and metabolism. When ambient temperature is greater than skin temperature (~33°C or 91.4°F at rest, up to ~36°C or 96.8°F during exercise) heat will be transferred from the surrounding air to the body. When exercise is performed, a large amount of heat is produced by the contracting muscles. In fact, less than 25% of all the energy produced by contracting muscles is used to perform work, with the remaining 75% converted to heat in the muscles. The combination of exercise and high environmental temperature (hereafter referred to as exercise-heat stress) presents a serious challenge to body core temperature regulation.[17, 39]

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The means by which the body gains and loses heat during exercise are summarized in Figure 1. Metabolic heat production is directly proportional to exercise intensity. Radiation is the transfer of heat between two objects, with no physical contact being involved. The direction of radiant heat transfer depends on a thermal gradient (e.g., body heat loss from the skin to the environment occurs when skin temperature is greater than air temperature and heat is gained by the body when solar energy from direct sunlight is absorbed by skin). Convection is the heat exchange between the body and surrounding moving air (wind) or body fluids (blood). In evaporation, heat is transferred from the body to water (sweat) on the surface of the skin. When this water gains sufficient heat, it is converted to a gas (water vapor), thereby removing heat from the body. Evaporation of 1 kg of sweat from the skin will remove 580 kcal of heat from the body.[44]

An increase in body temperature is sensed by central and skin thermoreceptors and this information is processed by the hypothalamus to trigger appropriate responses. The two basic physiological mechanisms by which humans dissipate excess heat are by (1) increasing skin blood flow, thereby allowing heat to be moved via convection from the body core to the skin and (2) secreting sweat onto

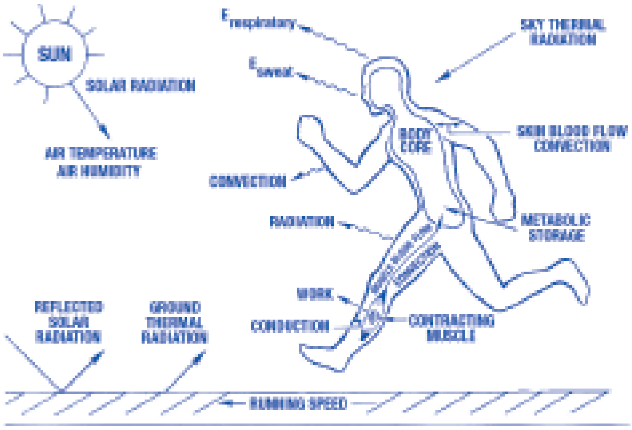

Figure 1.
Schematic diagram showing the means by which the body gains and loses heat during exercise[16]

the surface of the skin for subsequent evaporation. Heat loss via these two mechanisms increases in proportion to the rate of heat production and usually increases sufficiently to balance metabolic heat production, allowing a new steady-state (relatively constant) body core temperature to be achieved (slightly higher than resting body core temperature, e.g., ~38°C or 100.4°F). Of these two heat loss mechanisms, the most important during exercise is evaporation of sweat. In fact, when exercise is performed in an air temperature greater than skin temperature, evaporation is the only means of losing body heat. A key determinant of evaporative cooling capacity is the water vapor pressure gradient between the skin and the air. When the skin surface is saturated with sweat it has a high water vapor pressure (i.e., 100% relative humidity); thus, if ambient humidity is low (e.g., 20% relative humidity) the water vapor pressure gradient between the skin and the air is large and would permit a relatively high rate of evaporative cooling. By contrast, high ambient humidity (e.g., 80% relative humidity) results in a smaller vapor pressure gradient between the skin and the air, thereby reducing the rate of evaporation of sweat and severely limiting the body's cooling capacity. It should be noted that sweat dripping from the body is wasted water loss because sweat must evaporate to allow effective cooling. During vigorous exercise in an environment of high heat and humidity, body core temperature will not reach a steady state, but continue to rise, making the continuation of exercise especially difficult and potentially dangerous.[17, 39]

Cardiovascular Responses

The cardiovascular system is also important in temperature regulation. The demand for increased blood flow to both the exercising muscles and skin during exercise-heat stress places an increased strain on this system. For instance, the increase in skin blood flow during exercise-heat stress is accomplished by (1) an increase in cardiac output (volume (e.g., mL) of blood ejected from the heart each min) above that of exercise in cool conditions and (2) the redistribution of blood away from the gastrointestinal tract, hepatic, and renal circulations toward the skin circulation. Additionally, sweat loss during exercise-heat stress can cause a decrease in blood plasma volume. A smaller overall plasma volume will result in a reduction in the amount of blood that is returned to the heart (cardiac filling or venous return) and thus a reduction in the amount of blood that is ejected from the heart with each beat (stroke volume). A decreased stroke volume requires a compensatory increase in heart rate to maintain cardiac output. In this manner, a decrease in plasma volume causes cardiac strain and limits the amount of blood flow available to the muscles and skin during prolonged exercise-heat stress.[37, 39]

Heat-Related Problems

Table 1 describes the possible problems that may arise as a consequence of exercising in a hot environment.[2, 8] Heat exhaustion, syncope, and cramps are relatively minor and common problems that can usually be resolved by cessation of exercise, replacing fluid and electrolytes, and relocating to a cooler environment. These problems are

Table 1.
Injuries and illnesses associated with exercising in the heat.

Condition	Symptoms	Causes
Muscle (Heat) Cramps	acute, painful, involuntary muscle contraction	sodium deficiency, neuromuscular fatigue, dehydration
Heat Exhaustion	inability to continue exercise, fatigue, weakness, hyperventilation, headache, nausea, diarrhea	dehydration, hyperthermia, sodium deficiency, energy depletion
Heat Syncope	fainting after sudden cessation of exercise or sudden/prolonged standing, headache, nausea	peripheral pooling of blood, dehydration, cerebral ischemia
Heat Stroke	central nervous system dysfunction manifested as altered mental status (e.g., confusion, combativeness), seizures, coma	thermoregulatory overload or failure

associated with normal to slightly elevated body core temperature. On the other hand, heat stroke is a potentially life-threatening condition in which body core temperature rises to > 40°C (104°F) and requires emergency medical attention and rapid body cooling. All of these heat-related problems are preventable with heat acclimation, proper hydration practices, and behavioral adaptations (prevention is discussed in more detail later).

Fluid and Electrolyte Imbalances

When fluid intake is less than sweat loss a body water deficit, or dehydration, occurs. It is difficult to closely match the volume of fluid intake to the volume of sweat output because thirst does not provide a good index of body water requirements. *Ad libitum* drinking (i.e., drinking in response to thirst stimulus) during and/or after exercise-heat stress usually results in incomplete fluid replacement, a concept known as "voluntary dehydration". In fact, it is common for individuals to voluntarily replace only about 50% of sweat losses during a given bout of exercise in a hot environment.[8, 11]

Water accounts for approximately 60% of total body weight in the average adult. A reduction in body water is associated with impaired circulatory and thermoregulatory function during exercise. For instance, dehydration causes a decrease in plasma volume and therefore a decrease in stroke volume and a compensatory increase in heart rate to maintain a given cardiac output at a given work rate.[38] Body water loss also leads to a decreased capacity to sweat and augment skin blood flow.[15] By impairing heat-dissipating mechanisms and circulatory performance, dehydration results in an increased core temperature. The magnitude of hyperthermia depends on ambient conditions and exercise intensity, but the range is 0.1 to 0.4°C (0.2 to 0.7°F) per 1% dehydration. Thus, the higher the percent dehydration at a given exercise intensity and ambient temperature, the higher body core temperature will rise and the higher the risk for heat-related injury and illness. For a 70 kg (154 lb) individual exercising at a moderate intensity (55-70% maximal heart rate) on a hot day (85°F and 50% relative humidity), sweating at a rate of 1.0-1.5 L (2.2-3.3 lb) per hour, it would take about 60-80 min (without fluid replacement) to reach 2% dehydration, or about 120-160 min (without fluid replacement) to reach 4% dehydration. If sweat losses are fully replaced, body core temperature will typically stabilize at about 38.0°C (100.4°F). Conversely, if the individual becomes 2-4% dehydrated, body core temperature will continue to rise to ≥ 38.5-39.0°C (≥101.3-102.2°F). Body core temperature may reach higher levels (≥40°C or 104°F) if exercise intensity, air temperature, and/or relative humidity is increased (above that of the conditions in the example provided). As little as 2% dehydration is associated with mental/physical fatigue and impaired exercise performance.[4, 10, 13, 21] Other signs and symptoms of dehydration are headache, mild nausea, or dizziness.[8]

When individuals underdrink during exercise-heat exposure, they become hypovolemic (overall decrease in blood plasma volume) and hyperosmotic (an increase in the concentration of solutes in plasma, because of increased water lost as sweat). On the other hand, if someone overdrinks (drinks more fluid than they have lost through sweating), he or she can become hypervolemic (overall increased volume of plasma) and hypo-osmotic (dilution of plasma). The gross overconsumption of fluids (especially sodium-free fluid, such as water) over a prolonged period of exercise (usually ≥ 4hrs) can lead to the dilution of sodium concentration in the blood. This rare, but potentially dangerous condition is called hyponatremia, and is defined as plasma sodium concentration less than 135 mmol/L. Normal values are 135 to 145 mmol/L. The reduction in solute concentration in plasma promotes movement of water from the plasma and into cells, which can cause swelling in the brain, alters central nervous system function, and congestion in the lungs.[31] Symptoms of mild to moderate hyponatremia may include headache, nausea, dizziness, and muscle weakness, while severe hyponatremia (typically plasma sodium concentration < 125 mmol/L) is characterized by pulmonary edema, cardiorespiratory arrest, cerebral edema, seizures, and/or coma.[5, 31]

Exercise Performance

It is well established that heat stress and/or dehydration result in an earlier onset of fatigue during prolonged aerobic exercise compared to exercise in cool conditions and/or in a euhydrated state.[19, 38] There is also evidence that performance of intermittent, high-intensity exercise tasks, including skill sports (e.g., soccer and basketball), is negatively impacted by heat stress and/or dehydration.[13, 29, 32] Dehydration exacerbates hyperthermia by impairing evaporative and convective cooling capacity and increasing circulatory strain.[38] Additionally, blood flow to exercising muscles is attenuated with dehydration during exercise-heat stress.[20] Hyperthermia causes a shift in metabolism; such that muscle glycogen oxidation and blood lactate accumulation occur at a faster rate than if exercise was performed in a cool environment.[27, 39] Any of these factors could contribute to the early onset of fatigue during exercise-heat stress; however, the most important may be central nervous system changes that occur as a result of hyperthermia. According to the critical internal temperature hypothesis, individuals exercising in the heat consistently reach the point of exhaustion at the same threshold body core temperature (~40°C or 104°F). This critical core temperature coincides with voluntary fatigue despite variations in exercise intensity, initial core temperature, adiposity, acclimation, or hydration status. The concept underlying the critical core temperature hypothesis is that an increased body core and brain temperature is associated with a decreased central drive to exercise.[33] The diminished drive to exercise is associated with an increased rating of perceived exertion and reduced motor unit recruitment and firing rate to the exercising muscle. From an evolutionary perspective, central fatigue acts as a safety mechanism—by decreasing the drive to exercise and therefore decreasing the rate of muscle contraction—hyperthermia is minimized and dangerous increases in core temperature are prevented.[33]

Combating Hyperthermia

Heat Acclimation

One of the best methods for improving heat tolerance and decreasing risk of developing a heat illness or injury is to gradually acclimate to exercise in hot environments. Heat acclimation is a series of physiological adaptations that occur with repeated exposure to exercise-heat stress that makes humans better able to prevent dangerous increases in core temperature. Table 2 summarizes the adaptations that occur as a result of heat acclimation relative to a non-acclimated state.[43] Improved heat tolerance will occur within 1-2 weeks of aerobic exercise in a hot environment. When beginning a heat-acclimation regimen it is important to start slow (walking or jogging for as little as 10-15 min) and gradually increase the intensity and duration (up to 90 minutes) of exercise in the heat.[2]

Table 2. Summary of adaptations that occur after 1-2 weeks of repeated exercise-heat exposure.
Sweating Earlier onset Increased sweating rate More uniform sweating pattern over entire body surface area Decreased sodium concentration
Circulation Plasma volume expansion Stroke volume increases Heart rate decreases
Decreased core and skin temperature
Improved exercise performance or work capacity
Decreased rating of perceived exertion
Decreased mental fatigue

An earlier onset of sweating and increase in sweating rate enhances the body's cooling capacity, while a reduced sweat sodium concentration minimizes the risk for heat-related injury and illness associated with sodium deficiency. Prior to heat acclimation, local sweating rate is higher on the torso than the limbs. Repeated exercise-heat exposure results in a more uniform sweating pattern over the entire body surface area (by increasing sweating rate of arms and legs). Higher evaporation of sweat over the limbs may be more advantageous than that over the torso because of a larger surface area-to-mass ratio on the limbs. Plasma volume expansion occurs as a result of plasma sodium retention (via sweat sodium conservation) and translocation of protein and fluid from the interstitial space to the plasma. An increase in plasma volume reduces cardiovascular strain during exercise-heat stress by increasing stroke volume and decreasing heart rate compared to that of a non-acclimated state.[43]

All of the adaptations in sweating and circulatory function attenuate the increase in body core temperature during a given exercise-heat exposure, thereby improving physiological and psychological tolerance of exercising in the heat and lowering risk of heat-related illness or injury. Passive heat exposure or exercise training without heat exposure offers some but not all of the benefits of repeated exercise and heat stress combined. It is important to note that adequate fluid and sodium intake is necessary to experience complete heat acclimation (fluid and sodium replacement discussed in more detail later). Once heat exposure stops, the benefits of acclimation are retained for approximately 1-4 weeks. Sleep loss, alcohol abuse, salt depletion, and dehydration result in a rapid decay of acclimation, while high levels of aerobic fitness are associated with greater retention of heat acclimation.[34, 43]

Behavioral Adaptations

The risk of developing heat-related problems can also be reduced by properly adjusting the exercise program to account for the effects of the environmental conditions. When making exercise decisions based on the thermal environment, it is important to evaluate all aspects of the environment which impact exercise safety. Ambient temperature, humidity, air movement, and solar radiation are all important factors to consider. The outdoor Wet Bulb Globe Temperature (WBGT) is a useful index of environmental heat load as it represents a composite measure of all four factors. The WBGT can be calculated as follows:[3]

$$WBGT = 0.7\ T_{wb} + 0.2\ T_{bg} + 0.1\ T_{db}\ [°C \text{ or } °F] \quad \text{(Equation 1)}$$

Where T_{wb} is measured by placing a wetted cotton wick over the thermometer bulb (measures combined effect of humidity and air velocity), T_{bg} is the temperature inside a copper globe painted flat black (measures radiant heat load), and T_{db} is the direct measure of air temperature. T_{wb} makes the highest contribution to this heat stress index because, if the ambient water vapor pressure (i.e., humidity) is high and wind velocity is low, then the evaporation of sweat from the skin surface is limited. Directors of outdoor activities (e.g., road races) are encouraged to use the WBGT heat index chart to make decisions about whether or not to hold their events. The four categories of risk for heat illness or injury include:[3]

Very high risk: WBGT above 28°C (82°F);
High risk: WBGT 23-28°C (73-82°F);
Moderate risk: WBGT 18-23°C (65-73°F);
Low risk: WBGT below 18°C (65°F).

It is important to note that these measures of risk are based on individuals wearing shorts and a T-shirt. The wearing of additional clothing can greatly impede heat dissipation and increase heat stress. If available, light-colored (to minimize solar radiant heat gain), loose-fitting (for optimum ventilation, as tight or poorly ventilated clothing reduces the convective flow of air over the skin surface) clothing made of moisture-wicking fabric (to allow evaporation of sweat) should be worn while exercising in the heat.[18] To prevent sunburn, individuals should minimize exposure to the sun from 10 am-2 pm, wear a hat, and generously apply a sunscreen with SPF ≥ 15 about 30 minutes before sun exposure.[2, 14, 40]

It should also be noted that the risk for heat-related problems is much higher if exercise is vigorous (e.g., ≥ 70% of maximal heart rate), since metabolic heat production drives the increase in core temperature. In fact, exertional heat stroke often occurs in overzealous individuals who ignore safety recommendations and fail to make appropriate behavioral adjustments while exercising in hot and/or humid conditions. On especially hot and/or humid days exercise intensity should be reduced. This can be accomplished by slowing the pace or adding rest breaks to the exercise bout.[8] Another technique for maintaining a safe level of exercise intensity involves the use of target heart rate. As discussed previously, heart rate is higher during exercise in the heat, compared to exercise in cool conditions. In fact, heart rate increases by 5 beats per minute for every 3-4°C (5.4-7.2°F) increase in WBGT.[17] Adjusting exercise pace to stay within the target heart rate zone will cause an appropriate corresponding decrease in exercise intensity.

Fluid and Electrolyte Replacement

To prevent the circulatory and thermoregulatory strain and impaired exercise performance associated with dehydration, the recommended hydration strategy is to drink enough fluid to fully replace sweat and urine losses incurred during exercise.[11] A simple method to estimate fluid loss is to measure body weight before and after a workout. The goal during exercise and recovery should be to drink just enough fluid to maintain pre-exercise body weight (i.e., drink 16 oz of fluid for every lb of sweat lost). Sweating rates can vary from less than 0.5 to over 2.5 L (17 to over 85 oz) per hour depending upon exercise intensity, environmental conditions, amount and type of clothing or equipment, acclimation state, fitness level, and hydration status.[38] Because of this considerable variation, it is important to know the individual's sweating rate to avoid the negative effects of drinking too little or too much fluid.

The composition of fluid consumed during and after exercise-heat stress is also an important consideration. Prolonged and/or intense (especially stop-and-go type sports, such as soccer, basketball, or tennis) exercise can cause substantial fluid and electrolyte loss and reliance on carbohydrates as the primary fuel for muscles. Thus, a fluid replacement beverage with carbohydrates and electrolytes should be consumed for optimal performance during these types of activities.[28, 41] Carbohydrates supply energy to contracting muscles and also provide flavor which enhances palatability and promotes voluntary fluid consumption. Solutions with a carbohydrate concentration ≤ 6% are emptied from the stomach and absorbed from the intestine into the bloodstream at rates similar to that of plain water. Sodium ingestion during and after exercise helps maintain thirst (resulting in greater voluntary fluid consumption), protects plasma volume, maintains plasma sodium concentration, and reduces urine production.[11, 23] These responses aid in keeping exercisers well-hydrated, help sustain cardiovascular function,[12] and reduce the risk of electrolyte imbalances (e.g., hyponatremia).[30] It is important to note that exercisers who consume sports drinks should still take care to drink only enough fluid to maintain initial (i.e., pre-exercise) body weight. Although sports drinks contribute sodium to the blood, the sodium concentration of sports drinks is lower than that of the blood, so drinking substantially more fluid than is lost in sweat could eventually result in the dilution of blood sodium concentration (i.e., hyponatremia).

Considerations for Special Populations

Older Adults

Epidemiological data suggest that advanced age (>65 yrs) is associated with an increased risk of heat-related death.[9] Because of age-related changes in skin structure, older individuals have an attenuated sweat gland output and skin blood flow response to heat stress. However, studies which match healthy older and younger persons for body composition, aerobic capacity, and state of heat acclimation have concluded that older individuals respond to heat stress with a rate of heat storage and final core temperature similar to their younger counterparts.[24] Likewise, older athletes and young adults are equally capable of acclimating to exercise in a hot environment.[36] These findings suggest that it is not chronologic age *per se* that causes impaired temperature regulation, rather it is other factors which change concomitantly with advancing age that put older men and women at an increased risk for heat-related illness or injury. Examples of variables that typically change with age and that could affect heat tolerance include (1) decreased aerobic capacity, (2) sedentary lifestyle, (3) increased prevalence of chronic diseases (e.g., diabetes and cardiovascular disease), and (4) increased use of prescription drugs (e.g., diuretics and anticholinergics). Nonetheless, for healthy older men and women who maintain a high degree of aerobic fitness, the risk of heat-related illness is not significantly greater than that of young adults.[24] It is important to note, however, that since aging is associated with reduced thirst sensitivity in response to dehydrating exercise in a warm environment and increased water excretion by the kidney, adequate fluid intake should be particularly emphasized for older individuals exercising in the heat and sun.[26]

Children

In general, children are thought to tolerate exercise in the heat more poorly than adults. Several physiological characteristics put children at a thermoregulatory disadvantage. First, sweating capacity (sweating rate per unit body surface area and sweat production per gland) is much lower in children than adults. In addition, children experience greater cardiovascular strain during exercise-heat stress, as cardiac output per unit of oxygen uptake is lower and heart rate is higher in children than adults. Furthermore, compared to adults, children acclimate to the heat at a much slower rate and experience a greater increase in body core temperature when hypohydrated. For reasons not entirely clear, children expend more energy (and thus produce more metabolic heat) per kg body mass than adults at any given walking or running speed. Children also have a higher body surface area-to-mass ratio than adults; and since heat transfer between the environment and the body depends on the surface area of the body exposed to the environment, children absorb heat faster than adults whenever ambient temperature exceeds skin temperature. Having a higher body surface area and lower sweating capacity means that children rely to a greater extent on radiation and convection rather than evaporation of sweat to dissipate body heat. As long as the ambient temperature is no more than 5 to 7°C (9 to 12.6°F) above skin temperature (i.e., ambient temperature <42°C or 107.6°F), children regulate their core temperature as effectively as adults during ≤ 1 hr of exercise. However, in extremely hot environments (≥ 45°C or 113°F) children's ability to dissipate heat is compromised and exercise tolerance is significantly lower than that of young adults.[7]

Other Factors

Sex—In women and men who are matched for fitness, acclimation state, adiposity, and body size, there does not appear to be sex-related differences in thermoregulatory function other than a lower sweating rate in women as compared to men.[25] While having a lower sweating rate is a thermoregulatory disadvantage in hot-dry environments, it is actually an advantage for women in hot-humid conditions because they have a lower risk of dehydration. The menstrual cycle has minimal effects on tolerance to exercise-heat stress.[25]

Hyponatremia occurs more commonly in women; however, evidence suggests that this is most likely due to sex differences in body size, racing time, and fluid intake behavior, rather than sex *per se*. Women tend to have smaller body mass (and less total body water), slower marathon times (>4 hrs, which means they have more time to drink), and voluntarily drink more fluid per body mass than men, which puts women at an increased risk for developing hyponatremia.[1, 6, 22]

Recent Illness—Individuals who are currently or were recently ill may be at an increased risk for heat-related illness due to dehydration or fever. Additionally, individuals with a prior episode of heat stroke may be more susceptible for recurrent heat illness.[2, 8]

Sleep Loss—Prolonged sleep loss has been shown to decrease skin blood flow and sweating rate at a given core temperature.[2]

Chronic Disease—Medical conditions that can raise the risk of incurring heat-related problems include hypertension (alters the control of skin blood flow), diabetes (neuropathies may affect sweating and/or skin blood flow), obesity (increased rate of metabolic heat production during exercise), and cystic fibrosis (increased salt loss in sweat).[2, 8]

Medications and Drugs—Certain medications and drugs may predispose an individual to heat-related illness by promoting heat storage or impairing heat loss mechanisms. For example, antihistamines and anticholinergics reduce sweat production, beta-adrenergic and calcium-channel blockers impair skin blood flow, amphetamines and tricyclic antidepressants increase metabolic heat production, and alcohol, caffeine, and theophylline (found in tea) are mild diuretics (stimulate urinary fluid and sodium loss).[2, 8, 42]

Sunburn—When exercising in a hot environment, sunburned individuals exhibit an impaired ability to secrete sweat. In addition, sunburn increases ratings of perceived exertion and thermal sensation, which means that sunburned individuals feel more hot and fatigued when exposed to a given exercise-heat stress.[2]

Summary

Body core temperature during exercise-heat stress is determined primarily by the balance of environmental conditions (e.g., temperature, humidity, air velocity, and radiant heat load) and the body's heat dissipating mechanisms (e.g., skin blood flow and sweating). If body heat gain exceeds heat loss and/or if fluid intake is not sufficient to match sweat loss, problems related to hyperthermia and/or dehydration (e.g., muscle cramping, heat exhaustion, heat syncope, and heat stroke) can develop. Predisposing factors such as age (older adults or children), disease, and medication/drug use, may put certain individuals at an increased risk for heat illness and injury. However, physiological (e.g., heat acclimation) and behavioral adaptations (e.g., avoiding exercise when WBGT > 73°F, wearing light-colored, loose-fitting, moisture-wicking clothing, decreasing exercise intensity, consuming 16 oz of fluid for every lb of sweat lost) can minimize the risk for heat-related problems and thus facilitate the safe participation in regular exercise.

Exercising in a hot environment places an increased strain on the thermoregulatory and cardiovascular systems and increases one's risk for heat-related illness or injury. Understanding how the body responds and adapts to being physically active in the heat is critical to ensuring safe and effective exercise.

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