

Environmental Issues for Team Physicians

Michael J. DeFranco,* MD, Champ L. Baker III, MD, Jerome J. DaSilva, MD,
Dana P. Piasecki, MD, and Bernard R. Bach Jr, MD
From Rush University Medical Center, Chicago, Illinois

As outdoor sports continue to gain popularity, understanding the environmental factors that may influence athletes is becoming a more important aspect of medical care for team physicians. Temperature, ultraviolet light, lightning, and altitude are some of the most common elements that cause illness. Understanding how to prevent, diagnose, and promptly treat conditions caused by environmental factors is essential to optimizing athletic performance in outdoor sports and avoiding morbidity.

Keywords: team physician; environment; heat-related illness; cold injury; ultraviolet light; lightning; altitude

As outdoor sports continue to gain popularity among active individuals, it is essential for sports medicine physicians to understand the environmental factors that may significantly influence the performance and overall health of the athletes who are under their care. Heat-related illness, cold injury, ultraviolet light, lightning, and altitude represent some of the most common elements of nature that may afflict the outdoor athlete during activity. This review provides a synopsis of the physiology, clinical presentation, and treatment for each of these conditions. Understanding the symptoms and signs of each condition is essential to providing prompt care and preventing long-term disability and death.

HEAT-RELATED ILLNESS

Although medical research has led to a better understanding of fluid balance among athletes, heat-related illness continues to be a significant threat to athletic performance and overall health. Among high school athletes, for example, heat-related illness is the third most common cause of death.³⁷ Common risk factors include lack of acclimation to the environment, underhydration, medications (alcohol, stimulants), and illness (sweat gland dysfunction, urinary infection). Prepubescent age, obesity, poor fitness, and sleep deprivation may also play a role.⁷¹ For the most part, the conditions that define heat-related illness are largely preventable with careful attention to the environment, fluid balance, and activity level.

Most energy produced by the body is converted to heat. Heat production is proportional to body weight, while heat loss is proportional to body surface area.²⁷ Heat dissipates through evaporation, radiation, conduction, and convection

(Figure 1). Among these mechanisms, evaporation is the primary mechanism through which heat is dissipated by the body.³⁷ Radiation occurs when a warm body gives off heat as infrared radiation to a colder body or surroundings. This method of heat loss is described in more detail in the section on cold injury. Conduction is the transfer of heat from one object to another by direct physical contact. Conduction losses are greatest when an individual is wet because water is a much stronger conductor than air.²⁷

Convection losses are secondary to the motion of air across the body surface. Increased air speed across the body surface results in increased convection losses. Evaporation as well as perspiration and insensible losses from respiration lead to a significant amount of water loss and accompanying heat loss from the body to the surrounding environment. The hypothalamus controls 2 physiologic mechanisms that are essential to heat loss.^{27,37,71} One of the mechanisms is an increase in skin blood flow, and the other is an increase in sweat production.

Heat acclimation is a process that the body uses to protect itself from heat-related illness. Physiologically, acclimation is manifested as an increase in sweat rate and a decrease in electrolyte loss. As a result of these processes, there is an increased resistance to dehydration and improvement in "demand" drinking. In general, the key to preventing heat illness is hydration. Athletes should be encouraged to drink before, during, and after activity.^{29,37} Several methods (eg, measuring body weight) have been described to determine appropriate amounts of fluid intake. Many factors contribute to the amount of fluid athletes may need depending on their level of fitness and acclimation. Physicians should consult sports medicine nutritionists and the references in this article for specific details on this issue with regard to the types of athletes under their care. In general, the goal is the same for all athletes—to maintain adequate hydration throughout their activity. Rehydration requires maximizing voluntary intake and gastric emptying. The specifics on how to achieve these goals should be individualized to each athlete.

The mechanisms of heat production and dissipation influence the risk of developing heat illness. For example,

*Address correspondence to Bernard R. Bach Jr, MD, Director, Division of Sports Medicine, 1725 W. Harrison St, Suite 1063, Chicago, IL 60612 (e-mail: brbachmd@comcast.net).

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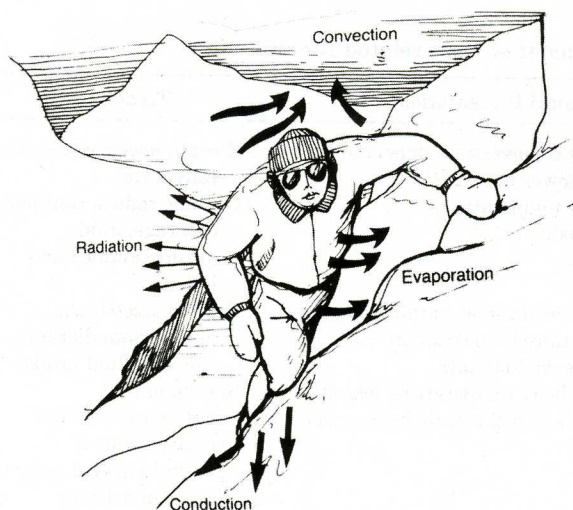


Figure 1. Four mechanisms of heat loss. (Reproduced with permission from Stanitski C. Heat intolerance problems. In: Delee J, Drez D, eds. *Orthopaedic Sports Medicine*. Philadelphia: WB Saunders; 1994:374-384)

larger body weight increases heat production more than dissipation due to the relationship between weight and body surface area; lack of wind disrupts heat dissipation via convection; lack of fluid disrupts heat dissipation via evaporation; high ambient temperature disrupts heat loss due to radiant heat (in extremely hot environments, athletes may gain heat from the environment due to radiant heat); and high relative humidity will disrupt evaporative heat losses. Clothing (material, color, permeability, etc) also has a significant effect on heat gain and loss as well as dehydration risk. Overall, consideration must be given to all these factors when assessing athletes for the risk of developing heat-related illness.

Wet bulb globe temperature (WBGT) is an index of environmental heat stress and is used to estimate the risk of heat-related illness.³⁷ It is defined by the temperature, humidity, and radiant heat. Howe and Boden³⁷ have defined the calculation and application of WBGT in detail. There is a low risk of heat illness if the WBGT is <65°F, moderate risk for 65° to 73°F, high risk for 73° to 82°F, and very high risk for >82°F. Wallace et al⁷⁷ reported on the relationship between continuous hot weather training and exertional heat illness. They determined that the risk of exertional heat illness is increased with WBGT as well as with the previous day's WBGT.⁷⁷ The American College of Sports Medicine (ACSM) recommends canceling sporting events when the WBGT is >82.4°F.¹ Overall, WBGT is a method to monitor athletes for heat-induced stress and the development of heat-related illness. Other experimental techniques currently under development include the use of thermal cameras and core temperature monitoring devices.

The clinical spectrum of heat-related illness includes heat edema, heat rash, heat cramps, heat syncope, heat exhaustion, and heat stroke. An extensive review of heat-related illness is provided elsewhere,³⁷ but significant points regarding clinical evaluation and management are

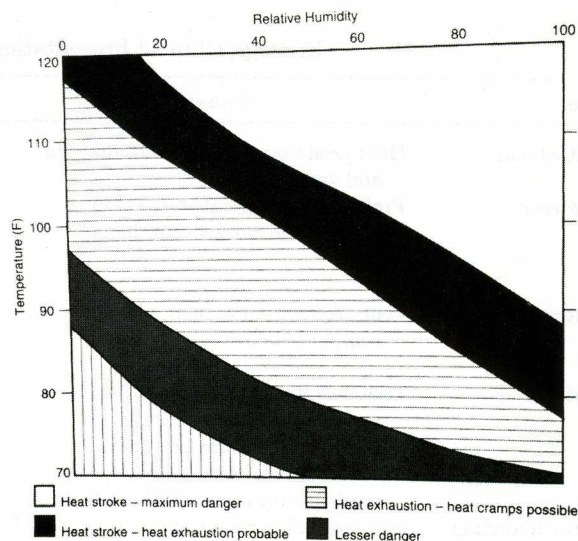


Figure 2. Relationship between temperature, humidity, and heat stroke. (Reproduced with permission from Stanitski C. Heat intolerance problems. In: Delee J, Drez D, eds. *Orthopaedic Sports Medicine*. Philadelphia: WB Saunders; 1994:374-384)

summarized here. Table 1 provides a synopsis of the causes, clinical presentation, and treatment steps for each of these conditions. The preventive measures for all these conditions include acclimating to warm weather before strenuous activity and maintaining adequate hydration. Understanding the relationship between temperature, humidity, and heat stroke is important (Figure 2). Heat edema is the mildest form of heat-related illness. At the other end of the spectrum is heat stroke, which is life-threatening and should be treated as a medical emergency. Heat cramps fall between these 2 extremes. Fatigue may alter the normal mechanism of muscle contraction and lead to the development of heat cramps.⁶⁷ Heat cramps commonly occur in the most worked muscles (calf, thigh) and after exertion. A recent study on National Collegiate Athletic Association football players revealed that large sodium and fluid losses in sweat may be characteristic of football players with a history of heat cramping.⁷³ It is important to recognize that heat cramps are a precursor and, therefore, an early sign of heat exhaustion. Furthermore, they are different from fatigue cramps, which occur in multiple muscles and have a poor response to stretching and massage.³⁷

Heat syncope, heat exhaustion, and heat stroke represent a continuum of more severe heat-related conditions. It is essential to distinguish heat exhaustion and heat stroke. In heat exhaustion, there is a lack of central nervous system dysfunction. These patients are usually alert and oriented. On the other hand, any change in mental status should be prudently managed as heat stroke.¹ Another important factor is that the presence of sweating is not a reliable method of distinguishing heat exhaustion from heat stroke.¹ To prevent progression of heat exhaustion to

