Heat Illness

On-Site Diagnosis and Cooling

Richard P. Sandor, MD

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In Brief: Heatstroke is a true sports emergency. By recognizing the key signs and symptoms--a core body temperature above 40.5°C and mental status changes--on-site physicians can begin urgent management of heatstroke. Cooling must begin immediately; ice water immersion is best if practical, but other measures can be effective. Other conditions common in the heat, like 'heat cramps,' 'heat exhaustion,' and 'heat syncope,' are less serious and generally require less drastic measures. Cramps typically respond to sodium replacement, and heat exhaustion and syncope require rest and possibly cooling and rehydration.

The spectrum of exertion-related heat illnesses (table 1) ranges from uncomfortable to fatal. Fortunately, heat disorders--most notably, heatstroke--are treatable and preventable, and knowledge of these conditions is the foundation for effective emergency treatment and improved counseling for those who exercise or face risky situations.

Table 1. Disorders Often Related to the Heat

Heatstroke

"Heat cramps"

"Heat exhaustion"

"Heat syncope"

Each heat-related syndrome represents a different outcome and possibly different pathophysiology in response to the same physiologic stress, ie, heat. Heat stress results from the interplay of a variety of factors (figure 1). Although heat illness is certainly more common in the summer, serious heat illness can, depending on endogenous and environmental factors, occur in even moderate conditions (1).

Understanding Heatstroke

Heatstroke is the most dangerous of the heat-related illnesses and can be fatal. Its exact cause is not known, but the result is marked hyperthermia that can produce widespread cellular damage if not treated immediately.

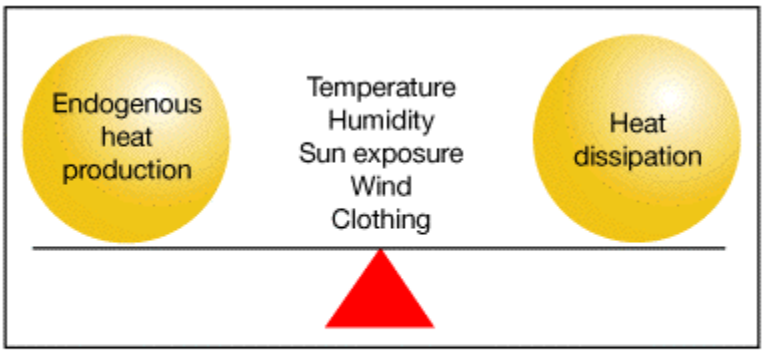


Figure 1. This schematic diagram illustrates heat balance. Heat production is balanced, in most cases, by heat dissipation. The environmental factors in the center can increase or decrease heat dissipation or add to the endogenous heat load.

Incidence and mortality figures for the athletic population are difficult to ascertain, but some have been reported. For example, five high school football players died of heatstroke in the United States in 1995 (William O. Roberts, MD, personal communication, 1996). Undoubtedly, the incidence of nonfatal heatstroke was higher. There are between 10 and 15 heatstroke casualties per year in the Falmouth, Massachusetts, road race (2). In the Peachtree 10K road race held on July 4, 1979, in Atlanta, 29 of the approximately 17,500 runners suffered severe heat injury (3). Among 7,000 marine recruits at Parris Island, South Carolina, during a 5 1/2-month summer period, there were 13 cases of heatstroke, none fatal (4).

Current heatstroke survival is 90% to 100% (8)--greatly improved from a rate of about 20% early in this century (5). This can be attributed in large part to improved initial management with early and aggressive cooling measures.

Heatstroke occurs in two forms, exertional and classic. The classic version is recognized by the well-known triad of hyperpyrexia, anhidrosis, and mental status changes. Classic heatstroke generally occurs during heat waves and typically affects the very young, the very old, and those with chronic diseases like diabetes, congestive heart failure, or coronary artery disease. This form is the result of an exogenous heat load that overwhelms the body's ability to cope with it.

In contrast, the athlete is at risk for the exertional form of heatstroke. The victim is not at the extremes of age and is usually free of chronic disease, and the occurrence is sporadic. Here the exogenous heat load (determined by air temperature, humidity, and solar radiation) combines with endogenous heat load (metabolism and muscle action) to overwhelm the body's heat dissipation mechanisms and create an uncompensated heat stress.

Unlike people with classic heatstroke, exertional heatstroke victims are almost always still sweating (5). Therefore, the diagnosis of exertional heatstroke is based on mental status changes and a core temperature greater than 40.5°C or 41°C (105°F or 106°F) rectally. For this reason, taking a rectal temperature as soon as possible is crucial in evaluating any ill athlete. Oral, axillary, and aural temperature measurements are all believed to reflect peripheral or shell temperatures, which may or may not match core temperature (6).

Mental status changes associated with exertional heatstroke include coma, confusion and disorientation, and psychotic behavior (4). Seizures may not be present initially but can occur during cooling (7). Patients most often physically collapse (1,5). Premonitory symptoms such as weakness and dizziness are common but often go unrecognized, and the patient presents acutely (3,5). Other initial physical findings can include sinus tachycardia, hypotension, and, rarely, shock (7). The physician must keep in mind other illnesses that can cause fever, mental status changes, and collapse (table 2).

Table 2. Differential Diagnosis of Exertion-Related Heatstroke

Pontine or midbrain infarct
Meningitis
Effect of drugs inhibiting autonomic function
Effect of drugs increasing endogenous heat production
Hypoglycemia
Hyponatremia
Malaria

When untreated, heatstroke can cause cardiac cellular damage, hepatic necrosis, rhabdomyolysis, disseminated intravascular coagulation, adult respiratory distress syndrome, and renal failure. Expedient on-field management, therefore, can save lives.

Urgent Management

ABCs. As always, when a patient has collapsed, the on-site physician should proceed with the ABCs (airway, breathing, and circulation). A secure airway must be established, followed by intravenous access in cases of hypotension or for the control of seizures.

Cooling. Some form of cooling must be started immediately. The cooling process begins by removing the athlete from competition, getting him or her to a cool or shady area, and removing any insulating clothing. The most effective cooling method is ice water immersion (8), which may augment blood pressure and decrease the need for intravenous fluid (William O. Roberts, MD, personal communication, 1997). Depending on the situation, however, immersion may not be practical. Other cooling methods include cool water immersion; wrapping in cool, wet towels; using fans; and applying ice packs to the neck, axilla, and groin. Evaporative techniques, though, have limited utility in humid conditions.

Stopping cooling when rectal temperature reaches 38°C (101°F) can help prevent overshooting normal temperature and producing hypothermia. Cooling should continue while transporting the patient to an emergency room. Transportation to an emergency room for further evaluation is prudent in most cases because of the need for prolonged monitoring and evaluation of serum chemistry and other hematologic variables. Certain competitions, like the Hawaii Ironman triathlon, have equipment and experience to treat athletes on site, but most don't.

Fluids. The use of fluids in the athletic setting is somewhat controversial. The controversy centers on whether an athlete should be presumed to be volume depleted when presenting to the medical tent. It has been shown that a small percentage of ill athletes who might appear to be dehydrated and heat exhausted may in fact be overhydrated and hyponatremic (9,10).

This topic is discussed in more detail elsewhere (11), but with a sweat rate of 1 L/hr or so, an otherwise healthy athlete who competes 1 hour or less is not likely to experience serious dehydration. In general, one should use oral fluids and leg elevation where possible and intravenous fluids only when necessary, as when the patient is unconscious, hypotensive, in shock, or severely dehydrated.

Heatstroke Prevention

Many factors may increase the risk of heatstroke (table 3). These include factors that either increase endogenous heat production, increase exogenous heat load, interfere with heat dissipation, or effect some combination of these.

Table 3. Risk Factors for Heatstroke

Increased Endogenous Heat Load
Overexertion
Drugs (eg, sympathomimetics, caffeine)

Increased Exogenous Heat Load
Temperature
Sun exposure

Decreased Heat Dissipation
Exogenous
- Humidity
- Occlusive or excessive clothing

Endogenous
- Dehydration
- Lack of acclimatization
- Healed burns
- Rashes
- Drugs (eg, phenothiazines, antihistamines, alcohol)

Other
Concurrent illness (eg, upper-respiratory infection, gastroenteritis)
Prior heatstroke

Drugs Reported to Predispose to Heatstroke(19)*
Sympathomimetics
- Amphetamines
- Epinephrine
- Ephedrine
- Cocaine
- Norepinephrine

Anticholinergics
- Atropine sulfate
- Scopolamine HBr
- Benztropine mesylate
- Belladonna and synthetic alkaloids
- Antihistamines

Diuretics
- Furosemide
- Hydrochlorothiazide
- Bumetanide

Phenothiazines

Prochlorperazine
Chlorpromazine hydrochloride
Promethazine hydrochloride
Butyrophenones
Haloperidol
Cyclic antidepressants
Amitriptyline hydrochloride
Imipramine hydrochloride
Nortriptyline hydrochloride
Protriptyline hydrochloride
Monoamine oxidase inhibitors
Phenelzine
Tranylcypromine sulfate
Alcohol
Lysergic acid diethylamide (LSD)
Lithium

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*May predispose to *classic* heatstroke. Research has not shown a direct application to the athletic setting.

Of heatstroke risk factors that are within athletes' control, by far the three most important are lack of acclimatization, overzealous performance or "competing above one's head," (1,3,4,12) and dehydration. When and where possible, athletes should be made aware of the need to acclimatize (13), maintain an athletic pace that is within their limits, and maintain adequate fluid intake.

Though physicians are not in control of the weather, they should be aware of the conditions and prepared to cancel or alter an athletic event as the risk of heat illness dictates (table 4) (14).

Table 4. Wet Bulb Globe Temperature* and the Risk of Heat Illness(14)

°F Range	°C Range	Risk Level
< 64	< 18	Low
64 < T $\leq$ 73	18 < T $\leq$ 23	Moderate
73 < T $\leq$ 82	23 < T $\leq$ 28	High
> 82	> 28	Hazardous

*Wet bulb globe temperature = 0.7 (wet bulb) + 0.2 (globe temperature) + 0.1 (dry bulb)

Other Heat-Related Concerns

Several other conditions that may occur in the heat warrant attention. So-called heat cramps are painful spasms of skeletal muscles that usually involve the arms, legs, or abdominal muscles. Typically they occur after several hours of exertion with the loss of large volumes of sweat (15). They tend to occur in the more acclimatized and conditioned athlete(16) and result from sodium depletion. Sodium replacement may provide effective therapy (16). This replacement can be oral or, in more severe or

recalcitrant cases, intravenous with normal saline. Increasing daily sodium intake slightly during the acclimatization period can be effective prophylaxis for those prone to heat cramps (17).

The poorly defined syndrome of "heat exhaustion" has been used to describe an inability to continue exercising or outright collapse in situations of heat stress. Some believe that heat exhaustion lies on a continuum with heatstroke; others think it is not directly related to heat stress. Heat exhaustion may be difficult to differentiate from heatstroke. Associated signs and symptoms can include dizziness, nausea, muscle cramps, piloerection, and elevated rectal temperature. The key differentiating feature between heatstroke and heat exhaustion is that in heat exhaustion there are no mental status changes other than mild confusion.

Risk factors for heat exhaustion are similar to those for heatstroke. Often, heat exhaustion can occur in deconditioned people who are unaccustomed to exercising in the heat and develop postural hypotension when they stop working out. Again, the most important factors within the athlete's control are exertion level and acclimatization. Acclimatization has been shown to decrease the signs and symptoms of heat exhaustion (18). Also, avoiding racing in hot conditions as well as walking after a race and not standing around may help prevent postural hypotension.

Treatment consists primarily of removing the athlete from competition. Cooling the patient is necessary in cases of elevated rectal temperature, but usually this simply involves getting the athlete to a cool shady spot and removing insulating clothes. Elevating the legs to reduce postural hypotension can also be effective. Fluids should be used as indicated by the patient's hydration status.

Finally, 'heat syncope' is an orthostatic syncopal episode or dizziness that usually occurs in nonacclimated individuals who may or may not be under heat stress. It can occur with prolonged standing or standing suddenly from a sitting or lying position. The presumed mechanism is peripheral vasodilation possibly exacerbated by some degree of dehydration. Treatment is placing the patient in a supine position and replacing any water deficit.

Heat-Seeking Knowledge

Heat illnesses are both treatable and preventable. A working knowledge of these illnesses and their risk factors ought to be part of the armamentarium of any physician who deals with athletes in the field.

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Dr Sandor is an orthopedic and sports medicine physician with the Camino Medical Group in Sunnyvale, California, and an emergency room physician for Kaiser South in San Francisco. Dr Howe is a team physician at Western Washington University in Bellingham, Washington, and an editorial board member of **The Physician and Sportsmedicine**. Dr Howe is a team physician at Western Washington University in Bellingham, Washington, and an editorial board member of **The Physician and Sportsmedicine**. Address correspondence to Richard P. Sandor, MD, 401 Old San Francisco Rd, Sunnyvale, CA 94088.