

## Heatstroke in the Forecast for the Summer

In most parts of the United States, warm weather is in full swing, and that means that millions of Americans are enjoying the outdoors. Whether participating in road races, team sports, or just being spectators, the summer heat may cause a variety of medical problems for these active individuals. Some heat injuries are minor and can be taken care of with simple good sense approaches, whereas other forms of heat illness are true medical emergencies. In fact, heat-related illnesses were the most common cause of nontraumatic deaths among athletes from 1980 to 2006 (9).

The body is designed to thermoregulate its core temperature within a narrowly defined physiological range. Using strategies including convection, radiation, and evaporation, our bodies can dump a great deal of heat into the environment if necessary. This becomes essential when we find ourselves in hot environments, especially when we are exercising. Even our resting metabolism generates a tremendous amount of heat, but while we are exercising, heat production can increase 10 to 20 times that of resting. For example, a person jogging at 6 mph produces 10 times more heat per minute than at rest. It is not difficult to see why exercising athletes are particularly prone to developing heat illnesses.

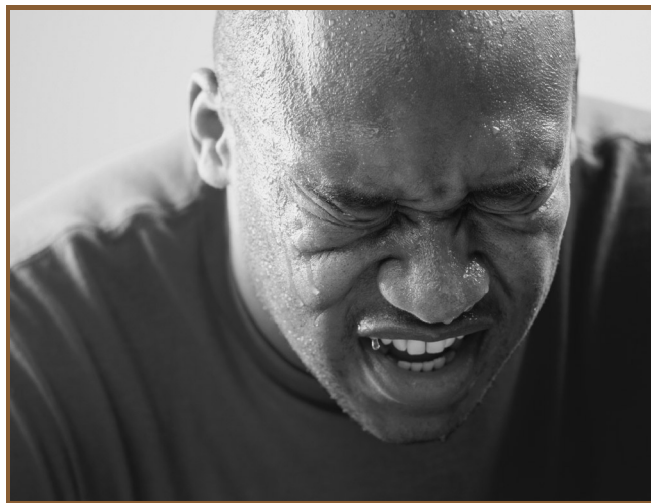
Some unique environments can contribute to heat overload. Much research on heatstroke comes from firefighters, who work intensely under conditions of extreme thermal stress (11). Their restrictive suits prevent them from dissipating heat, putting them at tremendous risk of heat illness. Another category of individuals at risk for heat illness are those on certain medications that compromise the body's ability to respond to thermal stress. Individuals with mental or

physical impairments may be unable to understand that they are becoming overheated, or they may be unable to respond once they do realize something is wrong. People intoxicated or otherwise mentally impaired have similar risks. Many cardiovascular medications interrupt the body's ability to vasodilate and shunt blood to the extremities, limiting its ability to cool down. Finally, some forms of stimulants may increase the basal metabolic rate, increasing the endogenous heat load to dangerous levels (14). All of these factors put individuals at increased risk so that any change in their thermal load may cause them to become dangerously overheated.

As we accumulate more heat, either by producing it or by absorbing it from our environment, we need to dissipate a similar amount of heat to stay in thermal balance and keep our core temperatures in a safe range. Among athletes, the most efficient means of dispersing accumulated body heat is through the evaporation of sweat. An acclimatized athlete can sweat up to 6 L/hour, which then evaporates off the skin, absorbing up to 590 Kcal for

each liter of sweat evaporated (6). It is important to consider that our ability to dump heat through convection and evaporation is dependent of gradients — that is to say, compared with our skin, our environment must be cooler, drier, or both. This partially explains why firefighters are at such risk for heatstroke and why warmer (but drier) air in deserts can be so much more tolerable than in jungles. Gradients in temperature and humidity make all the difference in letting our physiological mechanisms work efficiently.

Heat illness is a broad medical category, comprising two major diagnoses. Heat exhaustion is a mild form of heat illness that is typically self-limited. A patient with heat exhaustion typically has a number of nonspecific symptoms, such as dizziness, fatigue, nausea, and associated signs, including tachycardia and pyrexia (although their core temperature is rarely above 40°C). Patients who have heat exhaustion rarely need transfer to an emergency room, and they rarely are hospitalized. Cooling them passively (letting them rest in a cool place out of the sun and heat), allowing them to drink





if they are thirsty, and possibly cooling them with damp towels are usually sufficient to bring about their recovery after 30 minutes.

The diagnosis of heatstroke rests on two important physical signs: core temperature above 40°C and central nervous system impairment. Although heatstroke victims are frequently found to have very elevated core temperatures, this is not always the case. The dominant diagnostic tool is the presence of neurological impairment, which can take any number of different forms. Patients in early stages of heatstroke can appear to be confused, agitated, and unable to maintain balance. Those in a more serious condition can be minimally responsive or even comatose. The duration of time a patient is unconscious is thought to be a negative prognostic indicator (4). Because the differential diagnosis for central nervous system impairment is broad, early suspicion of heatstroke is essential to making the diagnosis and initiating treatment rapidly.

Accurate core temperature assessment is an important part of correctly diagnosing heat illness, and any practitioners caring for exercising athletes should be familiar with temperature measurement techniques. However, determining a patient's temperature is not as simple as it may sound. Repeated studies have shown that oral, tympanic, axillary, and forehead therm-

istors are inaccurate in correctly measuring temperature. This fact is pronounced especially at the extremes of temperature — in those who are either hypothermic or hyperthermic (5). Even rectal temperature has its problems. The gold standard for measuring core temperature seems to be esophageal temperature, although using a rectal probe is more practical and gives adequate results in most situations (5). Temperature measured by any other means should not be used to diagnose or manage a patient who is suspected of having heatstroke. Sports medicine practitioners should ensure that event and training room assessment tools include a rectal or esophageal thermometer for temperature measurement.

Once a patient is suspected of having heatstroke, cooling should begin immediately. This differs from many other situations where Advanced Trauma and Life Support protocols are initiated. Research on heatstroke cases strongly suggests that prognosis is inversely related to the amount of time a patient stays above a critical core temperature (1). A good approach with a heatstroke victim is to begin cooling while simultaneously completing Advanced Trauma and Life Support secondary surveys and other diagnostic workup as indicated.

Experts agree that immediate cooling is essential to reducing mortality and morbidity associated with heatstroke (1,8).

However, a great deal of controversy surrounds the correct approach to cooling a heatstroke victim. Some argue that the only appropriate way to cool an individual with heatstroke is through immersion in ice water. Proponents of this approach cite studies that show cooling rates in ice water of approximately 0.2°C per minute (3). They contend that faster is better in all cases, and they feel that ice water immersion is the fastest way to cool an individual.

Others, particularly in the field of emergency medicine and those outside of the United States, have adopted evaporative cooling as their standard of care (12). Studies of this method have demonstrated cooling rates of up to 0.31°C per minute, while avoiding complications of immersion (7). These complications include the fact that immersion is messy, it is difficult to maintain sterility in an immersed patient, it is impossible to cardiovert a submerged patient, and monitoring heart and pulse oximetry is complicated by the water. More dangerous complications include the fact that ice water causes shivering — a counterproductive response leading to internal thermogenesis and compromising cooling (13). Immersion can cause cardiac arrhythmias, including lethal ventricular rhythms, such as tachycardia and fibrillation (15). Finally, immersion leads to a phenomenon called *core afterdrop*, in which a subject becomes hypothermic after remaining in cold water too long. This has been shown to be present in a majority of cases, even when core temperature is monitored closely and the patient is taken out of the water before they reach normothermia (13). Clearly, ice water immersion is not without dangers. Advocates for evaporative cooling argue that slower cooling rates are a small price to pay for the safety and logistical advantages of evaporation. An emerging topic of interest is cooling in tepid water, which seems to offer comparable cooling rates without many of the dangers of ice water immersion (16). The only systematic review on the topic determined that no data exist to identify one cooling technique as

significantly superior to the others (2). However, because faster cooling rates have been recorded most consistently with the use of immersive cooling, it is likely that this approach should be used preferentially in cases in which the athlete is most critically ill.

Primary care physicians are likely to see patients in the office after they have experienced a heatstroke. The question of safe return to activity is a complex one. Although there are little objective data to guide clinicians in these decisions, consensus opinions based on military practice can be extremely helpful. Physicians should follow hematological markers until they are normal persistently and should assist patients in returning to heat exposure gradually after a period of recovery (typically 2 to 8 weeks) (10). The Israeli Defense Forces use a heat tolerance testing protocol, in which patients are monitored while exercising in a hot environment. They must pass this test before returning to active duty. It is not clear whether a previous heatstroke places an individual at any long-term risk of recurrence of heat injury.

For any physician caring for athletes, soldiers, or tradespeople exercising in warm conditions, heat illnesses are among the most significant conditions of which to be cognizant. Avoidable deaths occur each year as a result of heatstroke, primarily in the late summer when many organized sports practices begin. A high degree of awareness, prompt recognition of the signs of heatstroke, and rapid cooling are all keys

to preventing the morbidity and mortality associated with this condition.

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*James L. Glazer, M.D., FACSM, is an adjunct assistant clinical professor at Tufts University School of Medicine and a consultant at Coastal Orthopedics and Sports Medicine in Freeport, ME. He serves as medical director for triathlons in Maine and is a physician for the U.S. Ski Team.*