Heat Emergencies

In the United States, heat waves claim more lives each year than all other weather-related exposures combined (hurricanes, floods, tornadoes, & earthquakes). According to the CDC, from 2004-2018, an average of 702 heat-related deaths occurred in the USA annually. This timeframe included a total of 10,527 deaths resulting from exposure to heat-related conditions. Of these, approximately 90% occurred from May through September. Approximately one third (37%) occurred in Arizona, California, and Texas, despite these states comprising only 23% of the US population.

Heat-related illness can be **viewed as a continuum** related to the body's inability to cope with exposure to hot weather & sun. The body gains and retains heat faster than it can dissipate, resulting in a spectrum which includes:

- Heat edema – mild swelling & tightness of extremities
- Heat rash - (prickly heat)
- Heat cramps – due to salt depletion & some potassium loss
- Heat syncope (fainting) - blood vessels dilate in the skin & muscles, redistributing blood volume to the periphery

As the continuum progresses, heat illnesses become more severe.

- Heat exhaustion is a systemic (whole body) reaction to prolonged heat exposure; symptoms can include: dizziness, weakness, general body aches, lightheadedness, nausea, vomiting, profuse sweating, throbbing headache, rapid heart rate, hyperventilation.

Condition	Symptoms
Heat cramps	Heavy sweating Painful muscle cramps and spasms (usually in muscles of legs and abdomen)
Heat exhaustion	Heavy sweating Weakness Cool, pale, and clammy skin Weak pulse Possible normal temperature Possible muscle cramps Possible dizziness, fainting, nausea, and vomiting
Heat stroke	Altered mental state Possible throbbing headache Possible confusion, nausea, and dizziness High body temperature (105°F or higher) Rapid and strong pulse Possible unconsciousness Possible hot/dry skin Sweating likely if patient was involved in vigorous activity

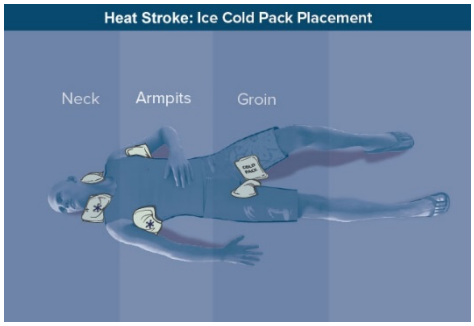
Heat exhaustion **can rapidly evolve to heat stroke and is the most severe heat-related illness.**

Heat stroke is defined as a body temperature > 103°F-104°F, (multiple sources do not agree on an exact number; however, note that when a victim is allowed to cool down prior to the measurement of temp, as may occur during transportation in a cool ambulance or evaluation in an ER, the measured temperature may be lower than 103°F- 104°F, making the temperature criterion relative. Initial signs of heat illness are frequently neurological because the brain is highly susceptible to hyperthermia. During this, the core temperature rises, causing the heart rate to increase. As the body preserves its heat, the person loses concentration and has difficulty focusing. A task may become irritable or sickening. Often a loss of desire to drink fluids is observed. This is followed by fainting and even death if the person is not cooled down by dissipation of the accumulated heat. Lack of sweating has been cited as a feature of heat stroke, but some victims with heat stroke present with profuse sweating. Because of variable presentations don't hesitate to avoid delays in treatment. The exact temperature at which cardiovascular collapse occurs varies among individuals because coexisting disease, drugs, & other factors may contribute to or delay organ dysfunction. Full recovery has been observed in victims with temperatures as high as 114°F, and death has occurred in victims with much lower temperatures. Body temperatures exceeding 106°F generally are catastrophic & require immediate treatment.

Hiking safety

"With extreme heat days, people have to **start super early in the morning**," says Scottsdale Fire Capt. Dave Folio. "You have to have a lot of water and **hydrate the night before.**" He says once you're halfway finished with the water you brought on your hike, you need to turn around and head back to the trailhead. Helicopters are becoming all too common in rescues – something Folio says is high risk. "For us to put six or seven crews on the trail … is asking a lot from our firefighters. Now we have to worry about getting them off the trail while they are rescuing hikers off the trail," he said. **Even firefighters are told to stay indoors, hydrate, and avoid strenuous outdoor activities when the temperatures reach 105 degrees or higher.** "It's probably our number one call … hikers in distress or injured," says MCSO Deputy and helicopter pilot Terry Heimgartner. The crew says these types of rescues are dangerous for everyone involved, and it puts first responders at high risk in extreme heat. "When you have two people in the back, plus me, we only have two seats back here, so it can get a little cramped," O'Meara said. **Temperatures over 118 degrees will ground their helicopters. Anything just under that will take a toll on their rescues.** "The hotter it is, you can't lift as much. We have to use less fuel, or you can't put as many people inside the helicopter," Heimgartner explained.

What to do



- Get person into shade or cool location
- Cool person with cool, wet cloths (neck, groin, armpits, head) and fan body
- Sip cool water if person is alert
- For muscle cramps, massage muscles gently, but firmly until relaxed
- *If symptoms worsen, call 911

1. **Do not give anything by mouth if person is vomiting, unable to swallow or unconscious**
2. **Do not underestimate the seriousness of a heat emergency**

Know your limitations

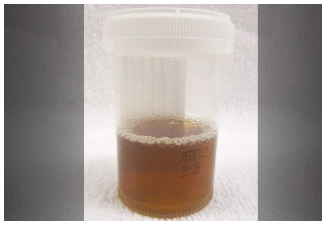
- Hydrate (begins day prior to hike/exercise, hour before hike, during and after)
- Wear proper clothing, lightweight and light color, protect head, proper shoes
- Always carry a cell phone and best to hike with company
- Be honest: Do you have a medical condition? Asthma, heart problems, diabetes, knee or back problems? Don't push yourself! "Even trained athletes have been caught off guard by getting dehydrated on Arizona trails."
- Don't trailblaze: Enjoy the Sonoran Desert's beautiful and undeveloped landscape, but please stay on designated trails.

Take responsibility: Don't be "that person" - the one who wasn't prepared, shouldn't have been there for health reasons or ignored safety guidelines. Be the responsible hiker, who takes a hike and does it right!

For Those Who Want More Information

1. The etiology of heat stroke may involve any of the following:
    a) Increased heat production - **Strenuous exercise can increase heat production 10-fold** and, when uninterrupted, can overwhelm the body's heat-dissipating mechanisms, leading to dangerous rises in body temperature.
    b) Decreased heat loss – Certain medications interfere with the cardiovascular responses to heat and, therefore, can interfere with heat loss:
    Drugs that can result in decreased heat loss include the following: Antihistamines, Beta-blockers, Calcium channel blockers, (BP & cardiac medications)
    c) Reduced ability to acclimatize - Elderly persons also are at increased risk for heat-related illnesses because of their limited cardiovascular reserves, preexisting illness, and use of many medications that may affect their volume status or sweating ability.
    d) Reduced behavioral responsiveness – failure or inability to control one's environment
2. How The Body Responds to Heat
    a) In a simplified model, thermos-sensors located in the skin, muscles, & spinal cord send information regarding the core body temperature to the hypothalamus, where the information is processed and appropriate physiologic and behavioral responses are generated.
    b) Physiologic responses to heat include an **increase in cardiac output and blood flow to the skin (as much as 8 L/min), which is the major heat-dissipating organ**; dilatation of the peripheral venous system; and stimulation of the eccrine sweat glands to produce more sweat.
    c) As the major heat-dissipating organ, the skin transfers heat to the environment through conduction, convection, radiation, & evaporation. At high ambient temperatures, evaporation becomes the most effective mechanism of heat loss.
    d) The efficacy of evaporation as a mechanism of heat loss depends on the condition of the skin and sweat glands, the function of the lung, ambient temperature, humidity, air movement, and whether or not the person is acclimated to the high temperatures. For example, evaporation does not occur when the ambient humidity exceeds 75% and is less effective in individuals who are not acclimated. **Non-acclimated individuals can only produce 1 L of sweat per hour**, which only dispels 580 kcal of heat per hour, **whereas acclimated individuals can produce 2-3 L** of sweat per hour and can dissipate as much as 1740 kcal of heat per hour through evaporation. **Acclimatization to hot environments usually occurs over 7-10 days** and enables individuals to reduce the threshold at which sweating begins, increase sweat production, and increase the capacity of the sweat glands to reabsorb sweat sodium, thereby increasing the efficiency of heat dissipation.
    e) When heat gain exceeds heat loss, the body temperature rises. The redistribution of blood flow to the periphery, coupled with the loss of fluids and electrolytes in sweat, **place a tremendous burden on the heart.** Factors that interfere with heat dissipation include dehydration, high ambient temperatures, high ambient humidity, and many drugs can interfere with heat dissipation, resulting in a major heat illness.
    f) On a microvascular level, heat stroke resembles sepsis and involves inflammation, translocation of lipopolysaccharides from the gut, and activates the coagulation cascade. Certain preexisting factors, such as age, genetic makeup, and the non-acclimatized individual, may allow progression from heat stress to heat stroke, systemic inflammatory response syndrome (SIRS), multiorgan dysfunction syndrome (MODS), and ultimately death.

3. **Damage to Vital Organs**: Heat stroke is a multisystem insult that potentially can affect almost every organ system. Heatstroke can cause the brain or other vital organs to swell without a quick response to lower body temperature. Swelling of these organs results in permanent damage to that tissue.
    a) **Central nervous system -** Symptoms of **CNS dysfunction is present universally in persons with heat stroke.** Symptoms may range from irritability to coma. Victims may present with delirium, confusion, delusions, convulsions, hallucinations, difficulty walking, tremors, & difficulty speaking. Seizures may occur. Heat stroke–related long-term CNS sequelae include dementia, hemiplegia, quadriparesis, and personality changes.
    b) **Eyes -** Examination of the eyes may reveal nystagmus and oculogyric episodes due to cerebellar injury. The pupils may be fixed, dilated, pinpoint, or normal.
    c) **Cardiovascular - Heat stress places a tremendous burden on the heart**. Victims with preexisting cardiac dysfunction do not tolerate heat stress for prolonged periods.
    d) **Pulmonary** – Victims with heat stroke commonly exhibit a rapid respiratory rate and hyperventilation caused by direct CNS stimulation, acidosis, or low oxygen saturation. **Pulmonary edema (swelling) is a common complication of heat stroke** and may be due to a number of factors, including fluid overload from aggressive rehydration, renal failure, congestive heart failure, and acute respiratory distress syndrome (ARDS), which may develop because of multiple insults, including heat-induced pulmonary damage, aspiration pneumonia, and as a complication of liver failure.
    e) **Gastrointestinal -** Gastrointestinal hemorrhage and intestinal infarction are complications that can occur in victims with heat stroke.
    f) **Hepatic (Liver) -** Heat stroke commonly leads to severe but reversible liver damage. Acute liver failure **generally occurs in the first 48 hours, but it can peak as long as 2 weeks after the onset of heat stroke.** Victims commonly exhibit jaundice and elevated liver enzymes. Rarely, full liver failure occurs, accompanied by brain swelling, low blood glucose, abnormal blood clotting (DIC) and bleeding, ultimately requiring liver transplantation.
    g) **Musculoskeletal -** Muscle tenderness and cramping are common; **rhabdomyolysis is a common complication** of exertional heat stroke. Rhabdomyolysis releases large amounts of myoglobin (O_2 binding protein found in muscles), which can precipitate in the kidneys and result in acute kidney injury (AKI). In one study, rhabdomyolysis was **observed in almost all victims with exertional heat stroke.** The occurrence of rhabdomyolysis may be heralded by the development of dark, tea-colored "Coca-Cola" urine and tender edematous muscles.



    h) **Renal -**Acute kidney injury (AKI) is a common complication of heat stroke and may be due to hypovolemia, low cardiac output, and myoglobin urine (from rhabdomyolysis). Renal failure especially is common in victims who develop hypotension or shock during the course of their disease and may occur in as many as 25-30% of victims with exertional heat stroke. Once renal failure occurs, dialysis is the only effective therapeutic modality for rhabdomyolysis.
    i) **Electrolytes –** Low potassium (hypokalemia), which is common in the early phases of heat stroke, may develop in response to increased respiration, diarrhea, and sweating. Similarly, low sodium (hyponatremia) may be due to sodium losses and/or rehydration with salt-poor solutions (eg, water); high sodium (hypernatremia) may be due to dehydration.

Morbidity and mortality from heat stroke are related to the duration of the temperature elevation. When therapy is delayed, the mortality rate may be as high as 80%; however, with early diagnosis and immediate cooling, the mortality rate can be reduced to 10%.