

Diagnosis and Prevention of Heat-Related Illness

Subjects: [Medicine, General & Internal](#) | [Medicine, Legal](#)

Contributor: Gabriele Savioli , Christian Zanza , Yaroslava Longhitano , Alba Nardone , Angelica Varesi , Iride Francesca Ceresa , Alice Chiara Manetti , Gianpietro Volonnino , Aniello Maiese , Raffaele La Russa

Hyperthermia is an internal body temperature increase above 40.5 °C; normally internal body temperature is kept constant through natural homeostatic mechanisms. Heat-related illnesses occur due to exposure to high environmental temperatures in conditions in which an organism is unable to maintain adequate homeostasis. This can happen, for example, when the organism is unable to dissipate heat adequately. Heat dissipation occurs through evaporation, conduction, convection, and radiation. Heat disease exhibits a continuum of signs and symptoms ranging from minor to major clinical pictures. Minor clinical pictures include cramps, syncope, edema, tetany, and exhaustion. Major clinical pictures include heatstroke and life-threatening heat stroke and typically are expressed in the presence of an extremely high body temperature. There are also some categories of people at greater risk of developing these diseases, due to exposure in particular geographic areas (e.g., hot humid environments), to unchangeable predisposing conditions (e.g., advanced age, young age (i.e., children), diabetes, skin disease with reduced sweating), to modifiable risk factors (e.g., alcoholism, excessive exercise, infections), to partially modifiable risk factors (obesity), to certain types of professional activity (e.g., athletes, military personnel, and outdoor laborers) or to the effects of drug treatment (e.g., beta-blockers, anticholinergics, diuretics). Heat-related illness is largely preventable.

environmental heat emergency

heat emergency

heat stroke

hyperthermia

1. Epidemiology

Heat illness is a commonly occurring disorder around the world, according to clinical research institutes, it is the leading cause of climate-related deaths, and its incidence is increasing. In the United States, according to some authors, it represents the third leading cause of death for high school athletes ^[1]. These data are corroborated by the Center for Disease Control (CDC) ^[2].

In the United States, between 2000 and 2010, there were over 30,000 hospitalizations for heat diseases, with a predominance of cases amongst the elderly, athletes, and outdoor workers. ED-visits in the same years were 5 per 10,000 mostly comprising of heat exhaustion (75%), with major clinical pictures representing about 5% of cases, and with mortality of less than 0.1% ^{[3][4]}. The regions most affected were the mid-west and the south, which have constant exposure to higher temperatures throughout the year. The number of hospitalizations depended on the maximum monthly temperature ^[5].

The incidence of heat-related illness in U.S. high school athletes is approximately 9000 cases annually ^[6].

These diseases also have a high prevalence in the U.S. armed forces, with an incidence of 1000 person-years, incidence has gradually increased since 2014 ^[7].

There are millions of annual presentations of minor clinical pictures. It can, therefore, be said that heat exhaustion frequently represents the first stage in a continuum of pathologic states that typically affect more fragile groups of people, or those more exposed to exercise or prolonged exposure in a hot humid environment, for example, for work reasons ^{[8][9][10][11][12][13]}.

2. Diagnosis and Management

Depending on how high the ambient temperature is and other environmental factors (e.g., humidity, ventilation), thermogenic factors, the functioning of heat dissipation mechanisms, and individual thermoregulation, which, in turn, are affected by various risk factors, heat illness manifests itself in a pathological clinical continuum from mild to major.

2.1. Mild Forms

Heat edema is a widespread symptom, characterized by gravitational soft-tissue edema, due to vasodilation and redistribution of body flows, typically involving the lower limbs. It is resolved by placing the legs in a supine position. Diuretics are not suitable for treatment of this type of edema ^[14].

Muscle cramps from heat: This is a common and benign form of heat disease. It manifests in short-term muscle cramps in the muscles subjected to stress. The cramps are often triggered by prolonged or intense physical activity, especially in athletes with incomplete physical training or in unacclimated workers. Excessive temperature is not necessary and often the subject's temperature is also normal. Sweating is normal or excessive. The patient is lucid and may report thirst or fatigue. The onset of pain and cramps can be rapid or slow. Usually, anamnestic data are silent, and objectivity is non-specific. The most widely accepted etiological hypothesis is that of neuromuscular control theory ^{[15][16]}. The abdominal and lower limb muscles are the most involved ^[14]. Treatment includes appropriate isotonic fluid replacement, stretching, and massage (**Table 1**).

Heat rash Clogged pores trap sweat in the skin, causing erythematous papules and pustules. Clothed skin is most affected. Usually, by moving the patient to a cool environment, the rash ends. Sometimes it is necessary to remove excess clothing; the rash disappears after the skin has dried. These disorders are self-limiting and rarely require medical attention. After the symptoms have disappeared, the patient can return to the activity they were pursuing ^[17].

Tetany: Although often confused with muscle cramps, tetany can be distinguished from them by the appearance of perioral spasms, spasms of the feet and hands, and distal paresthesias.

2.2. Moderate Forms

Exercise-associated collapse (or heat syncope): This occurs very frequently and is characterized by high body temperatures. It can be due to a lack of water or salt which results in volume depletion. The first situation is typical for geriatric people, the second is characterized by hyponatremia and hypochloremia due to inadequate salt intake. Worsening factors are peripheral vasodilation and decreased vasomotor tone. It typically occurs immediately after strenuous exercise. It is characterized by symptoms that may precede syncope, such as agitation, confusion, thirst, asthenia, and headache [18][19]. Syncope is short-lived and resolves with supine posture, so treatment is largely supportive. Affected individuals must be placed in Trendelenburg position, the recovery of liquids or salts must be performed. Rest in a cool environment is recommended. Symptoms thus treated usually resolve within 15–20 min [20]. Exercise-associated collapse can be difficult to distinguish from cardiogenic syncope [8].

Heat exhaustion is the most common heat-related illness and is characterized by volume depletion under heat stress conditions. The heat stress effectively exceeds cardiac output. The symptomatology of this clinical picture is represented by weakness, headache, nausea, dizziness, myalgia, hypotension, tachycardia, hyperventilation, and muscle cramps. At blood test, there can be a hypernatremic condition, especially in intense physical stress, such as military personnel or athletes, or hyponatremia in subjects who presented intense sweating but were able to take only free water. If not recognized and treated it can evolve into heat stroke. Heatstroke differs because there are evident manifestations of central nervous system alteration, the temperature exceeds 41 °C and transaminases increase after 24 h. Since mental status remains intact in heat exhaustion, any alteration affecting the central nervous system must be considered heat stroke even if the temperature does not exceed 41 °C (**Table 1**).

Treatment includes placing the patient in a supine position in a cool environment. Cooling of the head with cold water, moisturizing of the skin, and placing of iced bags. Water and electrolytes need to be replaced either orally or intravenously. Potential complications include electrolyte disorders (e.g., hypernatremia, hypokalemia), rhabdomyolysis, mild hepatocellular injury, and acute renal failure. The presence of these findings is clinically related to burns and often requires hospitalization. For this reason, lab test include complete blood count, basal metabolism panel, liver function test, coagulation test, and measurements of creatine kinase and myoglobin level. Most patients who are stable with reassuring test results can be safely discharged after observation [21].

2.3. Severe Forms

Heat stroke is a medical emergency caused by failure of thermoregulation and acclimatization mechanisms. It is characterized by a rapid increase in internal body temperature that exceeds 40.5 °C, resulting in multi-organ dysfunction.

Basically, the dysfunction of central nervous system, which leads to loss of consciousness, delirium, confusion, agitation, convulsions, and coma. The onset is usually sudden with symptoms of alteration of the central nervous system; there are rarely prodromal symptoms (**Table 1**).

The clinical picture is completed by warm skin with or without diaphoresis, hypotension, tachycardia, and tachypnea. Failure to sweat is a late manifestation. The organs most affected by high internal temperature are the brain and liver and the prognosis is related to the time spent in hyperthermia [22]. Although there is no cut-off temperature beyond which tissue damage occurs, many studies have shown that the severity of damage and cell death is related to the degree and duration of hyperthermia. Death can occur after the onset of heat stroke and is associated with heart failure, in fact the first fundamental line of treatment is reduction in body temperature that help out to the support of the cardiovascular system. About one-third of patients who survive the initial damage experience multi-organ failure. In the event of pre-shock or shock, treatment should include the ABCDE scheme with maintenance of the airways, respiration, and circulation, followed by rapid cooling. If cooling is completed within 30 min of collapse, the mortality rate approaches zero [23][24]. Patients who present to the emergency department with an internal body temperature of 41 °C or higher and prolonged hyperthermia have mortality rates of up to 80%.

The researchers distinguish two types of heatstroke: classic heatstroke and stress heatstroke. The classic type affects elderly people, children, or people of low economic status who live in unsuitable environments. It is diagnosed where the body temperature of the subjects is higher than 40.5 °C. In these cases, the beginning and evolution of the clinical picture can be deceptive. Frequently, there is dehydration and coma. The second category is hot exercise heatstroke. In this case, the affected subjects are younger, often athletes or military personnel, who have been engaged in intense physical activity. Coagulation disorders and rhabdomyolysis and latex acidosis are more frequent. Mortality can reach 50% of cases. In exercise heatstroke, the temperature is usually below 40.5 °C.

In both cases, it is possible to detect leukocytosis, thrombocytopenia, impaired coagulation, liver damage, renal damage, and rhabdomyolysis in the blood chemistry.

Where there is a suspicion of heat stroke, it is necessary to reduce the temperature as quickly as possible. In fact, as the researchers have already discussed, mortality and morbidity are dependent on the duration and severity of hyperthermia. Clothes should be promptly removed, and the patient immersed in cold water (46° to 57° F [8° to 14 °C]) or ice water (35.6° to 41°F [2° to 5 °C]), which can cool down by 0.26 °C per minute and up to 0.35 °C per minute, respectively [23][25]. Continuous monitoring of core rectal temperature is recommended during rapid cooling. There is no temperature cut-off value at which to stop cooling [14][26][27][28]. Where the patient cannot be immersed in water, wet towels, ventilators, or water nebulizers can be used, with less effectiveness, especially in pre-hospital environments where it is necessary to use any available means, in the absence of the most appropriate ones. If, on the other hand, the most effective techniques are readily available in the pre-hospital environment, it is necessary to follow the rule “cool first and transfer later”, and continue cooling during transport with available means [18][23][24][28][29]. For inpatient treatment of heat stroke, emergency room procedures will apply.

Table 1. Clinical patterns of heat disease.

Mild Form	Moderate Form	Severe Form
Heat edema	Exercise-associated collapse (or heat syncope)	Classic heatstroke

Mild Form	Moderate Form	Severe Form
Muscle cramps from heat	Hypernatremic heat exhaustion	Exertional heatstroke
Heat rash	Hyponatremic heat exhaustion	
Tetany		

3. Prevention

In most cases, the onset of heat-related disease can be avoided or its symptoms reduced to a mild level ^{[18][30]}. It is necessary to maintain adequate hydration, to wear loose and light-colored clothing and to avoid the hottest hours, and to perform activities only in the most appropriate hours (with the lowest temperatures) of the day. In the case of travel or movement to very hot places, it is necessary to allow complete acclimatization. When it is not possible to avoid the hottest hours or activity at high temperatures, frequent breaks for hydration, scheduled rest and recovery cycles, as well as careful monitoring, are recommended. Particular attention should also be paid to fragile categories of person, for whom these recommendations are mandatory. Children and the elderly who may not have symptoms of thirst or be unable to hydrate themselves should be hydrated.

References

1. Jardine, D.S. Heat Illness and Heat Stroke. *Pediatr. Rev.* 2007, 28, 249–258.
2. Centers for Disease Control and Prevention (CDC). Heat-Related Deaths after an Extreme Heat Event—Four States, 2012, and United States, 1999–2009. *MMWR Morb. Mortal. Wkly. Rep.* 2013, 62, 433–436.
3. Hess, J.J.; Saha, S.; Luber, G. Summertime Acute Heat Illness in U.S. Emergency Departments from 2006 through 2010: Analysis of a Nationally Representative Sample. *Environ. Health Perspect.* 2014, 122, 1209–1215.
4. Choudhary, E.; Vaidyanathan, A. Heat Stress Illness Hospitalizations-Environmental Public Health Tracking Program, 20 States, 2001–2010. *MMWR Surveill. Summ.* 2014, 63, 1–10.
5. Acharya, P.; Boggess, B.; Zhang, K. Assessing Heat Stress and Health among Construction Workers in a Changing Climate: A Review. *Int. J. Environ. Res. Public Health* 2018, 15, 247.
6. Kerr, Z.Y.; Casa, D.J.; Marshall, S.W.; Comstock, R.D. Epidemiology of Exertional Heat Illness Among U.S. High School Athletes. *Am. J. Prev. Med.* 2013, 44, 8–14.
7. Armed Forces Health Surveillance Branch. Update: Heat Illness, Active Component, U.S. Armed Forces, 2017. *MSMR* 2018, 25, 6–12.

8. Binkley, H.M.; Beckett, J.; Casa, D.J.; Kleiner, D.M.; Plummer, P.E. National Athletic Trainers' Association Position Statement: Exertional Heat Illnesses. *J. Athl. Train.* 2002, 37, 329–343.
9. Casa, D.J.; Armstrong, L.E.; Ganio, M.S.; Yeargin, S.W. Exertional Heat Stroke in Competitive Athletes. *Curr. Sports Med. Rep.* 2005, 4, 309–317.
10. Howe, A.S.; Boden, B.P. Heat-Related Illness in Athletes. *Am. J. Sports Med.* 2007, 35, 1384–1395.
11. Stapleton, J.M.; Wright, H.E.; Hardcastle, S.G.; Kenny, G.P. Body Heat Storage during Intermittent Work in Hot–Dry and Warm–Wet Environments. *Appl. Physiol. Nutr. Metab.* 2012, 37, 840–849.
12. Kalkowsky, B.; Kampmann, B. Physiological Strain of Miners at Hot Working Places in German Coal Mines. *Ind. Health* 2006, 44, 465–473.
13. Meade, R.D.; Lauzon, M.; Poirier, M.P.; Flouris, A.D.; Kenny, G.P. An Evaluation of the Physiological Strain Experienced by Electrical Utility Workers in North America. *J. Occup. Environ. Hyg.* 2015, 12, 708–720.
14. Lugo-Amador, N.M.; Rothenhaus, T.; Moyer, P. Heat-Related Illness. *Emerg. Med. Clin. N. Am.* 2004, 22, 315–327.
15. Nelson, N.L.; Churilla, J.R. A Narrative Review of Exercise-Associated Muscle Cramps: Factors That Contribute to Neuromuscular Fatigue and Management Implications. *Muscle Nerve* 2016, 54, 177–185.
16. Miller, K.C. Rethinking the Cause of Exercise-Associated Muscle Cramping. *Curr. Sports Med. Rep.* 2015, 14, 353–354.
17. Krau, S.D. Heat-Related Illness. *Crit. Care Nurs. Clin. N. Am.* 2013, 25, 251–262.
18. Casa, D.J.; DeMartini, J.K.; Bergeron, M.F.; Csillan, D.; Eichner, E.R.; Lopez, R.M.; Ferrara, M.S.; Miller, K.C.; O'Connor, F.; Sawka, M.N.; et al. National Athletic Trainers' Association Position Statement: Exertional Heat Illnesses. *J. Athl. Train.* 2015, 50, 986–1000.
19. O'Connor, F.G.; Casa, D.J.; Bergeron, M.F.; Carter, R.; Deuster, P.; Heled, Y.; Kark, J.; Leon, L.; McDermott, B.; O'Brien, K.; et al. American College of Sports Medicine Roundtable on Exertional Heat Stroke—Return to Duty/Return to Play. *Curr. Sports Med. Rep.* 2010, 9, 314–321.
20. Asplund, C.A.; O'Connor, F.G.; Noakes, T.D. Exercise-Associated Collapse: An Evidence-Based Review and Primer for Clinicians. *Br. J. Sports Med.* 2011, 45, 1157–1162.
21. O'Connor, F.; Casa, D. Exertional Heat Illness in Adolescents and Adults: Management and Prevention. 2021. Available online: <https://www.uptodate.com/contents/exertional-heat-illness-in-adolescents-and-adults-management-and-prevention> (accessed on 1 September 2022).
22. Atha, W.F. Heat-Related Illness. *Emerg. Med. Clin. N. Am.* 2013, 31, 1097–1108.

23. Casa, D.J.; Armstrong, L.E.; Kenny, G.P.; O'Connor, F.G.; Huggins, R.A. Exertional Heat Stroke. *Curr. Sports Med. Rep.* 2012, 11, 115–123.
24. Sloan, B.K.; Kraft, E.M.; Clark, D.; Schmeissing, S.W.; Byrne, B.C.; Rusyniak, D.E. On-Site Treatment of Exertional Heat Stroke. *Am.J. Sports Med.* 2015, 43, 823–829.
25. McDermott, B.P.; Casa, D.J.; Ganio, M.S.; Lopez, R.M.; Yeargin, S.W.; Armstrong, L.E.; Maresh, C.M. Acute Whole-Body Cooling for Exercise-Induced Hyperthermia: A Systematic Review. *J. Athl. Train.* 2009, 44, 84–93.
26. Belval, L.N.; Casa, D.J.; Adams, W.M.; Chiampas, G.T.; Holschen, J.C.; Hosokawa, Y.; Jardine, J.; Kane, S.F.; Labotz, M.; Lemieux, R.S.; et al. Consensus Statement- Prehospital Care of Exertional Heat Stroke. *Prehospital Emerg. Care* 2018, 22, 392–397.
27. Gaudio, F.G.; Grissom, C.K. Cooling Methods in Heat Stroke. *J. Emerg. Med.* 2016, 50, 607–616.
28. Nichols, A.W. Heat-Related Illness in Sports and Exercise. *Curr. Rev. Musculoskelet Med.* 2014, 7, 355–365.
29. Pryor, R.; Casa, D.; Holschen, J.; O'Connor, F.; Vandermark, L. Exertional Heat Stroke: Strategies for Prevention and Treatment from the Sports Field to the Emergency Department. *Clin. Pediatr. Emerg. Med.* 2013, 14, 267–278.
30. Armstrong, L.E.; Casa, D.J.; Millard-Stafford, M.; Moran, D.S.; Pyne, S.W.; Roberts, W.O. Exertional Heat Illness during Training and Competition. *Med. Sci. Sports Exerc.* 2007, 39, 556–572.

Retrieved from <https://encyclopedia.pub/entry/history/show/74624>