Heat-Related Illness in Children in an Era of Extreme Temperatures

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Practice Gap

1. It is important for clinicians to understand the increasing incidence of heat-related illnesses and their implications on children.
2. Clinicians should be able to recognize the difference between heat exhaustion and heat stroke.
3. Clinicians should learn how to implement rapid cooling in the treatment of heat stroke.

Objectives After completing this article, readers should be able to:

1. Distinguish between heat exhaustion and heat stroke.
2. Recognize risks and behaviors associated with heat-related illness.
3. Effectively diagnose and treat heat stroke.
4. Identify effective prevention strategies for both exertional and nonexertional heat stroke.

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ABBREVIATIONS

AMS	altered mental status
CNS	central nervous system
CTM	critical thermal maximum
HRI	heat-related illness
WBGT	wet bulb globe temperature

INTRODUCTION

A 12-year-old obese football player finishes his second 2-hour practice on a hot August day. His temperature is 105°F (40.6°C), and he is agitated and confused. His family calls you, his general pediatrician, seeking guidance. What advice do you give?

A bystander discovers a 23-month-old infant in the back seat of a minivan on a warm day. She is flushed, fussy, and has vomited. The baby is brought to your community emergency department for further management. What are your next steps?

As the planet gets warmer, the incidence of heat-related illness (HRI) and injury is increasing. (1)(2)(3)(4)(5) Among those suffering HRI, children compose almost half (47.6%) of this population. (1) In the pediatric population, the most common forms of heat-related pathology occur in exercising adolescents and in children left unattended in vehicles or excessively warm environments. Pediatricians must effectively counsel caregivers in recognizing the dangers related to heat exposure and preventing dehydration and HRI. When prevention fails, prompt recognition and treatment of HRI become paramount.

DEFINITIONS AND TERMINOLOGY

Heat-related illness refers to a clinical spectrum of disorders resulting from exposure to excessive environmental heat and the body's inability to effectively regulate heat. Presentation can range from mild (heat rash, heat stress) to severe (heat stroke). Note that tolerance to heat varies by individual. Many factors, including general health, overall conditioning, hydration status, and ability to acclimatize (or adapt over time to change in temperature) play a role in the effect that heat has on the individual.

Heat rash and *prickly heat* are colloquial names for miliaria. It is commonly seen in infants during periods of high heat and humidity. It is an erythematous, papular, or vesicular rash caused by the obstruction of eccrine sweat glands. (6) It may be pruritic and is benign and self-limited. Treatment is supportive and includes wearing light, loose garments and avoiding overheating. (7)

Heat edema is a mild form of HRI manifested as swelling of the feet, hands, and other dependent areas. It occurs in unacclimatized individuals as a result of vasodilation and venous pooling. (6) Although more common among the elderly, heat edema can occur in children as well. The body temperature of the individual is normal and the condition is unrelated to heart failure or kidney disease. Treatment is supportive: elevation, compression stockings, and moving to a cooler environment. (7)

Heat cramps are due to involuntary contractions of skeletal muscle that occur during or after exercise. (8)(9) The term *heat cramps* is a misnomer because the heat does not directly trigger cramping, and high-intensity exercise in cold environments (eg, hockey, swimming) can be associated with cramps. A more accurate term is *exercise-associated muscle cramping*. The spasms are painful and usually involve only the muscle groups actively involved in exercise. (8) They typically occur in the dehydrated, deconditioned, or poorly acclimatized athlete. (10) Risk factors include a history of muscle cramps or previous injury to the muscle, tendon, or ligament; heavy sweating; dehydration; or poor sodium intake before or during exercise. (9) Treatment is supportive: rest, hydration, and static stretching. (6)(8)(9)

Heat syncope is also related to vasodilation and venous pooling. It is an orthostatic event that causes brief loss of consciousness and is usually seen in an individual who is standing for a prolonged period or changing positions rapidly in a warm environment. (8) Heat exposure may contribute to the event but is not the causative factor. As with heat edema, body temperature is normal. Treatment is also similar: individuals should be moved to a cooler environment and remain supine until light-headedness has resolved and vital signs have normalized. Hydration status should be assessed while providing the patient with oral or intravenous fluids. (1)

Heat stress represents a mild form of HRI. It refers to perceived discomfort and physical strain that result from exposure to heat or a warm environment. Symptoms are typically mild, and core temperature remains within the normal range. (7)

Heat exhaustion (also called *heat injury*) is a moderate illness associated with increase in core temperature (98.6°F–104°F [37°C–40°C]) and symptoms include thirst, headache, weakness, syncope, vomiting, and dizziness. (6) Heat exhaustion is often accompanied by dehydration and heavy sweating. The patient's vital signs will likely demonstrate tachycardia and hypotension. An important feature of this clinical syndrome is that there is no central nervous system (CNS) dysfunction or end-organ damage. (9) If there are CNS symptoms (headache, slight confusion), they are mild and resolve quickly with cooling and rest. (7)

Treatment of heat exhaustion entails cessation of physical exertion, removal of excess clothing and equipment, movement to a cooler environment, and hydration with oral or intravenous fluids. (1) Cooling methods may include taking a cool shower or applying cold compresses. Heat exhaustion may progress to heat stroke if not recognized and managed promptly. (6) When treated promptly and appropriately, however, most patients' symptoms will resolve quickly, and hospital admission is unnecessary. (8)

Heat stroke represents the most severe form of HRI and results from thermoregulatory failure. It is a life-threatening condition defined as a core temperature greater than 104°F (>40°C) accompanied by CNS dysfunction in the setting of known heat exposure and/or strenuous exercise. The CNS abnormalities can include agitation, confusion, delirium, or coma. Henceforth, this review focuses on the differential diagnosis, pathophysiology, etiology, diagnosis, management, and prevention of heat stroke.

DIFFERENTIAL DIAGNOSIS

It is important for the clinician to be aware of and distinguish other causes of hyperthermia. Hyperthermia in the form of a fever is a common occurrence in the pediatric population. A fever is a normal physiologic response to infection or inflammation that causes a rise in body temperature. The response is controlled by central thermoregulatory centers in the brain, and the temperature rises, although not usually higher than 105.8°F (41°C), in a neurologically normal host. Fever is often, but not always, accompanied by other signs of infection, illness, or inflammation.

Less common causes of hyperthermia include neuroleptic malignant syndrome and malignant hyperthermia. Neuroleptic malignant syndrome is a life-threatening, idiosyncratic reaction in patients taking antipsychotic medications. It is characterized by the clinical triad of hyperthermia, muscle rigidity, and altered mental status in the setting of exposure to dopaminergic agents. Malignant hyperthermia is an inherited condition that occurs in susceptible individuals exposed to inhalational anesthetics and/or succinylcholine. It is characterized by hyperthermia and skeletal muscle rigidity and responds to treatment with dantrolene. (11)

PATHOPHYSIOLOGY

Human body temperature is regulated by the anterior hypothalamus and is maintained within a narrow range of 97.7°F to 99.5°F (36.5°C–37.5°C). (8) As the body's core temperature begins to rise (through exercise or exposure to ambient heat), the body shifts from heat storage to heat dissipation. (10) The body has several processes by which it can thermoregulate, although these processes become increasingly ineffective as ambient temperature increases.

Radiation of heat from the body to the environment will occur only if the ambient temperature is below the body temperature. Convection occurs when heat from the body is transferred to cooler air (gas), and conduction occurs when heat is directly transferred from a warmer surface (the body) to a cooler one. Thus, as ambient temperature increases, the primary method of thermoregulation is evaporation. (10) Sweat is vaporized at the skin surface, allowing heat dissipation and cooling.

Physiologic changes occur as the core body temperature increases: vasodilation leads to increased heart rate, stroke volume, and cardiac output. Warmer blood moves peripherally to the skin, allowing for sweat production and evaporation. (10) As blood moves from the core to the periphery, visceral perfusion is diminished, most prominently in the kidneys and gut. (2) If exposure to heat is excessive or prolonged, the body is less able to compensate.

The critical thermal maximum (CTM) reflects the core body temperature and duration of heat exposure that is lethal to an animal. In humans, the CTM is estimated to be 106.9°F to 107.6°F (41.6°C–42°C) for 1 to 8 hours. (12) Prolonged hyperthermia exceeding the CTM can lead to a dangerous cascade of ischemia, end-organ damage, multisystem organ failure, and potentially death.

As the body attempts to cool, high demand on the heart can progress to high-output cardiac failure and cardiogenic shock. Hypotension often develops and is multifactorial. It is commonly due to vasodilation (as part of the thermoregulatory process) as well as hypovolemia (secondary to profuse sweating and insensible losses). In the most severe cases, hypovolemia may also be secondary to cardiogenic shock. Prolonged hypotension will ultimately lead to poor perfusion, ischemic injury, and end-organ damage. In addition, the vascular endothelium is sensitive to heat, and excessive exposure may result in disseminated intravascular coagulation. As vascular and mucosal permeability is altered, cerebral and gut edema may develop. (2)(11)

On the cellular level, protective mechanisms against hyperthermia exist; however, exposure to extreme or prolonged heat will result in direct cytotoxic effects to cells as well as activation of various cytokines and inflammatory pathways. Protein denaturation and programmed cell death (apoptosis) will ultimately occur. (2)(11) Because hyperthermia can be life-threatening, it is important for clinicians to understand the thermoregulatory process and the manner in which age and development effect it.

AGE AND THERMOREGULATION

It had previously been suggested that pediatric athletes were less capable of effective thermoregulation during exercise; however, newer findings demonstrate this to be false and suggest that, from a physiology standpoint, young athletes are not more susceptible to heat injury. (13) In fact, children are generally not at higher risk for HRI than adults (who tend to have more cardiovascular disease and comorbidities that worsen HRI outcomes). However, there are physiologic and developmental differences unique to children regarding thermoregulation.

Children and adolescents take longer to acclimatize to a warm environment than adults. Acclimatization is the process by which an individual adapts to a change in temperature and/or humidity. Physiologic changes that occur during the acclimatization period include increased sweat production, reduced electrolyte losses in sweat, increased skin blood flow during exercise, larger stroke volume, larger plasma volume, increased aldosterone production with decreased urine sodium excretion, and decreased temperature threshold to start sweating. (8)(10) Student athletes should be given 10 to 14 days to acclimatize to new exercise in warm weather. (14) Furthermore, infants and young children are thought to have less effective thermoregulation than adults plus lack developmental capabilities to change their behavior in response to overheating (eg, drink water, remove seat belts or clothing, change environments). (15) Special care must be given to their unique needs during periods of extreme heat.

ETIOLOGY AND RISK FACTORS

Exposure to heat is the primary etiology of heat stroke. The nature of the exposure allows for further classification of heat stroke into nonexertional (classic) and exertional heat stroke. Nonexertional heat stroke results from exposure to high environmental temperatures in the absence of excessive physical activity. It is most commonly seen with extremes of age (young children and the elderly are at highest risk) during heat waves or extreme heat events. Common scenarios include a child left unattended in a vehicle (vehicular heat stroke) or living in a dwelling without central air-conditioning or climate control. (16) During extreme heat events, air-conditioning has been shown to be a protective factor and is associated with decreased risk of heat-related mortality. (17)(18)

In the pediatric population, vehicular heat stroke is not uncommon, with an average of 37 deaths due to vehicular heat stroke per year in the United States during the past 2 decades. Of these vehicular heat stroke deaths, 87% were in children younger than 3 years. (19) A review of 171 deaths from vehicular heat stroke found that fatalities were attributed to children playing in the vehicle (27%) or to children left in the vehicle (73%). (20) In the most common scenario, a parent forgets that the child is in the back of the car and unintentionally leaves him or her in the vehicle. This conceivably happens when a parent deviates from their daily routine. (21)(22) A parent who usually drives straight to work may, on a different day, take his or her infant to day care and then drive to work. Out of habit or absentmindedness, the parent may follow his or her typical routine and go straight to work, leaving the infant in the vehicle unintentionally. In other circumstances, poorly supervised young children may gain access to an unattended vehicle and risk entrapment when they cannot escape from the trunk or vehicle. Finally, a parent may intentionally leave a child unattended in a car not realizing that even short periods in a closed vehicle may cause a serious HRI. (20)(22)

It is an all-too-common misconception that vehicle-related HRI can happen only on extremely warm days. In reality, vehicles trap heat from the sun, causing the temperature within the car to rise rapidly. Even on days where the outdoor temperature is mild but sunny, the interior of the vehicle can reach dangerous temperatures. One study demonstrated these findings: on a day with an ambient temperature of 72°F (22.2°C), the interior of a car can reach 117°F (47.2°C) within 60 minutes. Furthermore, 80% of the temperature rise occurs in the first 30 minutes. (15) Cracking the car's windows does little to alter this effect. Thus, children should not be left alone in cars, even with the windows open. (21) In fact, at the time of this writing, 19 of the states in the United States have made it illegal to leave a child unattended in a vehicle. (23)

In contrast to nonexertional heat stroke, exertional heat stroke is most common in the athlete and occurs after prolonged strenuous exercise. It may also be seen in military recruits, public safety workers, and manual laborers who work in warm environments, often in uniforms or heavy protective gear.

It is estimated that more than 9,000 high school athletes are treated for exertional heat illness each year. (3) Football players are at highest risk for exertional heat stroke among athletes. (3) Between 1995 and 2010, an average of 2 high school football players died annually of exertional heat stroke. August is the most common month for exertional heat illness to occur, although athletes can be affected during cooler months as well. (3)(4)(11) August has an especially high incidence of HRI, in part due to high temperatures and in part due to adolescent athletes entering preseason sports (and lacking acclimatization) after becoming deconditioned over the summer.

Conditions such as obesity, sickle cell disease and trait, cystic fibrosis, and diabetes (mellitus and insipidus) can put adolescents at higher risk for experiencing HRI. (6)(10)(24) Also, drugs that decrease sweating (anticholinergics, phenothiazines), increase fluid loss (diuretics, alcohol), or increase heat production (sympathomimetics) may adversely affect thermoregulatory capabilities. (8)(10) Last, being generally deconditioned, being dehydrated, or recovering from a recent illness are all risk factors for exertional heat illness. Primary care pediatricians, sports medicine physicians, coaches, and athletic trainers should be aware of pediatric athletes' risk factors to target preventive measures against HRI.

DIAGNOSIS

Heat exhaustion and heat stroke are clinical diagnoses, both defined by hyperthermia after heat exposure. Recall that significant CNS dysfunction (ie, altered mental status) and core body temperature higher than 104°F (40°C) are what differentiate heat stroke from heat exhaustion. Regardless of the type of exposure, victims of exertional and nonexertional heat stroke will usually present with similar clinical findings; however, victims of heat stroke may also have evidence of end-organ damage. Clinical findings of heat stroke and heat exhaustion are summarized in Fig 1.

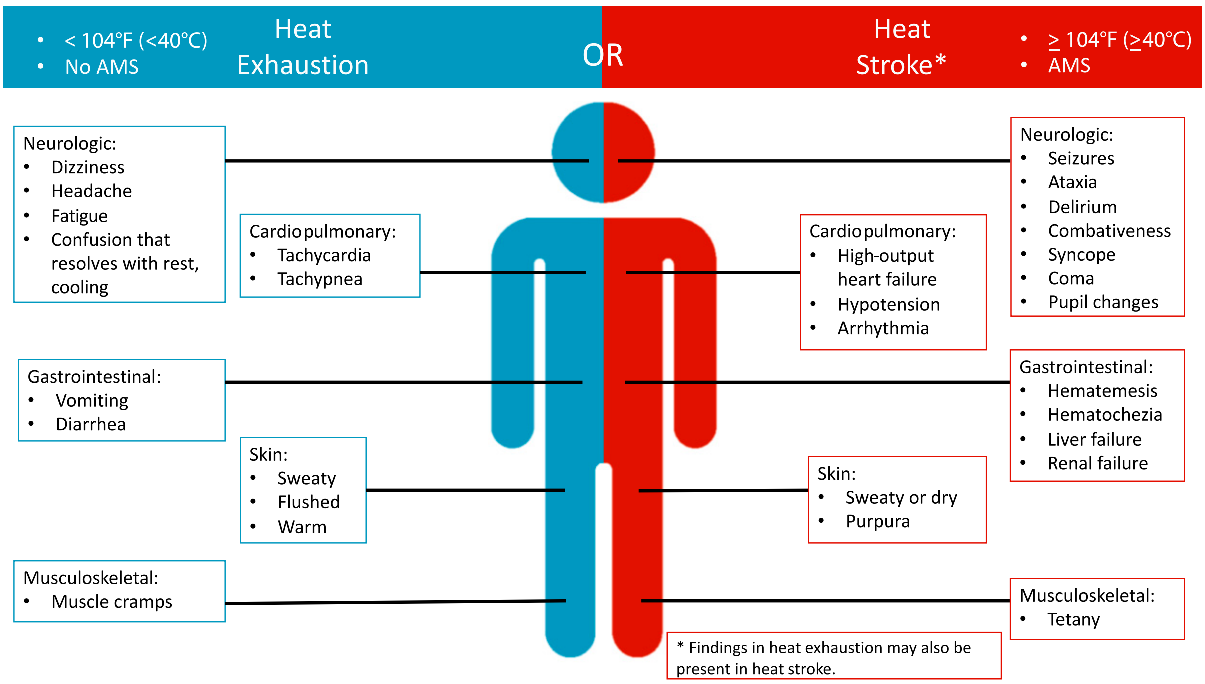

Figure 1. Clinical findings in heat exhaustion or heat stroke. AMS=altered mental status.

The CNS symptoms may begin as mild confusion but become severe (eg, delirium, seizures, encephalopathy, coma) and more apparent once core temperature is greater than 105.8°F (>41°C). It is important to remember that core temperature on presentation to medical care may be less than 104°F (<40°C) if cooling measures have already been initiated. Therefore, heat stroke should remain on the differential diagnosis for patients with the right exposure and clinical presentation even if core temperature is less than 104°F (<40°C). (6)(7) In terms of skin findings, patients with classic or nonexertional heat stroke will have hot, dry skin secondary to prolonged thermoregulatory dysfunction. (8) In contrast, patients with exertional heat stroke may have cool, clammy skin or be warm and diaphoretic if they were engaged in exercise or strenuous activity immediately before presentation. (25)

MANAGEMENT

Heat stroke must be recognized promptly and treated aggressively. Treatment is summarized in Table 1. Resuscitation begins first and foremost with rapid assessment of the patient's airway, breathing, and circulation per life-support protocols (with simultaneous emergency medical services activation depending on the site of presentation). Measurement of core temperature and initiation of cooling should be the next priority once the airway, breathing, and circulation have been addressed. Rectal thermometers are the gold standard to assess core body temperature. (9)(25) External commercial thermometers that assess body temperature tympanically, orally, or temporally are not reliable to assess core temperature and should not be used in place of a rectal thermometer. (8)

Cooling

Cooling must begin as soon as heat stroke is suspected. (25) The purpose of cooling is twofold: to return blood flow from the periphery to the core and to lower body temperature by reducing the body's hypermetabolic state. (9) The method of cooling will depend on the resources available and, potentially, the age of the patient. First, all clothing and equipment (sweaty garments, athletic gear, uniforms) should be removed while cooling is initiated and the child is moved to a shaded area.

For older children and athletes with exertional heat stroke, current data suggest that cold-water immersion (eg, in ice water or an ice bath) is the optimal and most effective cooling method. (9)(26)(27)(28)(29)(30) This can be initiated on-site, if available. Water temperature should be less than 60°F (<15°C), and the water should be continually circulated or stirred. The patient's body should be fully immersed when possible except for the head and neck (which can be covered by a wet towel). (25) If medical personnel are present, vital signs and temperature should be monitored frequently (eg, every 3–5 minutes). (9) For

TABLE 1. **Treatment Recommendations for Heat Stroke**

PREHOSPITAL CARE
◦ Assess the airway, breathing, and circulation
◦ Measure core body temperature (rectal)
◦ Remove clothing and athletic equipment
◦ Older (cooperative) child or adolescent:
■ Cold-water immersion (if available), cover head/neck with wet towel
◦ Infants, young child, or immersion not available:
■ Evaporative cooling with wet towels or sheets and high-flow fan
◦ Repeat assessment of temperature and vital signs every 3–5 min
◦ Initiate hospital transfer[a]
EMERGENCY DEPARTMENT CARE
◦ Assess the airway, breathing, circulation, and (neurologic) disability
■ Consider intubation if unable to protect airway
■ Consider benzodiazepines for combativeness, seizures, or excess shivering
◦ Measure core body temperature (rectal)
◦ Remove clothing and athletic equipment
◦ Apply cardiorespiratory monitor and rectal or esophageal temperature probe
◦ Establish vascular access, evaluate for associated complications
◦ Evaporative cooling with wet towels or sheets, water spray, high-flow fan, cooling blanket
◦ Normal saline bolus (at room temperature)
◦ Repeat assessment of temperature and vital signs every 3–5 min
◦ Continue cooling until core temperature is ≤102°F (≤38.9°C)
◦ Expectant management of end-organ damage and complications

[a]*If a physician is on-site and symptoms improve immediately, hospital transfer may be at the discretion of the physician. (7)*

athletes with exertional heat illness, it is recommended to cool first and transport second when feasible. (9)(25) If effective on-scene cooling cannot be achieved (or if the patient has other complications necessitating immediate emergency department management), transfer should be initiated promptly, although available cooling methods should be used en route. (25)

In infants and younger children, there are limited data regarding immersive cooling, and concerns have been raised about patient cooperation and safety regarding reflex bradycardia. (31)(32) In this population, some experts recommend evaporative cooling rather than cold-water immersion. Evaporative cooling should be used for young children or for older children when cold-water immersion is unavailable. Evaporative strategies include spraying the patient with lukewarm water while using fans to maximize air circulation.

Other methods for both young and older children may include application of cold, wet towels (which should be continuously resoaked and reapplied) or placing the patient in a cold shower. Ice packs to the axilla or groin have been shown to be only marginally effective and should be used only if there are no available alternatives. (8) The goal of cooling is to rapidly lower the core temperature while aiming to prevent overshoot hypothermia. The recommended threshold to stop cooling varies in the literature and ranges from 101.5°F to 102°F (38.6°C–38.9°C). (8)(10)(25)(28) Throughout the process, core temperature should be continuously monitored via a rectal or esophageal probe. (10) Other vital signs and mental status should also be continuously assessed. There are currently insufficient data to definitively recommend cooling with chilled intravascular fluids or gastric, rectal, bladder, or peritoneal lavage.

Additional Evaluation and Management

With the airway, breathing, and circulation addressed and cooling underway, secondary management includes assessment of hydration status and electrolytes as well as identification and treatment of any complications of heat stroke. Complications of heat stroke and associated diagnostic evaluation are summarized in Table 2. Evaluation should include identification of end-organ damage. (2)(6)(7)(10)(11)

Fluid Management

An indwelling bladder catheter may be used for accurate and continuous urine output measurements. (10) Rate and type of rehydration fluid should be guided by the patient's volume status, hemodynamic state, and any identified electrolyte imbalance. Patients in shock will require rapid administration of isotonic fluid. Most patients should be given a 20-mL/kg fluid bolus and then reassessed.

Medications

There are no specific medications indicated in the treatment of heat stroke. Antipyretics are not useful in lowering core temperature due to HRI. Similarly, dantrolene, which is used to treat malignant hyperthermia, has no role in the management of heat stroke. (11) Pharmacotherapy may be indicated in managing the complications of heat stroke and should be considered on a case-by-case basis. For example, benzodiazepines may be administered to help control the shivering mechanism and to prevent seizures, which may be a complication of heat stroke. (10)

OUTCOMES

The morbidity and mortality of heat stroke are incompletely characterized, although it is known that outcome is directly related to how quickly cooling is initiated. (10) It is also known that severity of the initial injury is related to the duration of hyperthermia and the height of the temperature. (11) Patients with mild heat stroke generally make a full recovery with normal neurologic function. Patients with severe heat stroke may survive but with permanent neurologic injury. (11) It is estimated that up to one-third of patients with severe heat stroke have permanent moderate or severe neurologic impairment and a mortality rate of at least 10%. (11) Poor prognostic signs include hemoptysis, hematuria, gastrointestinal bleeding, and conjunctival hemorrhage. (10) Patients with higher initial temperatures, hypotension, or low Glasgow Coma Scale scores (<12) are more likely to die, (33) and death is usually from cardiovascular collapse. (10)

PREVENTION

Nonexertional Heat Stroke Prevention

Pediatricians must be prepared to educate families and patients about the dangers of heat exposure. As the weather changes, families should receive basic counseling about appropriate clothing and coverage (bundling) for infants and children with special needs who cannot modify their behavior in response to high environmental temperature or overheating. Special attention should be paid to hydration status during periods of high heat and humidity as infants

TABLE 2. **Complications of Heat Stroke and Recommended Diagnostic Tests**

ORGAN SYSTEM	COMPLICATIONS	EVALUATION
Cardiac	Arrhythmia High-output heart failure and cardiogenic shock	Electrocardiogram Troponin, echocardiogram
Electrolytes and gastrointestinal	Hyponatremia, hypokalemia Lactic acidosis Renal injury or failure Hypocalcemia Liver injury or failure, gut edema	Basic metabolic panel Venous blood gas, lactate Urinalysis, urine output, electrolytes Ionized calcium Liver function tests, coagulation panel
Neurologic	Altered mental status Seizures, cerebral edema	Dextrose stick, urine toxicology Consider head CT or EEG if not improving with cooling
Musculoskeletal	Rhabdomyolysis	Creatine kinase
Pulmonary	Pulmonary edema	Chest radiograph
Hematologic	Anemia Disseminated intravascular coagulation	Complete blood cell count Coagulation panel, D-dimer, fibrinogen

CT=computed tomography, EEG=electroencephalogram.

Figure 2. Acclimatization recommendations. (Adapted with permission from Casa DJ, DeMartini JK, Bergeron MF, et al. National Athletic Trainers' Association position statement: exertional heat illnesses. *J Athl Train.* 2015;50(9):986–1000.) (14)

and children with special needs may have increased insensible losses that will require supplementation of additional fluids (human milk, tube feeds, free water, etc).

When it comes to vehicular-related HRI and classic heat stroke, there are many prevention strategies that can be used. Caregivers should be advised to never leave their child unattended in a vehicle and to keep car doors locked when not in use to prevent entrapment. (21) The organization KidsAndCars.org has launched an educational campaign that encourages caregivers to "Look Before You Lock." (34) Others suggest that the driver place a meaningful object (a purse, briefcase, or shoe) in the rear seat so that they are forced to check the back seat before exiting the vehicle.

Technology may also help prevent vehicular HRI. General Motors has developed a "Rear Seat Reminder" system to alert drivers to check the back seat once the vehicle is turned off. Future innovations may use sensors to detect the presence of an occupied rear seat and alert the driver accordingly. Last, the federal government may play a role in enforcing meaningful change. Lawmakers are considering legislation that will require the National Highway Traffic Safety Administration to set regulations enforcing automakers to equip vehicles with an alert system to remind parents to check the rear seat. (35)

Exertional Heat Stroke Prevention

Regarding exertional heat stroke prevention, various regulatory bodies, such as the American Academy of Pediatrics, the National Collegiate Athletic Association, and the National Athletic Trainer's Association, have established policy statements to guide education, management, and prevention of HRI in athletes, and their recommendations are summarized in the following subsections. (9)(14)(24) It is important for pediatricians, coaches, athletic directors, athletes, and caregivers to be familiar with identifying signs and symptoms of HRI as well as preventing these dangerous conditions. (9)

Screening. Before initiation of athletic activity, all athletes should undergo a preparticipation history and physical examination to identify any health conditions or medications that may predispose them to HRI. Athletes should be counseled about the risks of HRI and effective prevention measures. Caregivers and coaches should recognize that athletes with recent or current febrile or gastrointestinal illnesses should not be permitted to participate.

Acclimatization. As the athletic season begins, teams should follow guidelines for safe acclimatization. Training and conditioning for fall sports (eg, football) typically occur in August, during the warmest days of the year. Athletes should acclimatize to warm weather and increase activity over 1 to 2 weeks. The intensity and duration of physical activity should increase gradually during this period.

Athletic Gear and Garb. Athletes should wear light-colored garments that are lightweight and loose-fitting. Uniforms and practice gear should be made from open-weave or

TABLE 3. **Daily Water Intake Recommendations by Age and Sex**

AGE	SEX	TOTAL DAILY WATER CONSUMPTION, L[a]
0–6 mo	All	0.7
7–12 mo	All	0.8
1–3 y	All	1.3
4–8 y	All	1.7
9–13 y	Girls	2.1
	Boys	2.4
14–18 y	Girls	2.3
	Boys	3.3

[a]*Total water consumption includes all beverage and food sources of water. (37)*

sweat-wicking materials to facilitate evaporative heat loss. (6) Sweat-saturated garments should be removed promptly. (10) The amount of athletic equipment should be worn in incremental steps, as described in Fig 2. (14)

Hydration. Players should be encouraged to adequately hydrate before, during, and after physical exertion. During activity, players should have access to water and salt-containing beverages and should be allowed dedicated time to hydrate. (9) Offering flavored hydration products (such as sports drinks) has been shown to increase consumption and reduce dehydration. (36) Table 3 reviews guidelines for daily fluid intake.

Scheduling. When weather is extremely hot, practices should be scheduled for mornings and evenings, when temperatures are generally cooler. (24) Contingency plans should be in place to reschedule practices or games if heat or humidity is expected to be severe. The Wet Bulb Globe Temperature (WBGT) is an index of heat stress that accounts for temperature, humidity, and radiation. The WBGT may be used as an objective measure to assess whether environmental conditions pose a significant risk of HRI to athletes. There are published guidelines that suggest specific limitations on physical activity based on the WBGT. (8)(10) When the WBGT is not available, the heat index may also be used to guide decisions about activity and event scheduling.

Preparation. Medical equipment and resources for rapid cooling (cold-water tubs, ice towels, rectal thermometers, etc) should be available at athletic events. (9) There should be preestablished guidelines for practice and playing in heat and humidity. An emergency action plan should be in place should any athlete demonstrate signs or symptoms of heat exhaustion or heat stroke. (9)

Summary

- Based on observational studies (Evidence Quality C), the incidence of heat-related illnesses is increasing as the planet has more extreme heat waves; based on expert opinion (Evidence Quality D), clinicians must heighten awareness for caregivers and patients in prevention efforts. (1)(2)(3)(4)
- Based on strong research evidence (Evidence Quality A), heat stroke is differentiated from heat exhaustion by the presence of an elevated core temperature (≥104°F [≥40°C]) and neurologic dysfunction or altered mental status. (2)(11)
- Based on randomized, controlled trials and overwhelmingly consistent evidence from observational studies (Evidence Quality B), first-line management of heat stroke includes measuring a core temperature; assessing the airway, breathing, and circulation; and initiating cooling. Athletes with exertional heat stroke should undergo cold-water immersion when available. (8)(26)(27)(30)
- Based on observational studies (Evidence Quality C), children left in parked cars are vulnerable to heat-related death. Based on expert opinion (Evidence Quality D), parents should be counseled to never leave their child unattended in a vehicle. A useful reminder is to “look before you lock.” (20)(21)(23)(34)
- Based on observational studies (Evidence Quality C), coaches and athletic trainers must be familiar with the signs and symptoms of heat stroke and use prevention methods, including appropriate acclimatization time, adequate hydration, and strategic athletic event scheduling. (9)(14)(24)

References for this article are at http://pedsinreview.aappublications.org/content/40/3/97.

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1. A 16-year-old male adolescent is attending a crowded rock concert on a summer evening for which he has a standing room–only ticket. He has a syncopal episode lasting for 30 seconds. He was caught by his friend before falling to the ground. The emergency medical service is called, and the patient is moved to the security room. His heart rate is 90 beats/min, respiratory rate is 12 breaths/min, and blood pressure is 110/70 mm Hg. His body temperature is 98.6°F (37°C). His mucous membranes are dry, and he is alert to time and place. Which of the following is the most appropriate treatment measure in this patient?
   - A. Immerse the patient in ice-cold water.
   - B. Place the patient in an air-conditioned room and administer intravenous fluids.
   - C. Place the patient in a supine position and offer oral fluids.
   - D. Place the patient in a supine position and offer fluids and static stretching.
   - E. Spray the patient with lukewarm water and use fans to maximize air circulation.
2. A 17-year-old physically fit female adolescent accepted a dare to run 5 miles on a main highway at noon, where there are no trees or shady areas, near the ocean and then jump into the ocean on a very hot summer day where the outside temperature was 95°F (35°C). Just as she approached the beach she fainted. She was found to be diaphoretic, tachycardic, and hypotensive. Her temperature was 103°F (39.4°C). She appeared to be slightly disoriented to time and place, and she vomited once. Which of the following is the most likely diagnosis in this patient?
   - A. Heat cramps.
   - B. Heat edema.
   - C. Heat exhaustion.
   - D. Heat stroke.
   - E. Heat syncope.
3. A 13-year-old girl with bipolar disorder is brought to the emergency department with altered mental status, a temperature of 105°F (40.6°C), and muscle rigidity. Which of the following pieces of information in the history is most important to aid in making a diagnosis in this patient?
   - A. Family history of fever, muscle rigidity when exposed to inhalational anesthetics.
   - B. History of heat exposure.
   - C. History of travel to the Midwest.
   - D. History of strenuous exercise.
   - E. The patient has been taking risperidone.
4. A 17-year-old boy is delivering newspapers on his bicycle on a hot summer day. He has been found unconscious in a driveway by a neighbor. The neighbor calls 911 and the ambulance arrives. He is delirious when he is aroused and hypotensive, with a temperature of 105°F (40.6°C). Which of the following prognostic indicators best correlates with the severity of the initial injury in this patient?
   - A. Duration of hyperthermia.
   - B. Gastrointestinal hemorrhage.
   - C. Glasgow Coma Scale score of 10.
   - D. Hemoptysis.
   - E. Hypotension.

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5. Ryan, a high school senior, is obtaining clearance from his pediatrician to participate in high school football, which starts practice in August. In providing anticipatory guidance, which of the following prevention measures will most likely have the weakest effect in reducing the risk of exertional heat stroke in this patient?
    A. Access to water and salt-containing beverages.
    B. Acclimate to the warm weather gradually starting with maximum activity during the first few days.
    C. Advise against practicing if he currently has or recently had a gastrointestinal illness.
    D. Loose-fitting clothing.
    E. Uniform made from open-weave material.

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