Exertional Heat Illness

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PGY-5
Case

• 18 yo M healthy high school football player
• During preseason training has an episode of dizziness, muscle cramping, and muscle pain a
• Increased practice intensity for senior season
• States he takes care to adequately hydrate before and during practice
• South FL
Exertional Heat Illness Epidemiology

- 47.6% younger than 19 years old
- 71.9% are males
- 75.5% associated with sports or exercise
- Most common activities in men and boys were football (24.8%) and exercise (15.7%)
- Most common activities women and girls they were exercise (16.4%), softball (8.7%), and track and field (7.5%)
- Highest incidence of exercise-related heat illness in the United States occurs in August
- ~6500 high school football athletes treated annually
Most Common Heat-Related Diagnoses

- Heat exhaustion (72.7%)
- Dehydration (18.7%)
- Heat syncope (9.7%)
- Heat cramps (5.4%)
- Heat stroke (1.8%)
Spectrum of Illness

- Heat Exhaustion
- Hyponatremic Dehydrations
- Exertional Heat Stroke
- Exertional Rhabdomyolysis
Heat Exhaustion: Definition

• Primarily due to dehydration
• Athletes with heat exhaustion typically lose 10% or more of their body weight through sweating
• Diminished ability to exercise
• Thermoregulatory mechanisms unable to maintain the core temperature within normal limits
Heat Exhaustion: Pathophysiology

- Dehydration, central nervous system fatigue, depletion of muscle energy stores, and electrolyte imbalance
- Dehydration may be normonatremic, hypernatremic, or hyponatremic

Risk Factors
- High-temperature environments
- Moderate- to low-temperature environments with high humidity
- High Heat Index: Quantified relative contributions of temperature and humidity to an athlete’s heat
Heat Exhaustion: Diagnosis

Clinical diagnosis:
• Fatigue
• Weakness
• Dizziness
• Muscle cramps
• Abdominal pain
• Headache
• Nausea
• Mild mental status changes (mild confusion, irritability, and emotional lability)
• Physical signs: pallor, listlessness, and weakness
Heat Exhaustion: Diagnosis

Laboratory Findings:
• Most valuable in suspected hyponatremia
• Elevated urine-specific gravity and hemoconcentration reflect dehydration

Differential Diagnosis:
• Distinguishing isonatremia vs hypernatremia vs hyponatremia is very difficult
• Presentation may overlap with hyperthermia, hypothermia, viral illness, alcohol or other drug use, and cardiac problems.
Heat Exhaustion: Treatment

- Cool resting place
- Oral rehydration is the initial treatment of choice
- Goal of replacing 1.5 L of fluid for every kg of decreased body weight
- If body weight was not previously recorded, adequate rehydration is evidenced by an overall sense of well-being
- Cooled fluids and fluids containing less than 8% carbohydrate are absorbed more rapidly than plain water
- Rehydration fluids that contain sodium appear to restore total body water levels more completely than water alone
Heat Exhaustion: Treatment and Intravenous Hydration

- IV hydration may be required in persons who are vomiting or have orthostatic symptoms
- Recommended IV hydration solution: 5% dextrose in normal saline solution
- Physiologic markers of dehydration in athletes do not normalize more quickly with IV hydration
- World Anti-Doping Agency has banned the use of IV fluids to accelerate rehydration in otherwise healthy athletes
Heat Exhaustion: Return to Play Criteria

• Minimum of 24-48 hrs of rest
• No headache, GI symptoms, or muscle soreness
• Normal tolerance of orally ingested food and fluids
• Normal serum electrolyte (if previously abnormal)
• Normal-appearing urine
Heat Exhaustion: Prevention

Modification of Practice Routines
• Modifying outdoor physical activity when heat index values are in the “extreme caution” or “danger” zones
• Reducing the number of practices
• Scheduling practices during cooler times of the day
• Shedding equipment
• Increasing access to water
• These recommendations pertain especially to North American football, which is responsible for more cases of heat-related illness and deaths than any other sport
• Athletes education about gauging hydration status based on urine color: urine the color of apple juice reflects dehydration, whereas lemonade-colored urine reflects adequate hydration
Heat Exhaustion: Prevention

Acclimatization (Gradual exposure to hot environments)

• Initiation of sweating at a lower core temperature
• Increased sweat rate
• Initiation of thirst at a lower serum osmolality
• Increased sodium absorption from sweat and urine, and expanded plasma volume
Heat Exhaustion: Prevention

Factors affecting acclimatization time:

• Age
• Baseline level of conditioning
• Practice and equipment requirements
• Environmental factors

• College athletes have been shown to acclimatize in as few as 12 days of practice
• Younger athletes typically require a longer period of acclimatization
Hyponatremic Dehydration: Definition

• Dehydration that results in a low serum sodium level (<135 mEq/L)
• May lead to collapse, coma, seizures, and death
Hyponatremic Dehydration: Pathophysiology

- High loss of sodium through sweat
- Overhydration with plain water before and during exercise

Risk factors:
- History of endurance exercise
- Inexperience with racing
- Female gender
- Low sodium intake before exercise
- NAIDS
Hyponatremic Dehydration: Diagnosis

- Usually a clinical diagnosis when athletes symptoms fail to improve with water rehydration

Laboratory Findings
- Serum electrolytes should be evaluated if possible

Differential Diagnosis
- Isonatremic or Hypernatremic dehydration
- Other causes of Mental status changes and lethargy: encephalitis, drug overdose, and stroke
Hyponatremic Dehydration: Treatment

- Should be considered a medical emergency
- EMS should be activated
- Mild symptoms: oral rehydration solution containing sodium
- Oral fluid should be withheld from an athlete who appears to be worsening to avoid further diluting the serum
- Obtunded, encephalopathic, or seizing: immediately IV hypertonic saline solution (3%)
Hyponatremic Dehydration: Return to Play

• Without encephalopathy or seizures may return to activity according to the previously described guidelines for athletes with heat exhaustion

• With encephalopathy: more gradual return to activity after recovery

• Each case evaluated on an individual basis to prevent complications
Hyponatremic Dehydration: Prevention

• Athletes education
• Avoid overhydration with plain water before exercise
• Avoid continued ingestion of plain water during prolonged exercise (>1 hour)
Exertional Heat Stroke: Definition

- A form of hyperthermia associated with a systemic inflammatory response
- Syndrome of multi-organ dysfunction, including encephalopathy
- EHS usually occurs in otherwise healthy, fit persons participating in high intensity exercise in the heat
- It has also been reported with an ambient temperature of 14°C (57°F) in a heavily clad soldier
Exertional Heat Stroke: Pathophysiology

- Initial Increasing core temperature
- Sweating, rising cardiac output, vasodilation, and redistribution of blood away from the splanchnic organs to the muscles and skin
- Continued heat stress with increased shunting of blood flow from the core to the periphery
- Organ hypoxia and acidosis
- Organ damage allows endotoxins to enter the circulation, resulting in hypotension
Exertional Heat Stroke: Pathophysiology

• Further cell injury causes the release of inflammatory cytokines, which results in increased intracranial pressure, decreased cerebral blood flow, and neuronal injury, which lead to lethargy and seizure activity
• Muscle injury results in hyperkalemia and hypercalcemia
• Hypoperfusion forces anaerobic metabolism and depletion of carbohydrate stores, all of which compound organ damage
• Death usually occurs as a result of shock
Exertional Heat Stroke: Diagnosis

- Usually an otherwise healthy participant
- Mental status changes
- Tachycardia
- Hyperthermia
- Lethargic or Obtunded
- Early neurologic signs: throbbing headache, dizziness, nausea, and confusion.

Physical examination
- Hot skin
- Rapid pulse
- Body temperature is typically above 40°C (104°F)
- Rectal temperature is the most reliable method of monitoring core body temperature in persons experiencing heat stroke
Exertional Heat Stroke: Treatment

- Early recognition
- Minimal delay in initiating cooling
- Cooling should never be delayed while awaiting the measurement of rectal temperature in an athlete suspected of having EHS
- Activate EMS
- Clothing and equipment should be removed immediately
- Immersion of the entire body in cold water
Exertional Heat Stroke: Treatment

• Adequate cooling can also be achieved by pouring cold water continuously over the entire body, placing ice bags on the scalp, neck, axillae, groin, and popliteal fossae, and performing ice massage of large muscles.

• More invasive methods of cooling, such as peritoneal lavage and intravenous cooling catheters, have not been shown to cool more effectively than cold water immersion.

• Cooling should continue until the rectal temperature reaches 38.6°C (101.4°F) to prevent overcooling.
Exertional Heat Stroke: Return to Play

- Normal Mental Status
- Normal Dietary and Elimination habits
- Normal variation in daily body temperature
- Normal CBC, BUN/Cr, Anion Gap, Liver Enzymes, CPK, and UA (specific gravity)
- Normal EKG
Exertional Heat Stroke: Return to Play

Duration of Rest:
• Uncomplicated EHS (brief ER/Hospital stay): Refrain from exercise 1 week
• Complicated EHS (organ failure, extensive rhabdomyolysis): Refrain from exercise 1 month

Steps During Return:
• Begin exercise in cool environment
• Gradual increase in duration, intensity, and heat exposure
• Athletes tolerating heat after 2-4 weeks of training may return to competition
• Heat sensitivity may last for prolonged period of time (1yr)
Exertional Rhabdomyolysis: Definition

- Excessive acidosis during exercise leading to focal muscle necrosis
- Muscle injury presents with intense pain and weakness
- Elevated levels of creatine phosphokinase (CPK) generally greater than 20,000 IU/L
Exertional Rhabdomyolysis: Pathophysiology

• Duration and intensity of exercise exceed the working ability of muscles
• Other factors include dehydration, acidosis, excess ambient temperature, and hypoxia
• CPK up to 5000 IU/L have been observed in athletes without symptoms
• CPK up to 20,000 IU/L have been reported after intense activity without evidence of renal or metabolic complications (exertional myositis)
• Large amounts of myoglobin, proteases, and inflammatory mediators enter the circulation
• Filtration of myoglobin results in glomerular injury
• Proteases damage the respiratory epithelium (respiratory distress)
Exertional Rhabdomyolysis: Diagnosis

- Severe, diffuse muscle pain
- Cases involving specific muscle groups such as the deltoid, paraspinous muscles, and abdominal wall have been reported
- Muscles are tender to palpation
- May present with tachypnea, edema, renal failure, and acidosis

Laboratory Findings
- CPK levels often exceed 20,000 IU/L

Differential Diagnosis
- Localized ER must be distinguished from compartment syndrome and pyomyositis
Exertional Rhabdomyolysis: Treatment

Usually requires hospitalization:
- Correction of acidosis
- Careful hydration to aid in the clearance of myoglobin without inducing a state of fluid overload
- Monitoring of renal function
- Support of cardiac and pulmonary function

Criteria for outpatient treatment with close follow-up:
- CPK less than 15,000 IU/L
- Normal renal function and mild dehydration
- Absence of sickle cell trait, infectious disease, or an underlying metabolic syndrome
- Recover in a cool environment, refrain from exercise, and drink plenty of fluids
- Even in mild cases, a significant decrease in CPK may not be detected in the first 72 hours
Exertional Rhabdomyolysis: Prevention

Prevention Tips:

• Participant education
• Gradually increasing training intensity
• Avoiding excessive exercise
• Adequate hydration and recovery time
• Coaches should not use excessive exercise as a reprimand
• Provide free access to water
Return to Play: Exertional Rhabdomyolysis

- Absence of muscle soreness or tenderness
- Normal Strength
- CPK less than 5x upper limit of normal
- Normal UA, BUN/Cr
- Return to light activity when all above are met
Return to Play: Exertional Rhabdomyolysis

If significant cardiac, pulm, or renal dysfunction:
• No participation for 2-4 weeks after discharge
• Follow-up medical exam at 1 week
• Must tolerate 2-3 weeks of gradually increasing activity before competition
• Normal CPK
Implementing Exertional Heat Illness Prevention Strategies in US High School Football

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- Medicine and Science in Sports and Exercise, 2013
- In 2009, National Athletic Trainers Association Inter-Association Task Force released 17 preseason heat acclimatization guidelines

- Study designed to evaluate compliance (2011)
- Cross-sectional survey of 1142 certified athletic trainers, Online questionnaire

- Average program compliant with 10.4 of 17 guidelines
- 29 programs in full compliance (2.5%)
- Southern US with highest regional rating
- Programs with mandated guidelines were in better compliance
• Highest compliance with:
  • “One day of complete rest after six consecutive days of practice” (96.8%)
  • “Athletic trainer must be on-site before, during, and after all practices” (95.0%)
  • “No more than two practices/day” (91.5%)

• Lowest compliance with:
  • “During days 3–5 of acclimatization, only helmets and shoulder pads should be worn” (39.0%)
  • “Single-practice days consisted of practice no more than three hours in length” (39.7%)