Heat Related Illness: Diagnosis and Treatment

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I have no conflicts or disclosures.

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Objectives

- Discuss heat illnesses and review the pathophysiology of human thermoregulation
- Examine epidemiology of heat illnesses
- Review clinical signs of heat illness and outline diagnostic criteria
- Discuss treatment options and return to sport recommendations
- Identify risk factors associated with heat illness to develop prevention strategies

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Heat Illness

- Environmental heat represents a significant challenge to the athlete, especially in warmer climates
- The body has several mechanisms to prevent overheating, but when they become overwhelmed, the body's core temperature rises
- Heat illnesses can range from relatively benign to life threatening
- Heat stroke is a time-sensitive emergency!

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Epidemiology

- The number of sports-related EHS deaths in the United States has **doubled** since 1975, and more deaths were reported between 2005 and 2009 than during any 5-year period of the preceding 30 years
- Due to the wide range of heat illnesses, it is difficult to fully estimate the public impact
- According to the CDC, 8,081 deaths were due to excessive heat exposure from 1999 to 2010
  - 68% males, largest age demographic (36%) >65 years old
  - Almost all heat-related deaths occurred during May– September (94%), with the highest numbers reported during July (39%) and August (26%)
  - Arizona, **Texas** and California accounted for 43% of all heat-related deaths

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Epidemiology

- Football players at the highest risk among athletes
- The National High School Sports-Related Injury Surveillance Study found that high school football athletes experienced an 11.4-times higher rate of EHRI time-loss events compared with athletes participating in 8 other high school sports
  - The month of August, which is typically associated with pre-season football camps, accounted for 66.3 % of EHRI time-loss events
- According to National Center for Catastrophic Sports Injury at UNC, it is the 3rd leading cause of death among athletes (15.6%) and college football players were 3.8 times more likely to die from EHRI than high school football players
- HBO's "Real Sports with Bryant Gumble" reported that 30 players died from EHS from 2000-2018

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Thermoregulation

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physical activity produces **heat**

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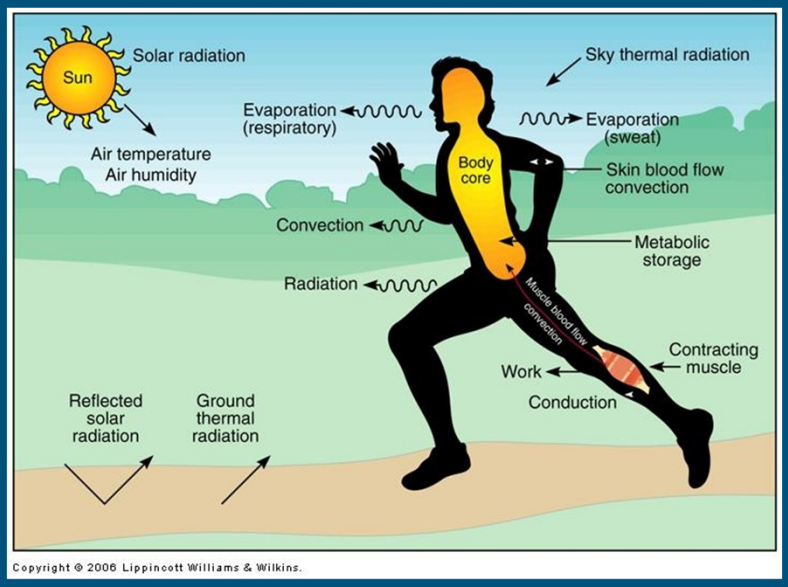

S = M (±work) - E ± R ± C ± K

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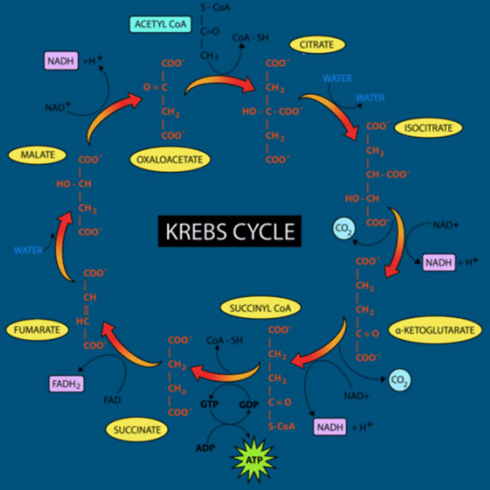
Mechanisms of Thermoregulation

- Metabolism
  - contributes to heat production
  - greater with exercise than rest
    - 15-20x

$$C_6H_{12}O_6 \text{ (glucose)} + 6O_2 \longrightarrow 6CO_2 + 6H_2O + ATP$$



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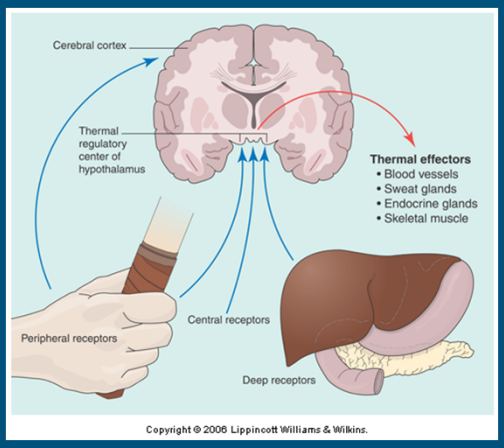
Hypothalamic Regulation

- When the hypothalamus detects a rise in core temp > 38C it activates efferent fibers of the ANS to increase cutaneous vasodilation and increase rate of sweating which leads to heat loss
- Certain hormonal adjustments, like rises in ADH, are initiated in heat stress as body attempts to conserve fluids and sodium



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Mechanisms of Thermoregulation

- Radiation
  - Transmission of heat through **electromagnetic** waves
  - Heat gain in partially clothed athlete > fully clothed athlete
  - Heat absorption in pigmented skin > nonpigmented skin

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Mechanisms of Thermoregulation

- Convection
  - Heat transfer between the body and circulating medium (air, water)
  - More wind = more rapid heat exchange
  - High humidity = high thermal conductivity = more rapid heat transfer

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Mechanisms of Thermoregulation

- Conduction
  - transfer of heat from warmer to cooler via direct contact

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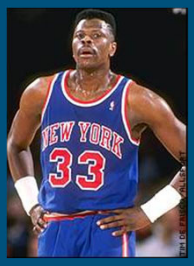
Mechanisms of Thermoregulation

- Evaporation
  - sweat vaporization → heat loss
  - sweating begins 1.5s after initiation of exercise
  - 580 kcal of heat is lost per liter of evaporated sweat
  - primary mechanism for heat dissipation when ambient temp >68F or with vigorous exercise
  - high humidity, lack of wind lead to reduced sweat vaporization
  - wearing hat and coat leads to impaired evaporative cooling



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Heat Illnesses

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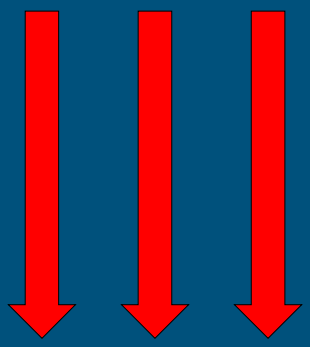
Heat Illnesses

- Spectrum of illness
  - Heat rash
  - Heat edema
  - Sunburn
  - Heat cramps
  - Heat syncope
  - Heat exhaustion
  - Exertional rhabdomyolysis
  - Exercise-associated hyponatremia (EAH)
  - Exertional heat stroke (EHS)



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Heat rash (Miliara rubra)

- Pruritic papulovesicular rash
- Rapid onset
- Due to occluded sweat glands
- Treatment = good hygiene, cooling and drying the skin
- Usually self resolves but can use topical anti-inflammatory
- Return to play: no delay

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Heat Edema

- Dependent edema of the extremities in an athlete without any other signs/sxs of organ failure
- Usually due to transient vasodilation, orthostatic pooling, and prolonged standing
- More common in the acclimatization phase of training or aging athletes
- Treatment = elevation of the extremities and acclimatization
- Return to Play: resolution of symptoms

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Sunburn

- Predominantly caused by UVB rays
- Risk factor for further heat illness because sunburned skin impairs heat transfer via evaporation or conduction
- Prevention: cover skin with clothing or sunscreen
- Treatment: symptomatic, self-resolves
- Return to play: no delay

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Exercise-Associated Muscle Cramps

- Painful involuntary cramps in large muscle groups
- Not directly related to core body temp
- Loss of fluid & sodium
- Theory
  - fatigue causes alteration in spinal neural reflex activity
  - dehydration, high sweat rates
- Treatment:
  - Rest
  - Salt tabs
  - Prolonged static stretching
  - Sports drinks, pickle Juice?, mustard?
- Return to play: resolution of symptoms

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Exercise-Associated Muscle Cramps

- Treatment
  - refractory cases may need IV Fluids or IV meds
    - Diazepam 1-5 mg IV
    - Midazolam 1-2 mg IV
    - Mag sulfate 2 g IVPB
- Prevention
  - conditioning
  - heat acclimatization
  - maintain fluid/salt balance

Caution for severe, prolonged cases + increased core body temp ~ Rhabdomyolysis

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Heat Syncope

- Defined by acute LOC (usually brief) w/out other neurological symptoms present
- No exercises needed
- Most commonly due to dehydration, orthostasis, peripheral vasodilation, and venous pooling
- Assessment: ABC
- Treatment: elevate legs, oral hydration, cool
- Most often better in 20-30 minutes / No follow-up necessary*
  - Consider EKG in at-risk populations
  - Consider transfer to ER if unable to ambulate after 1 hour or change in mental status
- Return to play: delayed

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Exercise Associated Collapse (EAC)

- Defined by acute LOC (usually brief) w/out other neurological symptoms present following prolonged exercise
  - marathons, ultramarathons, triathlon events
- Most commonly due to orthostasis, peripheral vasodilation, and venous pooling
- Assessment: neurologic exam, core body temp, serum sodium,
- Treatment: elevate legs, rehydrate (IVF if necessary) , cool
- Most often better in 20-30 minutes / No follow-up necessary*
  - Consider EKG in at-risk populations
  - Consider transfer to ER if unable to ambulate after 1 hour or change in mental status
- Return to play: delayed

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Heat Exhaustion

- inability to exercise in heat 2/2 CV insufficiency, hypotension, central fatigue and energy depletion
- Most common heat-related illness
- Characterized by profuse sweating, headache, nausea, weakness, malaise, inability to continue exercise.
  - Mild mental status changes may be present.
  - **No end-organ damage**
- Core (i.e. rectal) temperature < 40C (104F)
- Assessment: Vitals, rectal temp, oral fluids
- Treatment: discontinue activity, rehydration, remove excess clothing, **rapid cooling;** symptoms should resolve in 2-3 hours
- Return to play: delayed

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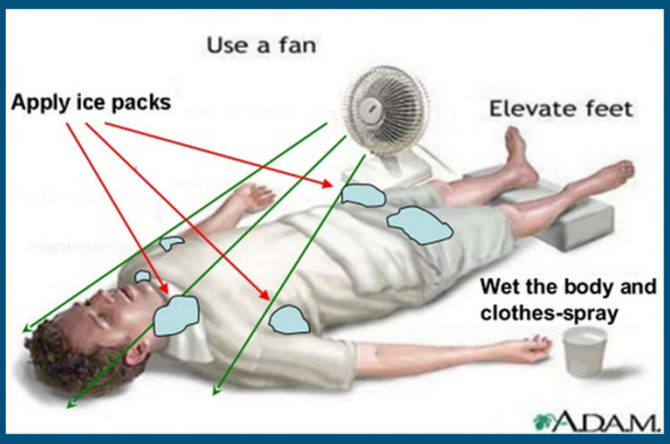

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Exercise-associated Hyponatremia (EAH)

- Potentially life-threatening condition characterized by Na <135 and mental status changes
- Most commonly presents in endurance athletes who ingest excessive quantities of hypotonic fluid causing a dilutional hyponatremia
- Risk factors include females, short stature, and longer race times
  - Runners who fail to lose 0.75 kg of body weight during a marathon

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Exercise-associated Hyponatremia (EAH)

- Early symptoms include vomiting, swelling of the hands and feet, restlessness, confusion, wheezing, and fatigue.
- Failure to reverse the low sodium concentration and osmolarity may cause progression to seizures, pulmonary edema, cerebral edema,brainstem herniation, coma, respiratory arrest, and death

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Exercise-associated Hyponatremia (EAH)

- Assessment: portable, rapid serum sodium measurement
- Treatment:
  - Mild cases: oral fluid restriction, salty food consumption, salt tabs
  - Severe cases (AMS or seizures): hypertonic saline @ 100cc/h and ER transport
    - If seizures continue, repeat hypertonic saline
    - Avoid raising Na more than 6 meq
- Return to play: delayed
  - individualized hydration protocols based on personal sweat rates, sport dynamics, environmental factors, heat acclimatization status, exercise duration, and exercise intensity

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Exertional Heat Stroke (EHS)

- classic triad: hyperthermia (> 104F), anhidrosis, and CNS disturbance
- Untreated EHS may progress on to multisystem organ damage, rhabdomyolysis, renal failure, acute respiratory distress syndrome, liver damage, hyperkalemia, hypercalcemia, cardiac arrhythmias, hypoglycemia, disseminated intravascular coagulation (DIC), and death.

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Exertional Heat Stroke (EHS)

- Assessment: Early recognition of s/sxs
- Treatment: **rapid cooling - Cold Water Immersion, IVF, and transfer to ER**
  - Morbidity and mortality are more closely related to time to immersion than initial core body temperature
  - Gold standard is water/ice bath immersion (2-15C) within 10 minutes
  - Cold water immersion leads to decrease in body temp by 0.5C within 3 minutes and then accelerates. Goal body temp should take about 20 minutes.
  - Monitor vitals at regular intervals
  - Goal core body temp - 102
  - Manage sequelae as appropriately until transfer to ER
- Return to sport: delayed
  - rest 7-21 days
  - low and cool progression; 2-4 weeks of training before competition

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Return to Sport

- Mild heat illness (e.g. mild heat exhaustion)
  - Return to exercise 48h after the athlete is asymptomatic
  - If symptoms return, discontinue activity and reevaluate the athlete
- Severe heat exhaustion or heatstroke
  - No exercise initially then f/u with physician 7 days after hospital discharge
  - At 7 days, recheck labs and if normal without s/sxs then gradual reintroduction of exercise over 2 weeks. Start with light exercise in a non-heat-stressed environment. Increase intensity, then heat stress.
  - If complicated return, consider exercise heat tolerance test at 1 month

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Prevention

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Acclimatization

- Gradually increase exercise duration/intensity over 10 to 14 days
- Physiologic changes in hot environments: increased plasma volume, earlier onset of sweating and increased sweating rate, reduction of electrolytes
  - Over 7-14 days, the body increases aldosterone to increase sodium reabsorption
- In 2009, the National Athletic Trainers' Association released guidelines for high school preseason sports which were found to be beneficial by follow up studies (although some argue for a period longer than 14 days), however, these guidelines are only mandated in 8 states
  - https://www.uiltexas.org/files/athletics/Fall_Football_Practice_Regulations.pdf

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RECOMMENDATIONS FOR THE 14-DAY HEAT-ACCLIMATIZATION PERIOD

1. Days 1 through 5 of the heat-acclimatization period consist of the first 5 days of formal practice. During this time, athletes may not participate in more than 1 practice per day.
2. If a practice is interrupted by inclement weather or heat restrictions, the practice should recommence once conditions are deemed safe. Total practice time should not exceed 3 hours in any 1 day.
3. A 1-hour maximum walk-through is permitted during days 1–5 of the heat-acclimatization period. However, a 3-hour recovery period should be inserted between the practice and walk-through (or vice versa).
4. During days 1–2 of the heat-acclimatization period, in sports requiring helmets or shoulder pads, a helmet should be the only protective equipment permitted (goalies, as in the case of field hockey and related sports, should *not* wear full protective gear or perform activities that would require protective equipment). During days 3–5, only helmets and shoulder pads should be worn. Beginning on day 6, all protective equipment may be worn and full contact may begin.
   A. Football only: On days 3–5, contact with blocking sleds and tackling dummies may be initiated.
   B. Full-contact sports: 100% live contact drills should begin no earlier than day 6.
5. Beginning no earlier than day 6 and continuing through day 14, double-practice days must be followed by a single-practice day. On single-practice days, 1 walk-through is permitted, separated from the practice by at least 3 hours of continuous rest. When a double-practice day is followed by a rest day, another double-practice day is permitted after the rest day.
6. On a double-practice day, neither practice should exceed 3 hours in duration, and student-athletes should not participate in more than 5 total hours of practice. Warm-up, stretching, cool-down, walk-through, conditioning, and weight-room activities are included as part of the practice time. The 2 practices should be separated by at least 3 continuous hours in a cool environment.
7. Because the risk of exertional heat illnesses during the preseason heat-acclimatization period is high, we strongly recommend that an athletic trainer be on site before, during, and after all practices.

https://meridian.allenpress.com/jat/article/44/3/332/110945/Preseason-Heat-Acclimatization-Guidelines-for

https://pediatrics.aappublications.org/content/128/3/e741.long

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Adequate Hydration

- Athletes should drink 5-7 m/kg of fluid 4 hours prior to exercise
- If urine output is low or dark in color, drink an additional 3-5ml/kg 2 hours prior to exercise
- During exercise, drink enough to prevent >2% weight loss (a weight loss of 1% during exercise is correlated with a 0.25C increase in core body temp)
  - Thirst is a valuable indicator of dehydration but does not occur until 1-2% body weight loss
- Pre-exercise/during exercise cooling: cold water on air or drink cold fluids - improves exercise tolerance/performance in heat stress environment
- Post exercise, each kg of weight loss should be replaced by 1 L of fluid

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Adequate Hydration

- *Misguided*
  - Thirst
    - Late sign
- Not evidence based
  - Urine concentration
- Evidence-based
  - Measure sweat loss
    - pre -exercise weight and post exercise weight
  - Calculate sweat rate
    - (pre-exercise weight - post-exercise weight) + (fluid intake - urine volume)/exercise time in hours

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Adequate Hydration

- Rule of thumb
  - For every pound lost → drink 2-3 cups of fluid
- Fluid type
  - Water = essential
  - Fluid with carb concentration of 6-8%
    - Especially for exercise that is greater than 60 mins

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Adequate Hydration

- A survey of NCAA D1 college football ATC's disclosed that 30% of programs used pre-game intravenous fluids, administered to an average of 2–3 players per game, with the intended purpose of preventing muscle cramps, heat illness, and dehydration.
  - The primary care team physician most commonly administered intravenous fluids, 47 % were given at player request, and 24 % reported the occurrence of intravenous infusion-related complications

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Maintaining Eunatremia

- Sweat losses must be replaced, especially in high environmental heat stress
- Sodium ingestion prevents EAH and promotes thirst and oral rehydration

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Wet bulb globe temperature (WBGT)

- Accurate quantification of environmental heat stress should be assesssed using WBGT. It takes into account humidity, solar radiation/cloud cover, wind speed, sun angle and heat. Recommended by ACSM.

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WBGT Index and Athletic Activity Chart	
WBGT Index (F)	**Athletic Activity Guidelines**
Less than 80	Unlimited activity with primary cautions for new or unconditioned athletes or extreme exertion; schedule mandatory rest/water breaks (5 min water/rest break every 30 min)
80 - 84.9	Normal practice for athletes; closely monitor new or unconditioned athletes and all athletes during extreme exertion. Schedule mandatory rest /water breaks. (5 min water/rest break every 25 min)
85 - 87.9	New or unconditioned athletes should have reduced intensity practice and modifications in clothing. Well-conditioned athletes should have more frequent rest breaks and hydration as well as cautious monitoring for symptoms of heat illness. Schedule frequent mandatory rest/water breaks. (5 min water/rest break every 20 min) Have cold or ice immersion pool on site for practice.
88 - 89.9	All athletes must be under constant observation and supervision. Remove pads and equipment. Schedule frequent mandatory rest/water breaks. (5 min water/rest break every 15 min) Have cold or ice immersion pool on site for practice.
90 or Above	**SUSPEND PRACTICE/MUST INCLUDE MANDATORY BREAKS AS DIRECTED BY GAMEDAY ADMINISTRATOR DURING CONTEST.**

https://www.weather.gov/rah/WBGT

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