

Heat Illness

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HEAT PRODUCTION

- Heat is a byproduct of the metabolic process
- Muscle contributes the largest amount of heat produced at rest
- Muscle work increases heat production
- Fever and shivering are other sources

HEAT DISSIPATION

- Primarily regulated by blood flow to the skin
- Three mechanisms of heat transfer:
 1. Radiative-primary mechanism and can occur anywhere within the body
 2. Conductive-capacity of blood flow to convey heat. Cooler medium than the skin like a cool towel, ice bag, etc. (temperature gradient)
 3. Evaporative- sweating

HEAT DISSIPATION

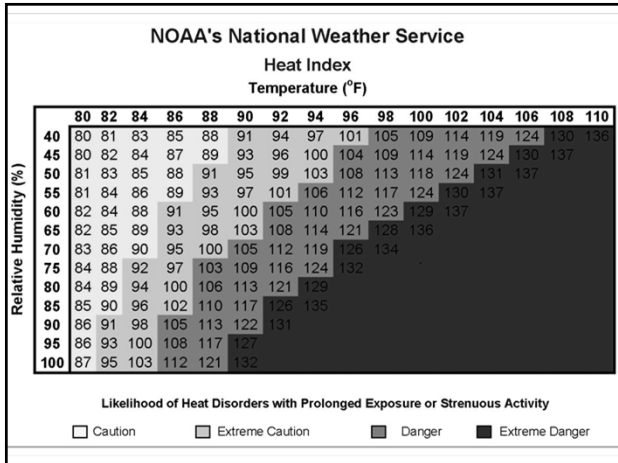
- Some of these forms of heat dissipation can be limited by equipment or gear worn by athletes (e.g., helmets, shoulder pads, pants)
- These types of equipment trap heat close to the body
- As a result, many athletes rely heavily on sweating for thermoregulation

HEAT INDEX

- Also known as the apparent temperature, is what the temperature feels like to the human body when relative humidity is combined with the air temperature

HEAT INDEX

- Heat Index = $-42.379 + 2.04901523T + 10.14333127R - 0.22475541TR - 6.83783 \times 10^{-3}T^2 - 5.481717 \times 10^{-2}R^2 + 1.22874 \times 10^{-3}T^2R + 8.5282 \times 10^{-4}TR^2 - 1.99 \times 10^{-6}T^2R^2$
- T - air temperature (F)
- R - relative humidity (percentage)



HEAT INDEX

- "Dry heat"
- Elevated temperatures with low relative humidity

HEAT INDEX

- Humidity effects evaporative heat dissipation
- Evaporation is a cooling process. When perspiration is evaporated off the body, it effectively reduces the body's temperature
- When the body gets too hot, it begins to perspire to cool itself off. If the perspiration is not able to evaporate, the body cannot regulate its temperature

PHYSICAL PERFORMANCE

- How does heat and humidity effect performance?
 - Hyperthermia
 - Acute dehydration

PHYSICAL PERFORMANCE

- Hyperthermia
 - Reduces muscular endurance (the ability to sustain muscular contractions for several minutes to hours)
 - It may alter performance in the long-distance events of cycling, track and field, and soccer

PHYSICAL PERFORMANCE

- Hyperthermia
 - Shifts metabolism from primarily the aerobic (with oxygen) to the anaerobic (without oxygen) form
 - This means that the body's stores of carbohydrate (e.g., glycogen) in skeletal muscles and liver will be consumed at a faster rate
 - This may partly explain why exercise in the heat cannot be maintained as long as in a cool environment

PHYSICAL PERFORMANCE

- Hyperthermia
 - Causes the dilation of blood vessels in the skin and pooling of blood in the limbs
 - Reduces the volume of blood that returns to the heart, reduces cardiac output, and increases circulatory strain
 - These effects are perceived as increased fatigue because the capacity to deliver oxygen to muscles is reduced

PHYSICAL PERFORMANCE

- Acute dehydration
 - Athletes routinely experience a 2-8% loss in body weight during competition and training
 - It is unlikely that small or moderate reductions in body weight due to dehydration (-1% to -3%) alter strength

PHYSICAL PERFORMANCE

- Acute dehydration
 - However, sustained or repeated exercise that lasts longer than 30 seconds deteriorates when moderate to severe dehydration exists

PHYSICAL PERFORMANCE

- Acute dehydration
- Degrades endurance performance, regardless of the environmental temperature or whole-body hyperthermia

HEAT ILLNESS

HEAT ILLNESS

- A spectrum of clinical conditions that range from muscle (heat) cramps, heat syncope, and heat exhaustion to life-threatening heat stroke incurred as a result of exercise or other physical activity in the heat

HEAT SYNCOPE

- Form of vasovagal syncope
- Not a result of excess body heat

HEAT SYNCOPE

- Current or recent illness (especially if it involves/involved gastrointestinal distress or fever)
- Clothing, uniforms, or protective equipment that contribute to excessive heat retention

HEAT EXHAUSTION

- Moderate heat illness, characterized by the inability to maintain blood pressure and sustain adequate cardiac output, that results from strenuous exercise or other physical activity, environmental heat stress, acute dehydration, and energy depletion
- Typical loss of 10% or more of body weight

HEAT EXHAUSTION

- Weakness
- Dizziness
- Nausea
- Syncope
- Headache;
- Core body temperature is $<104^{\circ}\text{F}$ (40°C).

HEAT CRAMPS

- Cause unknown
- Treatment gentle massage, stretching and electrolyte-containing drink
- Prevention- proper diet, prehydration and rest
- Recurring episodes consider primary myopathy

HEAT STROKE

- Severe multisystem heat illness, characterized by central nervous system abnormalities such as delirium, convulsions, or coma, endotoxemia, circulatory failure, temperature-control dysregulation, and potentially organ and tissue damage, that results from an elevated core body temperature (104°F [40°C]) that is induced by strenuous exercise or other physical activity and typically (not always) high environmental heat stress.

HEAT STRESS

- High air temperature, humidity, and solar radiation that lead to perceived discomfort and physiologic strain when athletes are exposed to such environmental conditions, especially during vigorous exercise and other physical activity

HEAT INJURY

- Heat injury: Profound damage and dysfunction to the brain, heart, liver, kidneys, intestine, spleen, or muscle induced by excessive sustained core body temperature associated with incurring exertional heat stroke, especially for those victims in whom signs and/or symptoms are not promptly recognized and are not treated effectively (rapidly cooled) in a timely manner

ACCLIMATIZATION (ACCLIMATION)

- Physiological adaptations to better resist the negative effects of heat

ACCLIMATIZATION (ACCLIMATION)

- Decreased core body temperature at rest
- Decreased heart rate during exercise
- Increased perspiration rate
- Initiation of sweating at a lower core temperature

ACCLIMATIZATION (ACCLIMATION)

- Initiation of thirst drive at a lower serum osmolality
- Decreased sodium losses in sweat and urine
- Expanded plasma volume
- 7-10 days for adults
- Approximately 2 weeks for children/teens

RISK FACTORS

- Hot and/or humid weather
- Excessive physical exertion
- Insufficient rest/recovery time between repeat bouts of high-intensity exercise (eg, repeat sprints)
- Insufficient access to fluids and opportunities to rehydrate

RISK FACTORS

- Poor preparation
 - Not heat-acclimatized
 - Inadequate prehydration
 - Little sleep/rest
 - Poor fitness

RISK FACTORS

- Multiple same-day sessions
 - Insufficient rest/recovery time between practices, games, or matches
- Overweight/obese (BMI 85th percentile for age) and other clinical conditions (eg, diabetes) or medications (eg, attention-deficit/hyperactivity disorder)

RISK FACTORS

- Current or recent illness (especially if it involves/involved gastrointestinal distress or fever)
- Clothing, uniforms, or protective equipment that contribute to excessive heat retention

ACTIONS

- Provide and promote consumption of readily accessible fluids at regular intervals before, during, and after activity
- Allow gradual introduction and adaptation to the climate, intensity, and duration of activities and uniform/protective gear
- Provide longer rest/recovery time between same-day sessions, games, or matches
- Avoid/limit participation if an athlete is currently or was recently ill

ACTIONS

- Physical activity should be modified
 - Decrease duration and/or intensity
 - Increase frequency and duration of breaks (preferably in the shade)
 - Cancel or reschedule to cooler time

ACTIONS

- Closely monitor participants for signs and symptoms of developing heat illness
- Ensure that personnel and facilities for effectively treating heat illness are readily available on site
- In response to an affected (moderate or severe heat stress) athlete, promptly activate emergency medical services and rapidly cool the victim

Case

- A 16-year old female crosses the finish line of a half-marathon and collapses. She's confused, slurring her words and becomes limp. What are your next steps?

Case

- Airway
- Breathing
- Circulation
- Temperature?

Case

- Temperature
- Rectal temperature is the standard of care. Studies have shown it's the most reliable route in someone who has been exercising
- Morbidity comes with how long the patient is hot, not how high there

Case

- Management
- ABCs
- Cool emergently (done in parallel)

Case

- Cold water immersion (cool skin to create gradient)
- Rotating cool towels (every 5 min or less)
- Ice burrito-barrel with cool sheets
- Fan cool air (spray)

Case

- When do you stop cooling?

Case

- Stop cooling between 101-102 degrees (15-20 min)
- Shivering. Can occur around 101-102 degrees
- Seizures not likely

Case

- You treat an athlete with heat stroke by cold water immersion and cooling techniques but they fully recover (normal vital signs and cognition) before EMS arrives. Send them home or to ER?

Case

- Send to emergency room
- Temperature variability can still occur
- 9/10 there is a reason for the heat stroke that needs be investigated (e.g. illness, dehydration, sleep deprivation, etc.)

Case

- Cooling continues via EMS and the emergency room
- F/U with medical provider after week for re-examination. Repeat labs if necessary.

Case

- There is no agreed upon Return-to-Play Protocol but reacclimatization is the key
- If they have trouble then refer to a Heat Lab for functional testing
- Exercise testing under highly controlled environmental conditions (2-hour heat load) and used to differentiate between rhabdomyolysis, malignant hypothermia, heat intolerance, etc.

Case

- Red Flags
 - Unable to return and having heat intolerance
 - No explanation for heat stroke
 - Consider Malignant hyperthermia

Case

- Malignant hyperthermia (MH) is a dominantly inherited disorder of skeletal muscle that predisposes susceptible individuals to a life threatening adverse reaction (fulminant MH event) upon exposure to potent volatile anesthetics (halothane, isoflurane, sevoflurane, desflurane, etc.) and the skeletal muscle relaxant succinylcholine.

Case

- In some individuals, fulminant MH events can be induced by stress, exercise and **high environmental temperatures** in the absence of anesthetics

Case

- Malignant hyperthermia, exertional rhabdomyolysis and heat intolerance are felt to be linked

Case

- So I had a patient with rhabdomyolysis (15 yr old male) relatively fit but not a competitive athlete otherwise healthy that had very elevated CPK after some weightlifting. Was admitted and had a sedated MRI and developed what seemed to be malignant hyperthermia with the anesthetic. I suspect a genetic disorder with the Ryr1 gene. That

Case

- Mother called asking if he could run in track and I had difficulty answering other than to tell her to allow him to do the running he has done in the past with slow, less than 10%, increase in distance or intensity every week and should he have any soreness longer than a day should cut back.

Case

- Obviously no exercise in heat and avoid any supplements and medication and keep hydrated and cool during and after exercise.

Case

- No. If the patient had an episode of malignant hyperthermia then moderately strenuous activity is not advised for 6-12 months. Despite normal labs they can have mild symptoms for 3-6 months following the episode.

Prevention

- Parallel training to acclimatize
- Know hydration strategy. Drink ad libitum.
- If ill, reconsider participating in the event

Thank you

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