Heat Illness & Hydration
OMED 2013
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Objectives

• Define exertional heat illnesses
• Epidemiology of exertional heat illness
• Review thermoregulatory physiology
• Review pathophysiology of heat illness
• Review emergent recognition & treatment of exertional heat illness
• Review prevention of exertional heat illness
  – Acclimation
  – Hydration
• Review current return to play guidelines

Heat Illness

• Increase in body temperature can lead to
  – Heat Stroke
  – Heat Exhaustion
  – Heat Cramps
Heat Stroke

- Defined by
  - Body temp > 104 F (40 C)
  - CNS Dysfunction
  - Organ Damage
  - Maybe we should have called it “Heat Shock”

Heat Exhaustion

- Inability to continue exercising
- Brain mediated “safety break”
- Temperature not as high as HS
  - Maybe we should have called it “Heat Syncope”

Heat Cramps

- Painful muscle cramps
  - calves
- Associated with large amounts of sodium loss
Epidemiology

• Highest death rates are with
  – Football
    • 35 total deaths from 1995-2010
    • Rate of EHI is 11 times that of other sports combined
  – Wrestling
  – Cross-country
• 9000 high school athletes EHI annually


Epidemiology

• From 2005-2009 more EHS deaths occurred in organized sports than in any other 5 year period over the past 35 years
• 1/3 of EHI occur when physicians or ATCs are not present at the time of onset
• EHI in practice usually occurs 2 hours after the practice session began


Thermoregulatory Exercise Physiology

• Intrinsic Factors
  – Genetics
  – Fitness/Acclimation
  – Medications
  – Sleep
• Extrinsic Factors
  – Exercise Intensity
  – Clothing/Equipment
  – Temperature/Humidity
  – Solar Radiation
Physics

• To understand how the body cools itself down you need to have a basic understanding of physics

• But I hate physics…

What do I like???

What do I like???
What do I like???

Brewing

Conduction

Convection

Brewing

Conduction

Convection
Thermoregulatory Exercise Physiology

- Extrinsic and intrinsic factors increase core body temperature
- Hypothalamus senses rise in body temperature
- Hypothalamus then activates
  - Increase in cardiac output
  - Vasodilation of skin blood vessels
  - Sweat gland secretion

What does sweat contain?

- Water
- Urea
- Electrolytes
  - Sodium

The composition is highly variable between individuals

- Person
- Environment
- Body weight
- Acclimated/Fitness level
  - Decreases sweat sodium concentration
Thermoregulatory Exercise Physiology

• As we sweat the extracellular fluid compartment becomes contracted
• The body can still maintain plasma volume, osmolality, and electrolyte levels through interstitial compartment shifts

Thermoregulatory Exercise Physiology

• Heat Shock Proteins (HSP)
  – At the cellular level
  – Prevent disaggregation of denatured proteins
  – Prevent endotoxin leakage
  – Interfere with oxidative stress and apoptosis cellular pathways
  – HSPs increase with heat acclimation
    • Some people have antibodies to HSPs

Thermoregulatory Pathophysiology

• Dehydration
  – Decreases blood volume and cardiac output
  – Decrease in sweat rate
• Endotoxins
  – Increase hypotension
  – Usually detoxified by liver – but hepatic blood flow is decreased
• Cerebral Blood Flow
  – Further hampers the thermoregulatory system
Thermoregulatory Pathophysiology

- Why athletes pass out with heat exhaustion (theory)
  - CNS “safety break” causes a wide spread peripheral vascular dilation
  - Syncope event
  - Dehydration plays a big role

- Why athletes cramp (theory)
  - Because interstitial volume is contracted, axon terminals can be mechanically deformed
  - This can cause an increase in neurotransmitters which can be spontaneously discharged resulting in cramping
  - When athletes rehydrate with plain water the extracellular plasma volume is restored but interstitial volume remains contracted
Hydration

- Total Body Water (TBW)
  - Averages approximately 60% of body mass
  - Trained athletes tend to be higher
    - Muscle is 70-80%
    - Fat is 10%

Performance & Hydration

- Performance has been shown to decrease secondary to dehydration
  - Physically
  - Mentally
- Decreases start to happen when there is a decrease in total body water of 2%

Swaka et al / Med Sci Sport 2007
Performance & Hydration

- People do not perceive the feeling of being thirsty until there is a decrease in total body water of 3%.

Dehydration and Effects

- 3-5%
  - Decrease in aerobic and anaerobic capacity
- 5-7%
  - Deterioration of cognitive function
- >7%
  - Severe electrolyte imbalances, possible death

Givan et al / Sports Health 2012

Rates

- Football players have shown an average sweat rate of 2.14 L per hr in summer training.
- Rates are maxed out at a core body temperature of 39 degrees C.

Swaka et al / Med Sci Sport 2007
Who’s at risk for heat illness?

- Those who have had it before
- Out of shape/Unacclimated
- Overweight
- Age...
- Dehydration
- People exercising in
  - WBGT > 82 F
  - VO2 Max > 75%
  - Duration > 1 hour

Warning signs

- Change in mental status
  - Disoriented, Confused, Unusual Behavior
- Dizziness
- Difficulty walking
- Vomiting
- Hyperventilation

Confused with Concussion

- Take a temperature
And it should be a rectal temp

- Ear, skin, axilla temperatures are inaccurate
  - By the time heat stroke is present skin blood flow is decreased
- Oral is also inaccurate
  - Hyperventilation
  - Oral cool liquids

Concerning News

- Mazerolle et al. 2010
  - N=497
  - Despite knowing that rectal temperature is the gold standard
    - Only 10% of high school and 26% of college ATCs do it
  - Why?
    - Invasiveness/privacy, lack of training

Treatment for Heat Stroke

- Remove athlete from play!!!!!
- Call EMS
- Place athlete in a shaded area
- Ice
  - Immersion
  - Bags on head, neck, armpits, groin
Effectiveness

McDermott et al / J Ath Trin 2009

Cool first, Transport second!!!!

Armstrong et al / Med Sci Sport 2007

Concerning News

• Mazerolle et al. 2010
  – N=497
  – Despite knowing that cold water immersion as the gold standard
    • Only 35% of high school and 62% of college ATCs use it
  – Why?
    • Limited resources, safety misconceptions, and belief transport is most important
Why a rectal temperature?

• "I see little benefit from taking rectal temperature. Removing pants and taking the temperature is too time consuming. That time is better spent in the ice bath bringing the temperature down."

• Mazerolle et al. 2010

You NEED to confirm that its heat stroke before you treat!!!!

• Similar to a CVA
  – And the rectal temp is similar to a CT scan
• Heat stroke symptoms are so non-specific and can mimic many other emergencies
• If you get tunnel vision, and treat for heat stroke you may miss something else or possibly send the athlete into hypothermia

Immediate Treatment of Heat Exhaustion

• Remove the athlete to a cooler area
• Supine position with legs elevated
• Oral fluids
• Monitor for progression into heat stroke
Immediate Treatment of Heat Cramps
- Stretch, massage, ice
- Oral high salt solution
- IVF???

Prevention
- Go into practice fully hydrated
- Wear light colored, loose fitting clothing
- Exercise during the cooler parts of the day
- Acclimate over time
  - Start 10-14 days before training camp
  - Start at 10 minutes
  - Increase by another 10 minutes every 2 days

WBGT
- Wet Bulb Globe Temperature
  - \( \text{WBGT} = (0.7T_{wb}) + (0.2T_{bg}) + (0.1T_{db}) \)
Using WBGT

<table>
<thead>
<tr>
<th>WBGT</th>
<th>Restrains on Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;70.0</td>
<td>All activities allowed, be alert for problems of heat-related illness in prolonged events</td>
</tr>
<tr>
<td>70.0-79.0</td>
<td>Longer rest periods in the shade, alternate drinking every 15 min</td>
</tr>
<tr>
<td>79.0-84.0</td>
<td>Stop activity of unacclimated persons and high-risk persons; limit activities of all others (e.g., long-distance races, cut the duration of other activities)</td>
</tr>
<tr>
<td>&gt;85.0</td>
<td>Cancel all athletic activities</td>
</tr>
</tbody>
</table>

Armstrong et al / Med Sci Sport 2007

Hydration Guidelines

- Drink 16 oz. of water or sports drink one hour before exercise
- Drink 4-8 oz. every 15-20 minutes of exercise
- Exercising less than an hour, drink water
- Exercising more than an hour, drink a sports drink
  - 16 oz. is about half a liter

After Exercise Hydration

- Weigh yourself before and after practice
  - For every 2 lbs. lost - drink 48 oz.
  - For every 1 kg lost - drink 1.5 L
History of Gatorade

• Created by researchers at the University of Florida in 1965 – "Gator"-aid
• Legend of the 1967 Orange Bowl win over Georgia Tech

Prevention of Heat Cramps

• It's all about sodium
  – Acclimate
  – Increase sodium in daily diet

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Electrolyte Table Salt</th>
<th>Frequency or Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drinking water</td>
<td>50 ml (1.6 fl oz)</td>
<td>0.05 tsp (0.1 g)</td>
</tr>
<tr>
<td>Drinking water</td>
<td>100 ml (3.4 fl oz)</td>
<td>0.1 tsp (0.2 g)</td>
</tr>
<tr>
<td>Drinking water</td>
<td>150 ml (5.1 fl oz)</td>
<td>0.15 tsp (0.3 g)</td>
</tr>
<tr>
<td>Drinking water</td>
<td>200 ml (6.8 fl oz)</td>
<td>0.2 tsp (0.4 g)</td>
</tr>
<tr>
<td>Recovery drink</td>
<td>100 ml (3.4 fl oz)</td>
<td>One per 1 hour</td>
</tr>
</tbody>
</table>

Bergeron / J Sport Rehab 2007

Pickle Juice

• Anecdotally, helps with muscle cramps
• High in sodium
IVF

• Controversial
• WADA illegal
  – >50mL per 6 hour period is prohibited
  – NCAA illegal for wrestling only
• 75% of NFL teams use it pre-game
• No improvement in performance studies
• Only anecdotal evidence exists for cramp prevention treatment

Current publications state
  – Routine IV therapy cannot be recommended as best practice for the majority of athletes.
  – IV fluid use may be beneficial for a subset of athletes
    • High level athletes with strong histories of symptoms in well-monitored settings

Return to Play

• For Heat Stroke
  – No exercise for a minimum of 7 days after medical release
  – 1 week follow up for physical exam and labs/test if indicated
  – Begin exercise in cool environment & gradually increase duration and heat exposure over 2 weeks
  – Clear for full competition if heat tolerance exists after 2-4 weeks of training

Givan et al / Sports Health 2012
Armstrong et al / Med Sci Sport 2007
Return to Play

- For Heat Exhaustion
  - Same day is not advised
  - Mild forms can return to training in 24-48 hours
  - Hydrate

Summary

- Educate
  - Physicians, ATCs
  - Coaches, Parents, Athletes
- Heat Illness is a multi-factorial
  - Genetics, environment
- Heat Illness is preventable
  - Common sense
  - Acclimate and stay in shape
  - Hydration is key

Summary

- Rectal temperature is the “gold standard”
- Confirm before you treat
- Ice immersion is the “gold standard”
- Delay in treatment results in
  - A slower return to baseline
  - Poor outcomes

Armstrong et al / Med Sci Sport 2007
References