Exertional Heat Illness (EHI) in Athletes
See also Heat Illness
See also Heat Related Illness (Peds)

**Background**

1. **Definition**
   - Potentially fatal process where elevated core temperature, vital organ dysfunction and dehydration occur as a result of exercising in warm/hot conditions

2. **General info**
   - Most likely to occur during late summer mos
     - Environmental conditions hot/humid
   - Football especially prone
     - 2-a-day practices-usually in first 4 days of practice
     - Bulky equipment, decr heat dissipation
   - Wrestling
     - Participants try to lose weight with sweat suits and plastic wraps
   - Young healthy athletes can be treated aggressively
     - Use caution treating athletes at extremes of ages
   - **Wet bulb globe temperature (WBGT)**
     - Developed in 1950's for military to help reduce heat casualties during training
     - Often used by occupational and athletic venues
     - WBGT = 0.7(T)wb+0.2(T)bg+0.1(T)db
       - (T)wb-temp measured by natural wet bulb for humidity
       - (T)bg-temp measured by black globe where a thermometer is placed into a black copper globe for radiant heat stress
     - (T)db-temp measured by ambient dry thermometer
     - Used to make recommendations for activity environmental conditions
       - Green <18°C (64.4°F)
         - Risk low but still exists
       - Yellow 18°-23°C (64.4-73.4°F)
         - Moderate risk incr as event progresses
       - Red 23°-28°C (73.4-82.4°F)
         - High risk be aware of injury potential
         - Individuals w/risk factors should not compete
       - Black >28°C (82.4°F)
         - Extreme risk reschedule or delay event
         - If event continues, must be on high alert for EHI
   - ACSM Position Stand: Exertional Heat Illness During Training and Competition
   - ACSM Position Stand: Exercise and Fluid Replacement
Pathophysiology

1. Pathology of dz
   - Imbalance between heat generation and dissipation
     - During exercise body generates heat as by-product of energy utilization
     - Body dissipates heat from convection, radiation, conduction
       - Conduction (evaporation) most effective in humans
       - Body produces sweat which cools body as it evaporates
     - If evaporation is impaired, body has difficulty cooling
     - Any environment where sweat cannot evaporate places athlete at risk for EHI
       - Exercising in a hot, humid environment
       - Wearing heavy restrictive clothing
       - Dehydration (SOR:B)
   - Unlike other heat related injuries, EHI pts
     - Sweat profusely
     - Respond rapidly to aggressive cooling measures

2. Incidence/prevalence
   - Most studies done in military athletes/settings
     - During 2002 the Army had 3.8/1000 person yrs for all heat related illnesses
   - National Center for Catastrophic Sports Injury Research report from 1995 to 2005
     - 26 high school, collegiate and professional athletes died from exertional heat injuries
   - Often seen in late summer when training begins
     - Football—single largest group of athletes at risk
     - Soccer
     - Cross country
     - Wrestling

3. Risk factors (SOR:B)
   - Lack of fitness
   - Obesity/elevated BMI
   - Not acclimatized to heat
   - Current illness
     - Diarrhea
     - Vomiting
   - Inadequate fluid intake/dehydration
   - Sweat gland dysfunction
   - Sunburn
   - Previous Hx of EHI
   - Lack of sleep
   - Medications/drugs
   - Additional risks
     - Alcohol/caffeinated drink consumption
     - Predisposing medical conditions
     - Excessive clothing/equipment
       - Especially dark colored clothing
       - Plastic wraps/sweat suits
     - Overeager athlete
4. Morbidity/mortality
   o Related to length of time between collapse and initiation of cooling therapy
   o If Tx w/in an hr of onset, most athletes recover fully

Diagnostics
1. History
   o Early detection important
   o Hx of strenuous exercise in hot environment
   o Heat injury spectrum
     ▪ Many athletes progress w/o recognizing S/S
       ▪ From heat rash through heat cramps
       ▪ Heat exhaustion to heat stroke
   o Wet bulb globe temp trend starting 3 days prior places athletes at risk
   o Absolute body core temp upon arrival is not critical for Dx especially if cooling began in field
   o Presents with:
     ▪ N/V
     ▪ Not feeling "well"
     ▪ Ataxia
     ▪ Confusion
     ▪ Delirium
     ▪ Obtundation
     ▪ Seizures
     ▪ Death
   o Children:
     ▪ See Peds Heat Related Illness
   o Older athletes
     ▪ More susceptible to heat injury
     ▪ Due to co-morbid conditions
       ▪ Aging physiology cannot tolerate aggressive cooling methods
   o Athletes with spinal cord injuries
     ▪ Increased risk for heat injury-autonomic instability
     ▪ Altered vascular tone leading to pooling in lower extremities
     ▪ More difficult to cool these athletes

2. Physical exam
   o Need RECTAL temp
     ▪ Typically between 38.9-43.3°C (102-110°F)
     ▪ If cooling has started enroute it may already be lower
     ▪ Check w/EMS for initial temp
   o VS
     ▪ BP usually low 90/60
     ▪ Tachycardia
     ▪ Hyperventilation
   o Mental status:
     ▪ Normal to obtundation
   o Skin:
     ▪ Sweating
3. Dx testing
   o Lab eval looking for evidence of end organ damage
     ▪ CBC
       • Elevated WBCs may suggest infectious cause for elevated temp
       • Elevated H/H: hemoconcentration
     ▪ Electrolytes
       • Low sodium: hyponatremia
       • Elevated BUN/creatinine: acute renal failure
     ▪ Liver enzymes
       • Elevated liver enzymes: liver injury
     ▪ UA
       • Concentrated specific gravity: dehydration
       • Blood or protein
     ▪ CPK
       • If elevated: consider rhabdomyolysis
   o Dx imaging
     ▪ Only if another dx is suspected

Differential Diagnosis
1. Illness
   o Pneumonia
   o Influenza
   o Sepsis
   o Meningitis
   o Viral illness
2. Electrolyte abnormality
   o Hyponatremia
   o Hypoglycemia
3. Drugs/toxins
4. CVA/seizures
5. MI/arrhythmia
6. Sickle cell crisis

Therapeutics
1. Acute treatment
   o Early on-site mgmt
   o Cooling athlete is most important
     ▪ Start in the field w/removing clothing down to t-shirt and shorts
     ▪ Ice packs to groin, axilla, neck
     ▪ Transport for definitive cooling
     ▪ Ice submersion (SOR:A)
       • Fastest cooling rate
       • Lowest morbidity/mortality
     ▪ Modified ice submersion:
       • Use sheets soaked in ice water placed over pt (SOR:C)
       • Incl massaging extremities to improve blood flow
   o IVF 1-2L bolus, best if cool~18°C (~65°F)
Athlete may need 3-4L
Cool until rectal temp of 38.8°C (102°F) to avoid over cooling
Maximum body temp not as important as duration of overheating

2. Further mgmt (24 hrs)
Should remain under supervision for 6 hrs
Repeat same lab eval at 6 hrs to ensure a trend towards or normalization of abnormalities
Follow urine output
- Ideal is > 50 mL/hr
Can discharge home if <6 hrs
- Labs return to normal
- Mental status clears
If evidence of ongoing end organ damage; need continued Tx
- In cr LFTs most common abnormality
  - May take up to a wk to return to normal

3. Long-term care
Usually not needed

Follow-Up
1. Return to play guidelines (SOR:C)
Recommended
- After discharge from medical care, no strenuous exercise for 7 days
- Follow up exam and lab testing should be at 1 wk
  - Repeat lab testing or dx imaging as indicated
- Once cleared for activity; gradually incr exercise and heat exposure based on athlete’s tolerance
  - Incr duration, heat exposure and intensity over 2 wks
- If return is difficult, consider a lab exercise heat tolerance test at one month
  - May take 2-4 wks to return to full activity

2. Refer to specialist
If continuing evidence of end organ damage

3. Admit to hospital
If mental status has not cleared after temp normalizes
Evidence of continuing end organ damage at > 6 hrs

Prognosis
1. Good if recognized and treated early
2. Can return to practice and competition when athlete has reestablished heat tolerance (SOR:B)

Prevention
1. Medical care available at practice/ events
  Providers familiar w/treating heat illness
2. Limit intensity/duration until acclimatized
3. Acclimatization
  10-14 days of exercise training in heat
  Reduces risk of EHI (SOR:C)
4. Proper hydration
   o Fluid replacement recommendations
     ▪ Urine color chart
       • http://www.owlnet.rice.edu/~heal103/docs/Am%20I%20Hydrated%20-%20Urine%20Color%20Chart.pdf
     ▪ <2% body wt change
       • Weigh athlete before and after practice
       • If > 2% change they should drink fluids until at pre-practice weight

5. Increased salt consumption to 2 g per day
6. Limit amount of clothing/ equipment
   o Light colored clothing
7. Assure good physical condition if exercising in heat
8. Avoid alcohol consumption
9. Limit caffeine consumption
10. Exercise when cool or early morning
    o Avoid 10am - 5pm
11. Workout to rest cycles
    o Increase number and length of rest periods

References
6. Kark JA MD et al. Exertional Heat Illness in Marine Corps Recruit Training. Aviation, Space and Environmental Medicine, 1996, April; (67) 4; 354-360

Evidence-Based Inquiries
1. How common is symptomatic hyponatremia in endurance athletes?

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