Hydration in Athletes

Background
1. Dehydration
   o >2% body weight loss from water deficit
2. Hyponatremia
   o Lower than normal concentration of sodium in blood
3. Euhydration
   o Normal body water content
4. Overview of hydration during exercise/sports:
   o Fluid replacement before, during and after sporting events/exercise is important for sustaining exercise performance and preventing morbidity (SOR:A)
5. For more information:
   o Mayo Clinic-Dehydration: http://www.mayoclinic.com/health/dehydration/ds00561

Pathophysiology
1. Pathology
   o Multiple factors influence sweat losses
     - Duration/intensity of exercise
     - Environment
       - Hot weather requires increased sweating: (SOR:A)
         o Dissipates metabolic energy
         o Avoids heat storage
       - Cooler environments:
         o Allow greater dry heat loss
         o Require lower sweating rates
     - Individual variation
   o Biochemistry of dehydration
     - Renin-angiotensin-aldosterone system regulates sodium retention
     - Vasopressin (anti-diuretic hormone ADH):
       o Regulates water retention in kidneys
       o Assists with thermoregulation
     - Atrial natriuretic peptide (ANP) secreted by the heart participates in water balance regulation
   o Daily water balance factors
     - Oral intake
     - Metabolic water produced 0.13 g/kcal
     - Respiratory water losses 0.12 g/kcal
     - Gastrointestinal tract losses 100-200 ml/day (excluding diarrhea)
   - Urine output:
     o Minimum 20 ml/hr
     o Maximum 1000 ml/hr
   o Total body water (TBW):
     - 60% of body mass (range 45-75%)
     - 70-kg person - approx 42 L of TBW
2. Incidence, prevalence
   o Based on specific activity and individual metabolic variability
   o Less incidence of dehydration:
      Swimming, netball, water polo, female tennis
      Intermediate incidence of dehydration
       • Male tennis, basketball
   o Higher incidence of dehydration
      Marathon/cross country running, ironman training/races, American football, soccer, rowing

3. Risk factors
   o Dehydration
      Poor oral hydration
      Diuretic use
      Alcohol consumption (SOR:B)
      Vomiting/diarrhea
   o Exercise associated hyponatremia
      Over drinking of fluids relative to sweat rate
      Inability to excrete relative fluid excess
       • During exercise
       • In initial recovery period
      Fluid replacement with water or electrolyte-poor beverages
       • Leads to dilution of plasma sodium
      Participation in endurance events
   o Age Related Variability
      Older adults
       • Have age related decreased thirst sensitivity when dehydrated making them slower to voluntarily reestablish euhydration (SOR:A)
       • Have age related slower renal responses to water and may be at greater risk for hyponatremia (SOR:A)
      Children
       • Have lower sweating rates than adults (SOR:B)

4. Morbidity / mortality
   o Dehydration-decrease in athletic performance (SOR:A)
      Low blood volume
      Reduced thermoregulation
      Decreased cognitive function (SOR:B)
      Reduced gastric emptying
      Worse in hot weather (SOR:A)
   o Heat stroke: (SOR:B)
      Core body temp >104°F (40°C)
      Hot dry skin
      CNS abnormalities:
       • Delirium
       • Convulsions
       • Coma
      Dehydration present in 17% of all heat stroke hospitalizations in U.S. Army
- Dehydration and vomiting may be associated with development of heat stroke (SOR:A)
  - Skeletal muscle cramps (SOR:B)
  - Rhabdomyolysis (SOR:B)
    - Release of skeletal muscle contents
    - Serum creatinine kinase >10 times normal
  - Acute renal failure
  - Exercise associated hyponatremia (SOR:A)
    - Sx occur with rapid plasma Na drop below 130 mmol/L
    - The lower plasma Na drops, the faster it continues to drop
      - Remains low longer
    - Increased risk for:
      - Dilutional encephalopathy
      - Pulmonary edema
  - Sx include:
    - Headache, vomiting, swollen hands and feet, restlessness, undue fatigue, confusion, disorientation, wheezing
  - Sx associated with plasma Na <120 include:
    - Seizure, coma, brainstem herniation, respiratory arrest, death

**Diagnostics**

1. History
   - Symptoms
     - Fatigue, muscle cramps, hypotension
   - Questions to ask
     - Fluid intake pre, during, post exercise
     - Fluid type: water, sports drink
     - Diuretic use
     - Alcohol consumption
     - Duration of exertion
     - Nausea/vomiting
     - Recent diarrhea
     - Recent bleeding/heavy menses

2. Physical exam
   - Assess skin turgor
   - Assess skin for presence of sweat
   - Weight
   - Mucous membranes-hydration assessment
   - Vital signs
   - Mental status

3. Diagnostic testing
   - Hydration biomarkers (urine and body weight)
     - Urine Specific Gravity of =1.020
       - Indicates euhydration
     - Am I Hydrated? Urine Color Chart:
     - Urine osmolality
       - More variability
       - Values < 700 mOsmol/kg indicate euhydration
• Baseline body weight for euhydration
  • First morning, post void, nude, body weight, taken over three consecutive days (SOR:B)
  o Laboratory evaluation
    • Electrolytes
    • Blood sugar
    • Urinalysis
    • BUN/Creatinine

Differential Diagnosis
1. Key DDx
  o Fatigue
  o Deconditioning
  o Anemia
  o Disruption of renin-angiotensin-aldosterone system
    • Kidney disease
    • Congestive Heart Failure
    • Previous MI
    • Medications
      • ACE inhibitors
      • AII receptor blockers
      • Aldosterone receptor blocker
2. Extensive DDx
  o Gastroenteritis
  o Diabetes

Therapeutics
1. Acute treatment:
  o Fluid replacement
  o Hydration before exercise
    • Prehydration with fluids should be initiated several hours before exercise
      • Enables fluid absorption
      • Ensures normal urine output
    • Consume beverages with sodium, salted snacks or small meals with fluids
      • Can help stimulate thirst and retain needed fluid.
    • 500-600 ml of water or sports drink 3 hrs before exercise
    • 200-300 ml of water or sports drink 10-20 mins before exercise
  o Hydration during exercise
    • Drink 0.4-0.8 L/hr
    • Use higher rate for faster, heavier individuals competing in warm environments
      • Football players
    • Use lower rates for slower, lighter persons competing in cooler environments
      • Marathon runners
• If exercise lasts >4 hours:
  • Consumption of electrolytes may reduce the risk of developing hyponatremia
• Prevent excess dehydration
  • >2% loss of body weight from water deficit
• Prevent significant changes in electrolyte balance
  o Hydration after exercise
    • Consumption of normal meals and beverages will restore euhydration if time permits between exertional events (SOR:A)
    • Rapid recovery from excessive dehydration may require 1.5 L of fluid for each kilogram of body weight lost
    • Consuming fluids and snacks with sodium will stimulate thirst and fluid retention
    • IV fluid replacement may be warranted in individuals with severe dehydration (>7% body wt loss) with nausea, vomiting, or diarrhea, or inability to ingest oral fluid

2. Further management (24 hrs)
  o Inadequate hydration—most common
    • Patient education
    o If dehydration was due to other cause—should have further work-up

3. Long-term care
  o Consider customized fluid replacement program
  o Should prevent >2% body weight reduction from baseline during exercise
    • Increased body weight during exercise from drinking may increase risk for hyponatremia

Follow-Up
1. Return to office
  o Return visit
    • 2-4 weeks if treated appropriately and Sx resolved in acute period
  o Earlier follow-up
    • If Sx were significantly recurrent or debilitation was prolonged
    • If associated with co morbid condition (cardiovascular or renal) dz

2. Refer to specialist
  o If associated with previously undiagnosed underlying medical condition
  o If significant dehydration occurred in spite of proper hydration before, during and after exercise

3. Admit to hospital
  o If dehydration is present with significant cardiovascular or renal disease
  o If significant dehydration is present in extremes of age
    • Infants or elderly without the means to hydrate themselves

Prognosis
1. Good if treated appropriately and no underlying medical conditions

Prevention
1. Prehydration
2. Educate patient
  o Performance can decrease with dehydration (SOR:A)
3. Meal consumption is critical to ensure full hydration on a day-to-day basis (SOR:A)
4. Sweat and electrolyte losses should be fully replaced to reestablish euhydration after exercise

**Patient Education**
3. Counsel patient on risk factors and strategies for hydration pre, during and post exercise

**References**
1. University of Nevada Sports Medicine Fluids Replacement Policy. Revised 6/24/08

**Author:** Christopher E. Kincaid, MD, *West Virginia SOM Department of FM*

**Editor:** Carol Scott, MD, *University of Nevada Reno FPRP*