No Sweat: Supporting Performance in Extreme Environments
Gord Sleivert, PhD

Overview
- Hydration and Nutrition in General for Sport
- Heat
- Cold
- Altitude
- Recovery

Water
Average Daily Water Needs in 70kg Athlete

<table>
<thead>
<tr>
<th></th>
<th>Warm weather</th>
<th>Warm weather</th>
</tr>
</thead>
<tbody>
<tr>
<td>No exercise</td>
<td>350 ml</td>
<td>350 ml</td>
</tr>
<tr>
<td>Exercise</td>
<td>650 ml</td>
<td>650 ml</td>
</tr>
<tr>
<td>Skin</td>
<td>1200 ml</td>
<td>500 ml</td>
</tr>
<tr>
<td>Stool</td>
<td>100 ml</td>
<td>100 ml</td>
</tr>
<tr>
<td>Sweat</td>
<td>1400 ml</td>
<td>5000 ml</td>
</tr>
<tr>
<td>Total</td>
<td>3300 ml</td>
<td>6600 ml</td>
</tr>
</tbody>
</table>

Factors that influence sweat loss

- Work Rate
- Skin temperature (environmental T°)
- Deep Body Temperature

LW Male Rowers (n=9)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (ml)</th>
<th>Range (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid Intake</td>
<td>204</td>
<td>0-1000</td>
</tr>
<tr>
<td>Sweat Loss</td>
<td>1091</td>
<td>300-2200</td>
</tr>
<tr>
<td>Deficit</td>
<td>416</td>
<td>0-2100</td>
</tr>
<tr>
<td>% Replacement</td>
<td>21.5</td>
<td>0-100</td>
</tr>
<tr>
<td>Dry Bulb (°C)</td>
<td>8.75</td>
<td>5.75-10.4</td>
</tr>
<tr>
<td>Humidity (%)</td>
<td>77</td>
<td>72.5-90</td>
</tr>
</tbody>
</table>

LW Female Rowers (n=3)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (ml)</th>
<th>Range (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid Intake</td>
<td>263</td>
<td>0-544</td>
</tr>
<tr>
<td>Sweat Loss</td>
<td>715</td>
<td>408-998</td>
</tr>
<tr>
<td>Deficit</td>
<td>415</td>
<td>91-635</td>
</tr>
<tr>
<td>% Replacement</td>
<td>21</td>
<td>0-86</td>
</tr>
<tr>
<td>Dry Bulb (°C)</td>
<td>8.3</td>
<td>5.8-10.4</td>
</tr>
<tr>
<td>Humidity (%)</td>
<td>82</td>
<td>77-90</td>
</tr>
</tbody>
</table>
Dehydration: The Signs

<table>
<thead>
<tr>
<th>% BODY WEIGHT LOSS</th>
<th>SIGNS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2%</td>
<td>↓ TEMP CONTROL</td>
</tr>
<tr>
<td></td>
<td>↑ HEART RATE</td>
</tr>
<tr>
<td>3%</td>
<td>10% ↓ MUSCLE PERFORMANCE</td>
</tr>
<tr>
<td>4-6%</td>
<td>↓ MUSCLE STRENGTH</td>
</tr>
<tr>
<td></td>
<td>↓ HAND-EYE CO-ORDINATION</td>
</tr>
<tr>
<td>+ 6%</td>
<td>↓ BLOOD VOLUME</td>
</tr>
<tr>
<td></td>
<td>↓ RESPIRATION RATE</td>
</tr>
<tr>
<td></td>
<td>NAUSEA &amp; CONFUSION</td>
</tr>
<tr>
<td>+ 10%</td>
<td>HEAT STROKE &amp; FAINTING</td>
</tr>
<tr>
<td></td>
<td>EXHAUSTION</td>
</tr>
</tbody>
</table>

Muscle ~77% water!

Hydration Monitoring

- Body Mass
  - requires precise scale and repeated measures
- Urine Volume & Colour
  - subjective
- Urine Specific Gravity/Osmolality
  - Objective, Valid
- Bioelectric Impedence?

Weight, Urine color, Thirst

A simple self-assessment hydration monitoring tool
Effect of Exercise Intensity on Muscle Fuel Source

Effect of Exercise Duration on Muscle Fuel Source

Amount of Optimal CHO Supplementation During Exercise

Peak CHO oxidation (burning) vs. amount of ingested carbohydrate per minute (g/min)

- Glucose
- Fructose
- Galactose
- Sucrose
- Maltose
- Maltodextrin
- Malt
Salt

Sodium Loss During Exercise

- Lower rates of loss with heat acclimation and training
- Large individual differences, regardless of acclimation status
- Rates of sodium loss increase as sweat rate increases (2500-5000mg/hr at 2.5 L/hr sweat rate).

Consequences of substantive sodium loss

- Heat Cramps?
  - Loss of electrolyte balance in nerves and muscle
- Hyponatremia
  - Serum sodium concentrations <125mmol/L
- Risk factors
  - Back to Back Competitions
  - High sweat Rates
  - Low sodium diets
  - Excessive water consumption

Identify those with high sweat rates and salty sweat (higher risk of sodium deficit).
Athlete Case Study

• 3 hrs
• Sweat Rate~ 2L/hr
• 2000mg Na/L sweat
• Total sodium loss = 2000mg x 2L/hr x 3 hrs
  = 12,000 mg sodium deficit

To replace this sodium with Sports Drink (110 mg/250ml) would require the consumption of 27 L.

The Cutting edge: Sodium (Citrate) Loading Pre-Competition

• Increase Plasma (Blood) Volume
  - Reduce Cardiovascular and Thermal Strain
  - Enhance performance in events lasting greater than 40 minutes
  • Sims et al. (2007), MSSE, 39(1), 123-130.
• Enhanced Buffering Capacity

Maintaining Sodium (Na) Balance

• Ensure adequate sodium content in food
• (1/4 teaspoon [1.5g] of salt (NaCl) = 590mg sodium
• Higher sodium content in pre-event beverage may preserve blood volume and enhance performance
• Sodium Citrate???

<table>
<thead>
<tr>
<th>Food or Beverage Item</th>
<th>Serving Size</th>
<th>Na (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chick. noodle soup</td>
<td>1 cup (250 ml)</td>
<td>1107</td>
</tr>
<tr>
<td>Baked Beans (can)</td>
<td>1 cup (250 ml)</td>
<td>1008</td>
</tr>
<tr>
<td>Dill Pickle (medium)</td>
<td>1 item</td>
<td>928</td>
</tr>
<tr>
<td>Salted pretzles</td>
<td>1 ounce</td>
<td>483</td>
</tr>
<tr>
<td>Tomato Juice</td>
<td>1 cup (250 ml)</td>
<td>882</td>
</tr>
<tr>
<td>Gatorade</td>
<td>1 cup (250 ml)</td>
<td>110</td>
</tr>
<tr>
<td>Water</td>
<td>1 cup (250 ml)</td>
<td>7</td>
</tr>
</tbody>
</table>
Heat Strain Reduces High Intensity Endurance Exercise

Environmental Temperature (°C)

Time to Exhaustion (min)


Work Against Gravity
Solar Radiation
Convective Heat Transfer
Evaporation From Airways
Evaporation From Skin
Metabolic Heat Production

Solar Radiation
Convective Heat Transfer
Evaporation From Airways
Evaporation From Skin
Metabolic Heat Production

Solar Radiation
Convective Heat Transfer
Evaporation From Airways
Evaporation From Skin
Metabolic Heat Production
**Exercise Intensity & Climate Effects on Core Temperature**

- **Core Temperature (°C)** vs **WBGT (°C)**
- **Compensable Heat Stress**
- **Uncompensable Heat Stress**
- **Prescriptive Zone**

- **Individual Differences**

- **Predicted Sweat Rates for slow and moderate running paces at different temperatures**

<table>
<thead>
<tr>
<th>Body Weight (kg)</th>
<th>Climate</th>
<th>8.5 km/hr</th>
<th>15 km/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>18 deg C</td>
<td>0.43</td>
<td>0.86</td>
</tr>
<tr>
<td>70</td>
<td>18 deg C</td>
<td>0.52</td>
<td>0.96</td>
</tr>
<tr>
<td>90</td>
<td>28 deg C</td>
<td>0.73</td>
<td>1.36</td>
</tr>
<tr>
<td></td>
<td>18 deg C</td>
<td>0.86</td>
<td>1.64</td>
</tr>
<tr>
<td></td>
<td>28 deg C</td>
<td>0.97</td>
<td>1.76</td>
</tr>
</tbody>
</table>

*ACSM Position Stand, Exercise & Sport Science, 2000*
Peripheral Influences on Sweat Rate

- Increased Sensitivity
- Training, Increasing Air Velocity
- Reduced Sensitivity
- Hypohydration, Wet Skin

Factors that may modify sweat rate

- Acute
  - Exercise Intensity and Duration
  - Environmental Conditions (temperature and humidity)
  - Clothing (insulation and permeability)

- Chronic
  - Aerobic Training
  - Heat Adaptation

Hydration Status of Canadian Swimmers upon arrival in Melbourne at the Commonwealth Games, 2006

- Severe
- Moderate
- Mild
- Euthydrated

Urine Specific Gravity

<table>
<thead>
<tr>
<th>1</th>
<th>3</th>
<th>5</th>
<th>7</th>
<th>9</th>
<th>11</th>
<th>13</th>
<th>15</th>
<th>17</th>
<th>19</th>
<th>21</th>
<th>23</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.980</td>
<td>0.990</td>
<td>1.000</td>
<td>1.010</td>
<td>1.020</td>
<td>1.030</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Hypohydration, Wet Skin
**Hydration Strategies: During Exercise**

- Match fluid intake with sweat loss as closely as possible (use accurate scale).
- Practice drinking during training and aim to replace about 80% of sweat loss.
- General guide: ingest 200-250 ml carbohydrate drink (6-8%) every 15 minutes 60 – 80 ml every 5 min if possible (up to~60g carb/hr) – set timer/mark lines on water bottle/specific # mouthfuls.
- Fluid should contain 400 – 1100 mg sodium/L (1/4 teaspoon salt has 590mg sodium).
  - Gatorade = 110mg/250ml
  - Powerade = 55mg/250 ml
- Cool, tasty fluids
- Maximum Gastric Emptying Rate ~ 1-1.2 L/hr
**Slushy Recipe**

- YOU WILL NEED:
  - BLENDER, ICE, WATER, GATORADE
  - THERMAL WATER BOTTLE
  - 600 ML ICE
  - 300+ ML WATER
  - 2 SCOOPS GATORADE
  - ADD ICE, WATER & GATORADE TO BLENDER
  - BLEND UNTIL SLUSHY CONSISTENCY – MAY NEED TO ADD MORE WATER
  - USE SCOOP TO TRANSFER FROM BLENDER TO THERMAL BOTTLE
  - ENJOY & STAY COOL

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**Go to Sweat Rate Calculator**

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**Carbs in the heat**

- Ingestion of CHO during events assists the liver in maintaining blood glucose.
- CHO supplementation has been shown to enhance performance in exercise lasting longer than 60 min.
- Can delay fatigue during stop & go events - central effect?
- CHO content of 6-8% appears to be optimal in drink. Higher than that reduces stomach emptying
- Maximal rate of ingested CHO use is ~1 g/min
Triathlon Hydration Plan

Name: Date: 4/3/2004

Scenario (Hot): 28°C Air Temperature

<table>
<thead>
<tr>
<th>Time</th>
<th>Food</th>
<th>Fluid</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Race</td>
<td>3:00–2:00 hr</td>
<td>Coffee</td>
<td>Instant Oatmeal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>Banana</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CHO/Water</td>
<td>750 ml</td>
</tr>
</tbody>
</table>
|         | 2–1 hr         | CHO drink   | + 2 eload capsules /bottle
|         |                |             | ½ power bar if early bkfst or hungry |
|         | 1 hr           | H2O + ½ Powergel | 20g                     |
| Race    | Swim           | H2O Only    | 100 ml                 |
|         | Bike           | H2O Only    | 100 ml                 |
|         | 2 × 650 ml (Polar bottles) | CHO + 170mg sodium | 40g                 |
|         |                | H2O + ½ Powergel | 14g                      |
|         |                |             | Try to evenly space hydration but a little more fluid first half |
|         | Run            | H2O Only    | 100 ml                 |
|         | Aid 1          | H2O Only    | 100 ml                 |
|         | Aid 2          | Powergel at 3k pre-aid | 250 ml                |
|         | Aid 3          | H2O Only    | 100 ml                 |
|         | Aid 4          | H2O Only    | 100 ml                 |
| Post-Race| O – 3 hrs      | Replace 150% of fluid loss | Water and Carbs (try sugar or sports drink if hungry)
|         |                | and Carbs (extra salt eg. ¼ teaspoon to Gatorade, salt food) | Weigh yourself! AM and Post-race ASAP |

Kids and Hydration

- Knowledgeable
- Irresponsible
- Need pro-active approach

Other environments

- Cold
- Altitude
Ray Zahab

<table>
<thead>
<tr>
<th>Activity</th>
<th>ZANAB: RAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre Wt</td>
<td>Post Wt</td>
</tr>
<tr>
<td>(kg)</td>
<td>(kg)</td>
</tr>
<tr>
<td>HEAT STRESS</td>
<td>Apr 17/06</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>COLD STRESS</td>
<td>Apr 17/06</td>
</tr>
</tbody>
</table>

Sweat Analysis:
- Heat Stress: sodium loss = 79.5 mmol/L
- Cold Stress: sodium loss = 50 mmol/L

Based on time-specific analysis.
Cold Factors and Hydration

- Lower Temperatures and Sweat Rate
- Vasoconstriction and increased urinary losses
- Enhanced Carbohydrate loss (shivering)
- Influence of Clothing
Key Points

- Altitudes above 1200m present sufficient hypoxia to:
  - ↓VO₂ max by 1% for each 100m
  - ↓ anaerobic lactic capacity due to loss of HCO₃⁻ (for at least 7 – 10 days)
  - Stimulate dehydration due to inhibition of Anti Diuretic Hormone
Body Composition

- Weight Loss and Muscle Atrophy (100-200g/day)
  - via: Increased Ventilation
  - Inadequate fluid
  - Decreased energy intake (appetite)
  - Increased energy expenditure
  - Decreased gut absorption & increased fecal loss
  - Increased catabolic hormones
  - Lack of Resistance Training

EPO Response?

Friedmann et al. (2005)
Responders vs. Non-Responders

- Potential reasons:
  - Iron deficiencies
  - Genetics - EPO response and sensitivity (?)
  - Hypoxic ventilatory response (?)
  - Fitness level (?)
  - Previous exposures (?)

Iron is a building block

- Iron status is critical because iron utilization increases 10x at altitude
- Must supplement & measure routinely during exposure
- Physician/Dietician Directed
Optimization of Recovery

- Hydrotherapy
- Nutrition
- Massage
- Active Recovery

Working Hard at Recovery

- Metabolic Clearance
- Re-fuelling
- Hydration
- Hydrotherapy
- Sleep & Rest

Performance Level

Fatigue

Poor Nutrition
Inadequate Rest
Other Stressors

Time to Eat

- Recovery nutrition essentials:
  - Re-hydrate, Refuel, Rest

  Consider:
  - Duration/Type of activity
  - Time available for recovery: 4 hours? 24 hours?
Rehydration

- Weigh self post event = aim to regain lost weight
- Consume 150% of fluid losses – sip for decreased diuresis
- Sodium – higher sodium content necessary if shorter recovery time
  - ** 3300mg/L sodium beverage only fluid that produced euhydration at 6 hours post exercise
  - unpalatable!
- Greatest fluid intake with sodium/carb beverage
- Carbs facilitate faster fluid absorption from gut in short term

Refuel

- Replenish both carbohydrate and protein
- Adequate calories/eat to a plan
- Plan for and have a portable nutrition source close at hand

Recovery Bar
**Turf and Essentials**
- Tables/Chairs
- Treatment area
- Recovery Bar
- Cold Tub
- Blood Analysis
- Video Feedback
- Secure Storage
- Sanctuary
- Fly the Colours

**Recovery Carbohydrate**
- **Timing**
  - First minutes/hours are important

- **Type**
  - Easily digested and absorbed CHO low in fat, fiber
  - Liquids usually better tolerated until body cools down
  - Moderate to High Glycemic Index in short term
  - Low GI over long term

- **Amount**
  - If possible approximately 0.5g of carbohydrate/kg at 30 minute intervals (Van Loon 2000) for approx. 5 - 6 hrs or
  - 50 - 100g within 15-20 minutes and then 50 + g every 2 hours until next big meal (or ~1 - 1.2g CHO/kg/hr)

**Examples of Glycemic Index**

<table>
<thead>
<tr>
<th>High: Post Exercise</th>
<th>Low: Pre Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose, Honey</td>
<td>White and Wholemeal Pasta</td>
</tr>
<tr>
<td>Sports Drink, Jelly Beans</td>
<td>Baked Beans</td>
</tr>
<tr>
<td>Bananas, Watermelon</td>
<td>Porridge, All Bran</td>
</tr>
<tr>
<td>Cornflakes, Coco Pops</td>
<td>Apples, Oranges, Grapes, Peaches</td>
</tr>
<tr>
<td>Rice Krispies</td>
<td>Flavoured Yogurt</td>
</tr>
<tr>
<td>Potatoes</td>
<td>Chocolate</td>
</tr>
<tr>
<td>Wholemeal and White Bread</td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>Carbohydrate grams/30 min.</td>
</tr>
<tr>
<td>------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>45 – 50</td>
<td>3 cups sport beverage, 1 cup fruit juice, 1 250 ml carton chocolate milk, ½ package Carnation Instant Breakfast (CIB) in 1 cup milk – check labels of other meal replacements, small cupped handful of raisins</td>
</tr>
<tr>
<td>40 – 45</td>
<td>2 cups sport beverage, 1 – 1.5 cups fruit juice, 1 SunRipe Fruit and Veggie Bar, 1 Organic Food Bar – check labels of other bars</td>
</tr>
<tr>
<td>35 – 39</td>
<td>2.5 cups sport beverage, 1 Organic Food Bar, 1 Optimum Energy Bar, 1 Rebar, 1 slice whole wheat bread with 1 Tbsp honey or jam</td>
</tr>
<tr>
<td>30 – 35</td>
<td>3 cups sport beverage, 1 cup Vector with 1 cup skim milk – can blend before, 1 Power Bar, 1 Cliff Bar - check labels of other bars, 1 full package CIB in 1 cup milk</td>
</tr>
<tr>
<td>25 – 29</td>
<td>2 cups sport beverage, 1 – 1.5 cups fruit juice, 1 SunRipe Fruit and Veggie Bar, 1 Organic Food Bar – check labels of other bars</td>
</tr>
<tr>
<td>20 – 24</td>
<td>3 cups sport beverage, 1 – 500ml carton of chocolate milk, scant ½ cup raisins, 1 high carbohydrate sport bar (check labels for 30+ grams) + 1 cup juice</td>
</tr>
</tbody>
</table>

**Nutrition & Protein Synthesis**

- Carbohydrate may stimulate Insulin and enhance uptake of amino acids
- Amino acids can stimulate protein synthesis
- What kind of fuels? **Milk Protein**
- Timing? **Immediate Post Exercise**
- How much? **10-15g enough with 35-50g Carbs**
  - 9g protein, 30g CHO in 250 ml of Chocolate 1% Milk

**Easy Protein Sources**

- **Milk** 8g/250 ml
- **Yogurt** – 9 - 11g/250 ml
- **Meal Replacements** - Carnation Instant Breakfast - liquid or powder, Vega, Boost...8+g/serving – check labels
- **Sport bars** - check labels – 4 – 30+
- **Protein powders** – 10 – 15 grams/Tbsp
Alcohol increases urination, dehydration

Although they restricted themselves to one drink at lunch time, Howard and Tom still found they were not at their most productive in the afternoon.