Athletic Performance Optimization in Hot Environments

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Tokyo Braces for the Hottest Olympics Ever

In 1964, the Tokyo Olympics were held in October. There was a reason for that. It was hot then. It's hotter now.

Idaho Statesman

When will it end? Idaho heat wave to produce many more 100-degree days in Boise

The New York Times

Climate Change Is Making It Harder for Campers to Beat the Heat

Burn bans, flashflood campfires, extreme heat and stronger rainstorms: Today's campers are experiencing their summer fun against the backdrop of climate change.
Athletic Performance in hot environments

• What is a hot environment?
• How does it affect performance?
• Physiological adaptations
  - Improved performance in hot conditions
• Close the Research to Practice Gap
  Evidence based Practice to help you at home
But first….
Extreme Environment as a Physical Stressor

Acclimation is a product of: Impulse = Intensity x Duration

- Basic formula for training
What is a hot/ extreme environment?

Combination of conditions that present an added heat stress on the body. Extreme heat stress can overwhelm the body’s coping mechanisms and lead to a variety of serious conditions.

- “Real Feel” of 91F (extreme caution) >30C + 60% humidity
- Air temperature
- Humidity
- Solar radiation (sunny or cloudy), air movement
Hot Environment as a continuum

![NWS Heat Index chart]

- **NWS Heat Index**
- **Temperature (°F)**
  - 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104, 106, 108, 110
  - **Relative Humidity (%)**
    - 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95

**Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity**
- **Caution**
- **Extreme Caution**
- **Danger**
- **Extreme Danger**

**Types of Heat Disorders**
- Heat Stroke
- Heat Exhaustion
- Heat Cramps
- Sunstroke

**Prevention Tips**
- Stay hydrated
- Wear appropriate clothing
- Avoid strenuous activity during the hottest parts of the day
- Check weather forecasts and alerts

**Important Note:**
- The chart provides estimates based on the intersection of temperature and relative humidity, indicating the potential for heat disorders.
- Always be cautious when working or exercising in hot environments.

**Source:** National Oceanic and Atmospheric Administration (NOAA)
Negative impact of heat on performance

Degradation of performance is rooted in core temperature

- Dissipation of heat is paramount to maintaining performance in hot weather.
- Humans are only 20% efficient, meaning 80% of energy we use is lost as heat.

When core temp begins to rise…

- Central Nervous System
  - Multiple changes that occur in an overheated brain.
  - Alter brain function- “safety brake” + slow reactions+ poor decision

- Cardiovascular function
  - Increases blood demands everywhere
    - Skin, Muscles compete heavily for blood.
      - When plasma volume drops, compromises are made
Negative impact of heat

Muscle function - Fatigue more quickly

- Increase in Glycogen breakdown + accumulation of metabolites
- Hyperthermia from environment will reduce time to exhaustion
- Hyperthermia from environment reduces muscular force generation, PNS
  - Different from “warm up” - heat from exercise improves muscle function

Performance when dehydrated

- 2-4% loss of body mass to dehydration
  - 6-16% loss of Vo2 max, or more
91-100F Performance Decline:
- 20min power shows >10% drop
- All time best efforts.
- Gap only widens throughout a session
Heat-Related Illness

Heat Exhaustion

**WHAT TO LOOK FOR**
- Heavy sweating
- Cold, pale, and clammy skin
- Fast, weak pulse
- Nausea or vomiting
- Muscle cramps
- Tiredness or weakness
- Dizziness
- Headache
- Fainting (passing out)

**WHAT TO DO**
- Move to a cool place
- Loosen your clothes
- Put cool, wet cloths on your body or take a cool bath
- Sip water

**Get medical help right away if:**
- You are throwing up
- Your symptoms get worse
- Your symptoms last longer than 1 hour
Heat-Related Illnesses

Heat Stroke

**WHAT TO LOOK FOR**
- High body temperature (103°F or higher)
- Hot, red, dry, or damp skin
- Fast, strong pulse
- Headache
- Dizziness
- Nausea
- Confusion
- Losing consciousness (passing out)

**WHAT TO DO**
- Call 911 right away—heat stroke is a medical emergency
- Move the person to a cooler place
- Help lower the person’s temperature with cool cloths or a cool bath
- Do not give the person anything to drink
Benefits of Adaptation

Very possible and effective.

However…

All adaptations to the heat are predicated by an increased ability for your body to more effectively thermoregulate. This is primarily accomplished through increased sweating. HYDRATE!
Benefits of Adaptation

All adaptations to the heat are predicated by an increased ability for your body to more effectively thermoregulate. This is primarily accomplished through increased sweating. HYDRATE!
Benefits of Adaptation

• Body is able to more effectively regulate core temperature through sweating and evaporative cooling. Dry and breezy conditions are ideal for this mechanism.
• Core Temperature at rest and during exercise: DECREASED
• Sweating: trigger, rate, sensitivity: IMPROVED (1L/hr → +2L/hr)
• Skin Temp: REDUCED
• Skin blood flow: INCREASED
• Fluid Balance: thirst: IMPROVED. Electrolyte loss: REDUCED. Plasma volume: INCREASED
• Cardiac: Output, HR, SV, efficiency: IMPROVED
• Whole body metabolism: LOWERED
Benefits of Adaptation

• Muscle Glycogen: SPARED
• Lactate Threshold (FTP): INCREASED
• Force Production: INCREASED
• Vo2 Max: INCREASED (4.6%)

• In essence, Heat Adaptation is very powerful ergogenic aid… Power Up.
All of these methods have the same goal: Increase core temp moderately to stimulate thermo-regulation (sweat) without causing heat illness.
Evidence Based Practice- Heat Adaptation

• The training process needed to render an athlete fully heat acclimated takes time.  
- It is a 14 day or more process.  
- Despite the advantages ONLY ~15% of athletes will become heat adapted
• As we saw before there are a number of ways to execute. They all work and they all have the same fundamental goal.  
- Increase core temperature, stimulate sweating, stop prior to heat illness
• Basic Formula:

  Heat Adaptation = (Intensity of Heat + Exercise Intensity) x Duration x number of exposures (can me more than one per day). Exposures should not be uninterrupted
  Lower heat = longer duration.
Evidence Based Practice- Heat Adaptation

General common practices:

- Once or twice daily exposure
- 40-100 minutes each. 7-14 days
- Exercise Intensity: FTP or lower, no HIIT
- Real Feel: 91F or more (using relative humidity)

Post Exercise Hot Water Immersion

Post training, 40min @ 40C, 104F hot water immersion. 6 days.
Evidence Based Practice- Heat Adaptation

General common practices:

- Using the altitude training analogy:

  - Minimize exposure to air conditioning and maximize time spent in a warm/ hot ambient environment. This approach typically requires >4 hours per day for 1-2 weeks.
Evidence Based Practice- Heat Adaptation

Only ~15% of athletes will execute a proper heat adaptation protocol

JD Periard, S. Racinais, MN Sawka 2015
Evidence Based Practice- Heat Adaptation

Adaptations and mechanisms of heat acclimation

PROGRESSIVE
Not much until Day 3.
Day 6: Plasma Volume
Day 11: Sweat Rate
Takes TWO WEEKS

JD Periard, S. Racinais, MN Sawka 2015
Adapting to the heat
How long are benefits maintained?

- 2.5% loss of heat adaptation per day of non-heat exposure

Daanen 2018
Evidence Based Practice- Heat Adaptation

Strategy vs tactic

- Ultimate goal is to maintain core temperature as close to normal as possible regardless of conditions
- Multiple actions, no one thing will be crucial
- Taken together, the sum of their effect is substantial

- Hydrate!
Evidence Based Practice- Heat Adaptation

Pre-competition (minimizing exposure to heat stress) (Assuming heat adapted)

- Stay in air conditioning
- Take extra care to stay hydrated
  - Begins 2-3 days before competition
- Morning pre-competition rides completed before temperatures become elevated/extreme
Evidence Based Practice - Heat Adaptation

Pre Cooling

• Meta-analysis of 21 studies shows that pre-cooling helps preserve hot weather performance.
• Most studies were cycling. Some running.
• Ingesting cold water, ice slurry, ice packs
• Limited to shorter (<60min) events
Evidence Based Practice- Heat Adaptation

• **During** your event
  – Hydrate, hydrate, hydrate!
    • Sweat rate
    • Drink mix vs water
  – **Cold drinks!**
    • Ice slurry
  – Ice and other auxiliary cooling methods
Evidence Based Practice - Heat Adaptation

During your event

● How much to drink?
  ○ More is more (2x normal feeds)
  ○ 1 cold bottle every 40-60 minutes
    ■ Still does not match sweat rate of up to 2.5L/hr
  ○ Keep in mind gastro-intestinal considerations

● Performance when dehydrated
  ○ 2-4% loss of body mass to dehydration
  ○ 6-16% loss of VO2 max
Evidence Based Practice- Heat Adaptation

24oz

20oz

33oz. 1 Liter
Evidence Based Practice- Heat Adaptation

During your event

● PER HOUR:
  ● 60oz.
  ● 2L
Evidence Based Practice - Heat Adaptation

During your event

- PER HOUR:
  - 48oz.
  - 1.4L
Evidence Based Practice- Heat Adaptation

During your event

- PER HOUR:
  - 68oz.
  - 2.01 L
Evidence Based Practice - Heat Adaptation

During your event
● PER HOUR:
  ● 66oz.
  ● 2.00 L
Evidence Based Practice- Heat Adaptation

1.4 L / 48oz vs 2.0L / 66oz per hr

Deficit:
5 hr = 3L. 101oz. 0.8 gal
8 hr = 4.8L. 162 oz. 1.25 gal
Evidence Based Practice - Heat Adaptation

Cramping?

- Long established to have debunked the link between electrolytes and cramping
- Established that exercise-related muscle cramping originates in the motor neuron and is a result of nerve fatigue and muscle damage from lack of “fitness”
  - Spice - TRP channel agonists: HOT Shot
    - Combo Hydration and relative intensity cold have a role
Evidence Based Practice- Heat Adaptation

Post event

- Emphasis on bringing core temperature to normal ASAP
  - Ice slurry
  - Cool water immersion

Yeargin et al. (2006)
Preserving Performance in hot conditions

Post event Cool Water Immersion
- Return to A/C
- Maintain elevated hydration

Ihsan et al. (2016)
Adapting training to heat

- Competition still requires each of us to reach to that upper echelon of our physical ability.
- Nationwide, ability is relatively consistent and thus, regardless of weather, there is still a demand for a high level of performance.
  - Need for high power efforts has not diminished.
Evidence Based Practice- Heat Adaptation

Adapting training to heat

● Train in the coolest conditions of the day- “Dawn Patrol”
  ○ Moderate heat (80F) can give you the same benefits but allow higher training stress
  ○ Consider indoor training if necessary to get the exposure at the highest intensities

● Maintain exposure to heat and the beneficial adaptations

● NEVER, ever stop with hydration. EVER.
Evidence Based Practice- Heat Adaptation

Hopefully you learned
● How does it affect performance?
● Physiological adaptations
● Behavior modification
● Improve performance in hot conditions
References


References, cont.


References, cont.


Questions?

- For more articles and athlete highlights from Source Endurance: [http://source-e.net](http://source-e.net)
- To schedule a follow up 10 minute consult with a SE coach or sign up for coaching stick around and we’ll redirect you to a page where you can request a consult.