GOING THE DISTANCE: FUELING ENDURANCE PERFORMANCE

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The endurance athlete

Energy

Hydration

Structure

Key takeaways
THE ENDURANCE ATHLETE
All Athletes

- Use and need fuel for energy to train/compete
- Sweat and need hydration
- Use muscles and need strength

Endurance Athlete Specific

- Train and compete for long durations – typically 2+ hours at a time
  - Low-moderate intensity exercise
- Steady state vs. intermittent high intensity exercise
- Sport specific: runners, cyclists, or triathletes
  - Compete in marathons, triathlon, and ultra endurance events
Sport nutrition needs of any athlete can be divided into three categories: Energy, Hydration, Structure.

However, the energy and hydration needs of the endurance athlete are unique and should be addressed as such.
ENERGY
Carbohydrate improves endurance performance

Consuming carbohydrate during exercise results in:

- Maintenance of blood glucose levels
- Maintenance of carbohydrate oxidation
- Sparing of muscle and/or liver glycogen

One of the first studies to show that carbohydrate ingestion benefits endurance exercise

Fatty acids are stored in the adipose tissue

- Everyone, even the leanest athletes have enough stored fats to exercise for a very long time
- The body relies primarily on fats during lower intensity exercise

Carbohydrates are stored in the liver and the muscles

- There is limited storage capacity for carbohydrate
- The body relies primarily on carbohydrates during higher intensity exercise
- Eating carbohydrates helps replenish glycogen stores

AS INTENSITY INCREASES, carbohydrate use for energy increases and fat decreases.
Exercise intensity impacts how quickly muscle glycogen stores are used up

- At lower levels of exercise intensity muscle glycogen utilization is spared
- At high levels of exercise intensity muscle glycogen utilization accelerates
- In general, there is a dose/response relationship between exercise intensity and muscle glycogen use

% refers to exercise intensity

Gollnick et al., J Physiol 1974
SUBSTRATE UTILIZATION & EXERCISE DURATION

Exercise Time (hrs)

% of Energy Expenditure

MUSCLE TRIGLYCERIDES
PLASMA FFA
BLOOD GLUCOSE*
MUSCLE GLYCOGEN

Endurance Athlete Zone

• We can adapt how much carbohydrate is stored in our muscles through diet

• In this study, those with higher carbohydrate diet (red oval) have significantly more muscle glycogen

• Those with higher carbohydrate diets have longer time to exhaustion

CARBOHYDRATE TRANSPORTERS

SGLT1 - GLUCOSE
~60 g/h max

GLUT5 - FRUCTOSE
~30 g/h max

INTESTINAL LUMEN

GLUCOSE

FRUCTOSE

BLOODSTREAM

The body’s ability to use ingested carbohydrate is limited.

- Use about 1 gram of glucose alone per minute.

- With multiple source carbohydrate of glucose and fructose, rate can be increased it to ~1.5 grams per minute.

- No additional benefit above ~1.5 grams per minute combined type – and typically end up with GI discomfort.

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**Exogenous Carbohydrate Oxidation**

- Single source carbohydrate
- Multiple source carbohydrate

Exogenous carbohydrate oxidation rate (g/min) vs. Carbohydrate intake rate (g/min)

Oxidation equals ingestion: 100% oxidation efficiency line.

• Glucose plus fructose empties the gut quicker than glucose alone

• Fluid and carbohydrate get into the blood faster than glucose and almost as fast as water


Performance and carbohydrate blends

Time Trial Performance (Duration)

Glu+Fru: 00:56:07
Glu: 01:00:41
Placebo: 01:07:00

8% improvement compared to Glu+Fru
19% improvement compared to Glu+Fru
## CARBOHYDRATE DURING TRAINING & COMPETITION

<table>
<thead>
<tr>
<th>Duration</th>
<th>CHO (g/hour)</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;30 min</td>
<td>None</td>
<td>-</td>
</tr>
<tr>
<td>45-75 min</td>
<td>Very small amounts</td>
<td>Most carb forms or mouth rinse</td>
</tr>
<tr>
<td>1-2 hours</td>
<td>Up to 30 g/h</td>
<td>Most carb forms</td>
</tr>
<tr>
<td>2-3 hours</td>
<td>Up to 60 g/h</td>
<td>Rapidly oxidized sugars</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Examples: sucrose, glucose, maltodextrin</td>
</tr>
<tr>
<td>&gt; 2.5-3 hours</td>
<td>Up to 90 g/h</td>
<td>Blend glucose + fructose</td>
</tr>
</tbody>
</table>

Example

- 1 hour Swim: Amount of Carbohydrate (grams) = 30
- 2 hour Run: Amount of Carbohydrate (grams) = 90
- 4 hour Ride: Amount of Carbohydrate (grams) = 60
The stomach is an organ that can be trained.

It is important that an athlete gradually increase the amount of fluid and fuel intake during exercise to meet the recommendations.

Consuming more fluid or carbohydrates than an athlete is used to can result in a “sloshy” stomach and other more intense gastrointestinal (GI) discomfort.
Carbohydrate is well known to improve endurance

Endogenous stores are limited and disappear quicker as exercise intensity increases

Chronically, through diet, we can manipulate endogenous stores

Acutely, by feeding carbohydrate before and during, we can also top up our fuel supply and improve performance

One of the limitations to using fed carbohydrate is gut absorption, with single carbohydrate absorption and oxidation limited around 60 g/h

This rate can be increased to 90 g/h with multiple transportable carbohydrates

Such carbohydrates also have benefits on fluid delivery and performance
DEHYDRATION

Impaired ability to remove heat, leading to:
- Increased cardiovascular strain
- Increased glycogen use
- Altered metabolic & CNS function
- Decreased fluid absorption
- Risk of heat illness
• Dehydration can cause performance impairment for endurance athletes
• Typically, the more dehydrated, the greater chance of performance decrements
• 2% body mass loss during exercise is a threshold when performance can be impacted
• Some athletes can tolerate slightly greater losses and some can tolerate less
• Practicing hydration strategies is key to endurance athletes to find out what is tolerable for each athlete
• The next slide shows results from a review paper regarding the amount of studies that show endurance performance decrements at different levels of dehydration
HYDRATION & PERFORMANCE

Percentage of Studies with Impaired Endurance Performance

<table>
<thead>
<tr>
<th>Degree of Dehydration (%)</th>
<th>Percentage of Studies</th>
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</thead>
<tbody>
<tr>
<td>2</td>
<td>14/26</td>
</tr>
<tr>
<td>3</td>
<td>8/13</td>
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<td>4</td>
<td>12/13</td>
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<td>4/5</td>
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<tr>
<td>6</td>
<td>1/1</td>
</tr>
<tr>
<td>7</td>
<td>2/2</td>
</tr>
</tbody>
</table>
• Hyponatremia is a result of a decreased plasma sodium concentration below 135 mmol/L

• The longer it remains low, the greater the risk of dilutional encephalopathy and pulmonary edema

• Contributing factors to exercise-associated hyponatremia:
  • Overdrinking hypotonic fluids
  • Longer duration events
  • Large sweat sodium losses

• It is important for endurance athletes to know their losses and have a hydration strategy

FACTORS INFLUENCING HYDRATION

- Fluid Intake: Water
- Fluid Absorption: Carbohydrate
- Fluid Distribution: Sodium
- Fluid Retention: Sodium

- Training
- Beverage Preferences
- Temperature & Humidity
- Environment & Equipment

• Obtain body mass before training
• Know the mass of the food and fluids consumed during this session
• Know the mass of any urine or stool lost during this session
• Obtain post-exercise body weight after toweling dry
• Know how long the training session lasted – meaning how long from the pre-exercise to post-exercise body mass.

\[
\text{Body Mass}_{\text{PRE-Ex}} - \text{Body Mass}_{\text{POST-EX}} - \text{Fluid Intake}_{\text{EX}} + \text{Urine Loss}_{\text{EX}}
\]

Exercise Duration

Fluid Loss Calculator

https://www.gssiweb.org/toolbox/fluidLoss/calculator
Example of an athlete that conducted a sweat test during training and how to use that information to build a hydration plan for a marathon

- **Sweat test exercise duration:** 90 minutes
- **Sweating rate:** 1.5 L / 1.5 hours = 1 L per hour
- **4 hour marathon = 4 L or 4 kg body mass loss**
  (in similar conditions at similar intensity as sweat test)
- **Drinking volume (sweat loss – 2% window):**
  4-1.4 = 2.6 L
- **Hydration strategy:** 2.6 L/4 h = 650 ml/h OR 220 ml/20 min
Sweat sodium loss by sport

- Endurance athletes lose more sodium than many other sports
- Endurance athletes sweat sodium losses very and can be quite high

Sweating rate by sport

- Endurance athletes lose more fluid than several other sports despite being smaller in stature on average
- Endurance athletes sweating rate is highly variable between and within athletes
During Exercise

- Practice your hydration strategy
- You should expect to lose some weight during exercise due to dehydration – this is normal
- However, you should try to drink enough fluid throughout exercise to maintain body weight change within 2% for hot conditions and 3% for cooler conditions when possible
- Sweat losses vary between and within sports, so you need to know your losses whenever possible throughout a season
- Don’t overdrink
- Include sodium to improve palatability, stimulate drinking, retain fluid
- Focus on sodium intake >2h exercise, when sodium losses are high (>3-4 g)

Daily Intake

- Drink gradually throughout the day
- Avoid drinking too much too quickly
Do you think post-exercise protein intake is important for endurance athletes? Why or why not?
Human body is about 45% protein

All athletes need protein for success

The primary function of proteins in the human body are:

- Structure – example, collagen
- Movement – contractile proteins
- Immune function – Antibodies
- Transport – hemoglobin
- Hormones
- Enzymes – facilitate biochemical reactions
- Cell signaling, or communication pathways in cells
Different types of exercise stimulate the synthesis of different sets of proteins:

**Resistance type** exercise strongly stimulates the synthesis of muscle contractile (myofibrillar) proteins

**Endurance type** exercise has a greater impact on stimulating the synthesis of mitochondrial proteins

This allows for exercise-specific muscle adaptations
Endurance exercise also stimulates increased amino acid oxidation.
Protein replenishment is necessary to restore amino acid building blocks after exercise.

**Post-Exercise:**
- Protein ingestion increases muscle fiber and mitochondrial protein synthesis.
- Aim for ~20 g, or 0.25-0.3 g/kg.

**Daily Intake**
- Needs are elevated above the RDA to support the demands of training and adaptation.
- Consume ~1.2-1.4 g/kg/d protein.

QUANTITY OF PROTEIN

170 LBS
X 1.3 (g/kg)
88g PROTEIN PER DAY

120 LBS
X 1.3 (g/kg)
71g PROTEIN PER DAY

~1.2-1.4 g/kg/d
Protein intake is important for recovery, but does NOT further improve endurance performance based on VO$_2$ max

- 12 week protein supplementation after exercise and prior to sleep did not improve endurance performance when compared to an energy matched carbohydrate placebo
- Chronic endurance training improved performance in both groups by 11%
- There were no differences between groups

The literature on the addition of protein to a sport nutrition beverage containing carbohydrate DURING exercise shows mixed results. Some of the variability in results could be from:

- The type of study: time to exhaustion vs. time trial
- The placebo used
- The caloric differences of the beverage/gel

**EXAMPLE:** When a study looked at CHO+PRO vs. Placebo, CHO, and CHO that was energy matched to the CHO+PRO:

- CHO+PRO and CHO+CHO were longer than PLA
- Placebo and CHO were not different
- CHO+PRO was not different from CHO or CHO calorie match

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The ingestion of protein with carbohydrate during exercise does not acutely improve exercise performance above carbohydrate ingestion alone, when ample carbohydrate is ingested.

Figure 2: Overview of studies investigating the impact of dietary protein ingestion during endurance type exercise on subsequent performance capacity. Performance capacity was assessed either as time to exhaustion (red) or as time trial performance (blue) in the various studies. *: significant improvement in performance reported following protein co-ingestion during exercise.
• Endurance exercise may stimulate increased amino acid oxidation and synthesis specifically of mitochondrial proteins, leading to training adaptations

• Endurance athletes should consume at least 1.2-1.4 g/kg/d of quality protein per day and ~20 g post-training

• Protein intake during endurance training is not warranted
**KEY TAKEAWAYS**

- Endurance athletes fueling and hydration needs are unique and require specific replacement during and after exercise to perform optimally.
- Therefore, endurance athletes need to experiment and adapt.
- Do that by logging:
  - Exercise intensity and duration
  - Nutrition content & timing (start lower and increase)
  - Hydration/sweating rate assessments
  - Environmental conditions
  - Self assessment of performance rating (1-5, +/-)
  - Comments
  - Racing
- Fine tune and practice nutrition and hydration during build up races.
- Include nutrition as part of your race/event report.

**RACING**

Fine tune and practice nutrition and hydration during build up races.

Include nutrition as part of your race/event report.