HYDRATION PRINCIPLES:
INTAKE, ABSORPTION, DISTRIBUTION & RETENTION
OVERVIEW

• Physiological importance of hydration

• Effects of dehydration on performance

• Sweat rate estimation

• Fluid absorption and gastric emptying

• Hydration and rehydration recommendations
Waste excretion, blood volume & pressure regulation, transport of oxygen & nutrients, heat transfer
HYDRATE TO SUPPORT

- Cardiovascular function
- Body temperature regulation
- Performance
Impairs the ability to remove heat

**Leading to:**
- Cardiovascular strain
- Increased glycogen use
- Altered metabolic & CNS function
- Decreased fluid absorption
- Risk of heat illness

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DEHYDRATION

Increases physiological strain

Can impair performance, especially in the heat

SWEATING

Cools the Body

SWEAT RATE
~1-2 L/h
FACTORS INFLUENCING SWEAT RATE

- Temperature
- Environment & Equipment
- Humidity
- Training Status & Intensity
Figure 1: Approximation of hourly sweat rates for runners at different paces and heat stress conditions (Sawka, 1992).
PHASES OF HYDRATION

1. INTAKE
2. ABSORPTION
3. DISTRIBUTION
4. RETENTION
THIRST & FLUID FACTORS

PHYSIOLOGICAL THIRST

CENTRAL NERVOUS SYSTEM

HYPOVOLEMIA

INCREASED Plasma OSMOLALITY

BEVERAGE

PERCEIVED THIRST

OROPHARYNGEAL FACTORS

Temperature

Flavor

Texture

Composition

ORAL METERING (swallowing)

DRY MOUTH

Availability
THIRST, HYDRATION & ADH

(Modified from) Robertson GL. Kidney Int. 1984 Feb;25(2):460-9
**PLANNED VS DRINKING TO THIRST**

**Planned Drinking**
- Longer duration activities > 90 min
- Particularly in the heat
  - High intensity
  - High sweat rates
- When performance is a concern
- When carbohydrate intake of 1 g/min

**Drink to Thirst**
- Short duration activities < 60 to 90 min
- Cooler conditions
  - Lower intensity
Despite having access to cool palatable fluid, athletes typically dehydrate during exercise.
Figure 2: Plot of average running speed of finishing time for 42 km against the magnitude of post-race hypohydration when drinking ad libitum (Cheuvront et al., 2007).
Effects of progressive dehydration

SLOWER SPRINT SPEED AND FEWER SHOTS MADE AS LEVEL OF DEHYDRATION INCREASES

SWEAT RATE ESTIMATION

1 LB WEIGHT LOSS = 16 OZ OF SWEAT LOSS

SWEAT RATE (L/H) = \frac{WEIGHT LOSS + FLUID INTAKE}{DURATION OF EXERCISE (HRS)}

FLUID ABSORPTION
FACTORS IN GASTRIC EMPTYING

- Gastric volume
- Energy content
- Carbohydrate type
- Body position
- Dehydration
- Exercise intensity
- Beverage osmolality
- Beverage pH
IMPORTANCE OF ENERGY DENSITY

6% CARBS

WATER

8% CARBS

If an athlete is training or competing for 60 minutes or longer with a performance goal.

Add 30-60 g/h carbohydrate, resulting in no more than a 6% solution (6% = 14 g/8 oz).

Choose quickly oxidized carbohydrates to provide energy and minimize GI upset.
INTESTINAL WATER ABSORPTION

**SGLT1** GLUCOSE

GLUCOSE

**GLUT5** FRUCTOSE

FRUCTOSE

INTESTINAL LUMEN

BLOODSTREAM

INTESTINAL WATER ABSORPTION

SGLT1

2 Na⁺
2 Na⁺

GLUCOSE
GLUCOSE

H₂O

GLUT 5
FRUCTOSE

DRTS
SUCROSE

FRUCTOSE
GLUCOSE
FRUCTOSE

PLASMA

Importance of drinking pattern
FLUID DISTRIBUTION & RETENTION
INTRACELLULAR FLUID

EXTRACELLULAR FLUID

Potassium

Sodium
CONSUMING SODIUM PROVIDES:

- Better maintenance of blood sodium concentration
- Better maintenance of plasma volume
SODIUM & FLUID RETENTION

BEVERAGE WITH SODIUM
- Blood Osmolality
- Blood Sodium
- Reabsorption

WATER
- Blood Osmolality
- Blood Sodium
- Reabsorption

FLUID VOLUME & REHYDRATION

- Replace up to 150% of fluid loss
- 20-24 oz / lb body weight
- Sodium critical for complete rehydration
REHYDRATION RECOMMENDATIONS

**DURING**

~16 oz/lb lost

**AFTER**

~20-24 oz/lb lost
REHYDRATION IS IMPORTANT…

- During two-a-day practices
- Throughout day-long competitions
- Tournament play
- After weigh-ins

REHYDRATION BEVERAGES

<table>
<thead>
<tr>
<th>Phase of Rehydration</th>
<th>Beverage Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid Intake</td>
<td>Water</td>
</tr>
<tr>
<td>Fluid Absorption</td>
<td>Carbohydrate</td>
</tr>
<tr>
<td>Fluid Distribution</td>
<td>Sodium</td>
</tr>
<tr>
<td>Fluid Retention</td>
<td>Sodium</td>
</tr>
</tbody>
</table>
HYDRATION RECOMMENDATIONS

Before: Drink ~5-7 mL/kg of fluids with sodium ~4 h prior and another 3-5 mL/kg ~2 h prior if athlete cannot urinate or the urine is dark

During: Amount of fluid based on sweat rate

After: 20-24 oz/lb lost
Exercise Associated Muscle Cramps

The cause and treatment of exercise-associated muscle cramps (different from whole-body cramping) is not well understood.

Some cramps may be associated with disturbances of water and salt balance, but not all.

When water and salt losses are high, drinks containing electrolytes, especially sodium, should be used rather than plain water.

Table 4: Theoretical framework for football athletes having appropriate and inappropriate hydration practices during intense exercise in the heat and associated outcomes on performance and safety.
KEY TAKEAWAYS

✓ Sweating cools the body, but dehydration impairs the ability to lose heat.

✓ Athletes should aim for no greater than 2% body weight loss during exercise.

✓ For exercise where performance is a goal, and in hot, humid environments, athletes should have a drinking plan based on their unique sweat profile.

✓ A small amount of carbohydrate (6%) does not delay gastric emptying of fluid and provides energy.

✓ Sodium helps retain fluid with proper distribution.