

AI-03473 Endurance Physiology

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Explain the science of hydration on endurance event. Explain the physiology. How is it related to hydrolysis, nutrition, oxygen transport and metabolism.

Here you go, Pilot — a **clear, scientific, and physiologically accurate explanation** of hydration in endurance events and how it ties into **hydrolysis, nutrition, oxygen transport, and metabolism.**

I'll keep it rigorous but easy to visualize, the way you like to mentally model systems.

THE SCIENCE OF HYDRATION IN ENDURANCE EVENTS

Endurance performance is essentially a **battle between fluid loss and your body's ability to maintain homeostasis.** Hydration isn't just about drinking water — it's a coordinated system involving:

- Cellular chemistry
- Electrolytes
- Energy production
- Cardiovascular efficiency
- Thermoregulation
- Substrate metabolism

Let's break it down from **molecules** → **cells** → **organs** → **performance.**

1 HYDRATION & HUMAN PHYSIOLOGY DURING ENDURANCE

A. Thermoregulation (Cooling the Engine)

During running, cycling, or any endurance sport, your body must dump heat generated by working muscles.

How hydration matters:

- Sweat evaporates → removes heat.
- Sweat comes from **blood plasma** → reduces blood volume.
- Reduced blood volume = harder to transport oxygen + harder for the heart to maintain stroke volume.

What happens if dehydrated:

- Heart rate climbs (cardiac drift).
- Core temperature increases.
- Perceived effort skyrockets.
- VO_2 max drops 2–5% per 1% bodyweight loss.

Performance impact:

Even a **2% dehydration** can reduce endurance capacity by **10–20%**.

2 HYDRATION & HYDROLYSIS (CELLULAR CHEMISTRY)

Hydrolysis = water-driven chemical reactions.

Think of hydrolysis as the **chemical “unlocking mechanism”** of fuel.

 **ATP hydrolysis**

Energy release during muscle contraction requires the reaction:



Without water, ATP **can't be broken down** efficiently → less muscular contraction power.

Glycogen breakdown (glycogenolysis) also uses water

Your stored carbohydrate (glycogen) is released using water molecules in each step.

Fat metabolism (lipolysis) also uses hydrolysis

Breaking triglycerides → fatty acids + glycerol requires water-driven enzymatic reactions.

Conclusion:

Water isn't just coolant.

Water is literally **reactant fuel** enabling ATP generation at the cellular level.

3 HYDRATION & NUTRITION (ABSORPTION & UTILIZATION)

Your gut needs fluid and electrolytes to absorb nutrients efficiently.

A. Sodium & glucose co-transport

The small intestine absorbs glucose using the **SGLT1 transporter**, which requires sodium AND water.

This is why:

- Water alone fails in long endurance events.
- Electrolyte + carbohydrate drinks (6–8% carb) are ideal.
- Sodium prevents hyponatremia and improves fluid retention.

B. Muscle glycogen storage needs water

For every **1 gram of glycogen**, your body stores **2.7–3 grams of water**.

Good hydration = more glycogen available for performance.

C. Dehydration slows gastric emptying

- stomach cramps
- GI distress
- reduced carb intake
- bonking (sudden energy crash)

4 HYDRATION & OXYGEN TRANSPORT (CARDIOVASCULAR PHYSIOLOGY)

Plasma volume is critical for oxygen delivery to muscles.

When dehydrated:

- **Blood becomes more viscous**
- Stroke volume drops
- Heart rate rises to compensate
- Less oxygen reaches working muscles
- Lactate accumulates faster

This is why dehydration feels like your heart is “working double.”

The cycle looks like:

Dehydration → ↓ Plasma volume → ↓ Stroke volume → ↑ Heart rate → ↓ $\dot{V}O_2$ max → Early fatigue

Hydration = efficient oxygen circulation.

5 HYDRATION & METABOLISM (FUEL BURNING RATES)

Hydration influences:

A. Carbohydrate metabolism

Dehydration causes the body to shift to **glycogen-heavy metabolism**, burning carbs faster → shorter endurance window.

B. Fat metabolism

Fat breakdown requires:

- Water (for hydrolysis of triglycerides)
- Oxygen (fat burning is oxidative)

Dehydrated → heart struggles → oxygen delivery drops → fat burning drops → dependence on carbs increases.

C. Thermogenic inefficiency

The more dehydrated you are, the more energy goes into cooling — not forward motion.

6 THE INTEGRATED PICTURE (SYSTEMS VIEW YOU WILL LIKE)

Here's how everything ties together during an endurance event:

Sweat Loss

↓
↓ Blood volume → ↓ Oxygen transport → ↑ Heart work
↓
↓ Hydrolysis efficiency → ↓ ATP production
↓
↓ Nutrient absorption (carb + sodium)
↓

↓ Fat metabolism and faster glycogen depletion
↓
↑ Core temperature
↓
Performance collapse

Hydration is not about “avoiding thirst.”

It is literally about **preserving the body’s entire metabolic and cardiovascular system.**

Rigel, your cycling intuition is correct

Your 53.1-mile Cebu ride is a perfect real-world example:

- Humidity increases sweat rate
- Sweat evaporation is poor
- Blood pressure and heart rate rise
- You lose electrolytes
- Carb burning accelerates
- Perceived effort spikes

Your body was balancing **cooling vs. oxygen vs. ATP generation** in real time.

Want a continuation?

I can also give you:

- ✓ A hydration strategy for **cycling** (before–during–after)
- ✓ A physiology diagram linking all concepts
- ✓ A 1-page Notion summary
- ✓ A comparison of water vs. electrolyte drinks vs. gels
- ✓ How deep breathing & HIIT affect hydration and oxygen delivery

Just tell me what direction you want to go next.