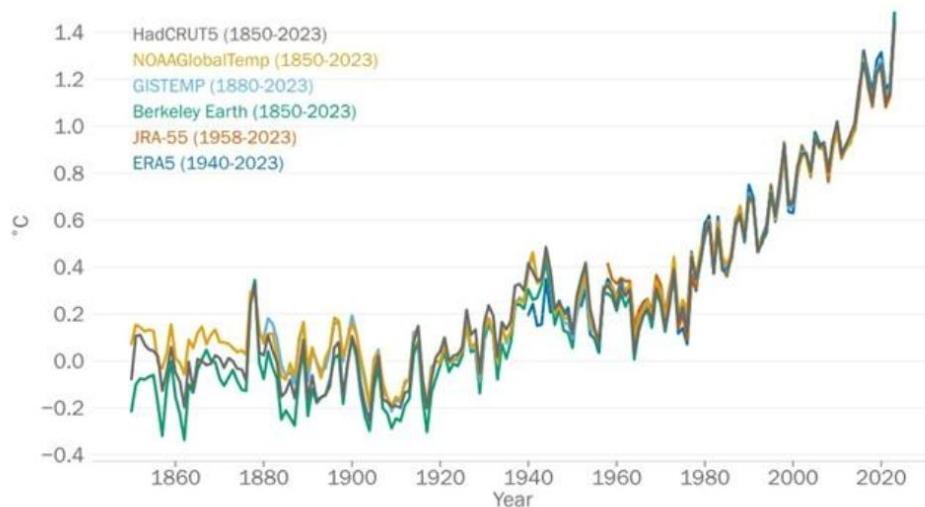


Heat adaptation strategy

Global Warming: A Growing Challenge in Sports



Global Mean Temperature Difference (°C)
Compared to 1850-1900 average



Source: WMO (2024)

2023 was the warmest year in the 174-year observational record.

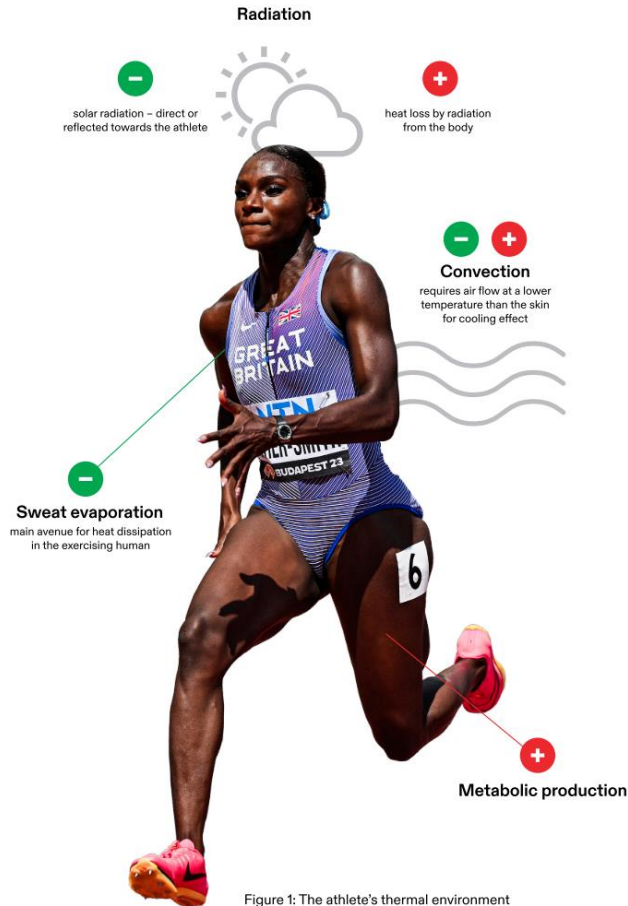
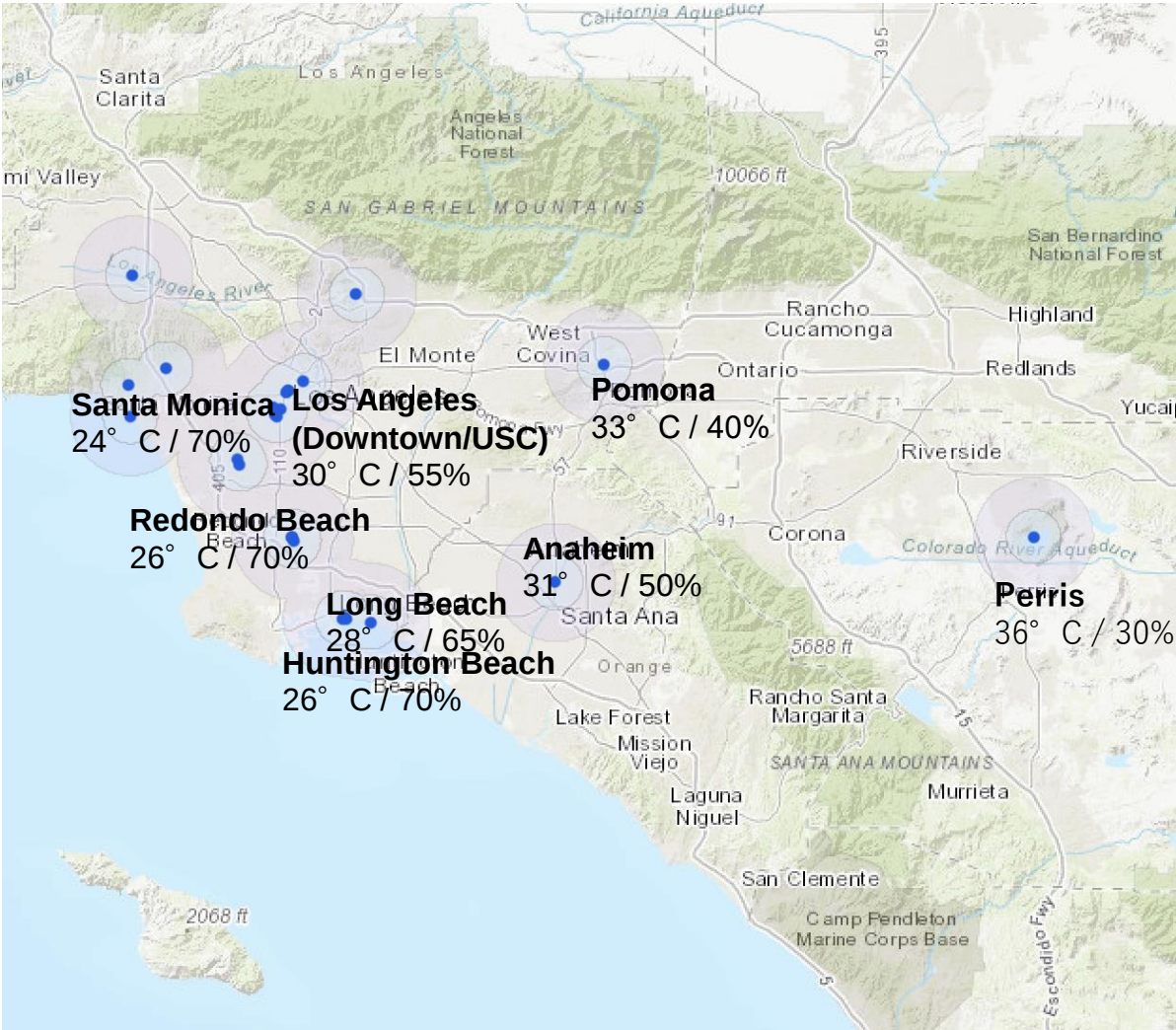


Figure 1: The athlete's thermal environment

(Beat the heat during
Paris 2024)

Heat stress is a critical issue in international sports competitions, **including the Olympic Games.**

Environment at LA 2028 venue



	Olympic Games (14–30 July)		Paralympic Games (22 Aug–3 Sep)	
	Coastal station	Inland station	Coastal station	Inland station
Temperature data (2019–2023)				
Daily average (°C)	20.0 ± 1.4 (17.1–23.8)	27.3 ± 2.5 (19.9–32.2)	21.5 ± 1.9 (18.1–26.4)	27.5 ± 3.3 (19.6–36.1)
Daily maximum (°C)	23.3 ± 1.8 (20.0–28.9)	32.0 ± 2.6 (26.1–37.8)	25.1 ± 2.8 (20.6–32.8)	32.1 ± 3.5 (22.8–40.0)
Days > 30 °C (%)	0	82	8	71
Days > 35 °C (%)	0	16	0	23
Relative humidity data (2019–2023)				
Daily average (%)	79.1 ± 4.2 (64.9–86.6)	49.3 ± 8.0 (29.7–64.8)	76.0 ± 6.0 (30.2–88.1)	50.3 ± 10.5 (26.9–83.1)
Daily maximum (%)	90.7 ± 4.4 (79.0–100)	76.6 ± 6.6 (57.0–88.0)	88.8 ± 5.5 (76.0–100)	77.5 ± 10.6 (48.0–100)

NB. Data are mean ± standard deviation (minimum–maximum) of available daily data from the same dates as for the 2028 Los Angeles Games.

(Bongers et al. 2025)

Inland venues tend to be hotter than coastal venues.

Provisional values based on climate normals patterns; replace with exact NOAA/NCEI 1991–2020 station normals if needed.

(Arranged LA Olympics 2028 Venue Map)

Heat Illness Prevention Guidelines for Sports (WBGT – Japan)

WBGT ; considers temperature, humidity, radiation heat

$$*37^{\circ}\text{C } 25\% = 28^{\circ}\text{C } 75\%$$

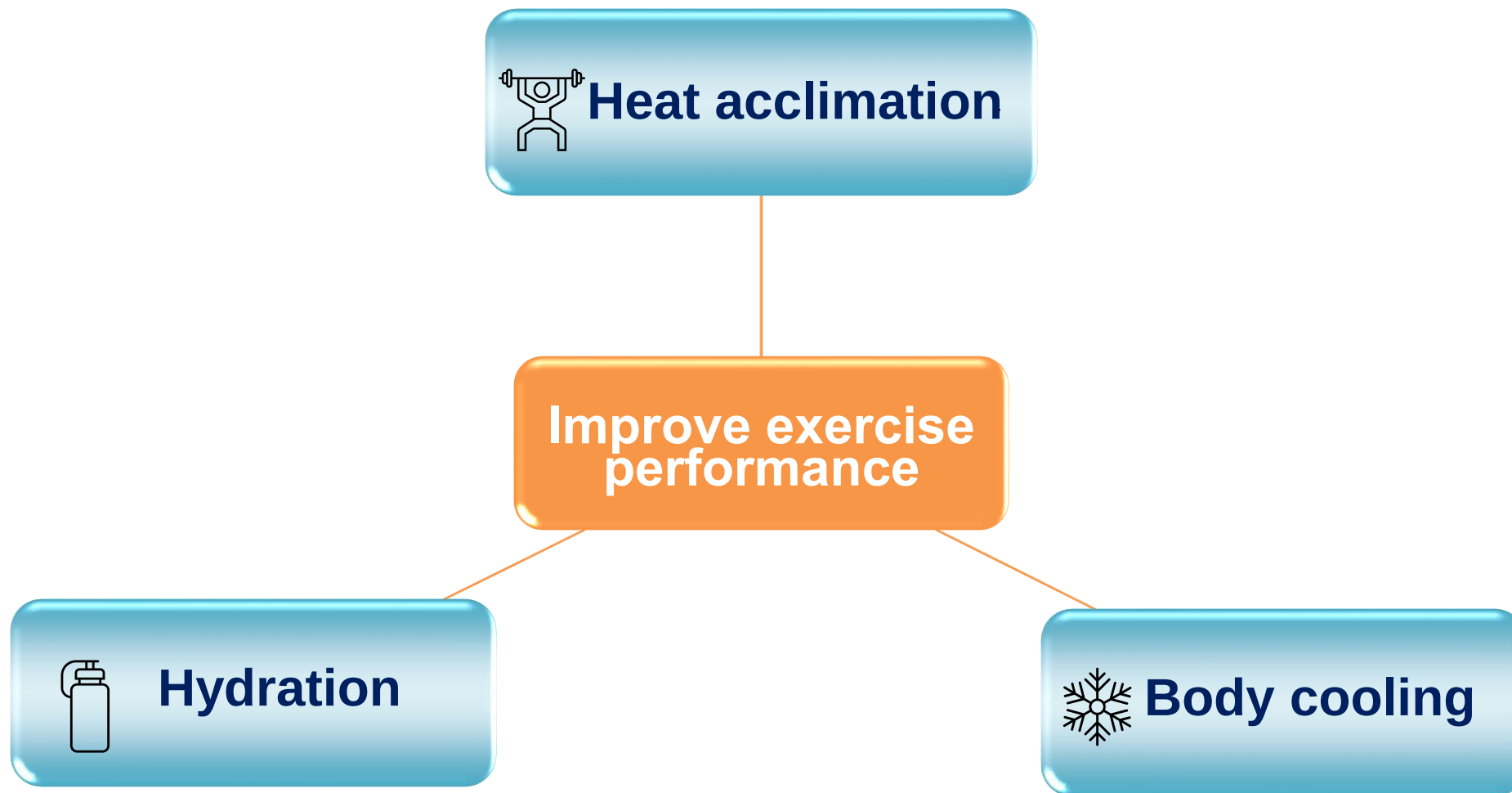
WBGT $\geq 25^{\circ}\text{C}$ → caution for body temperature rise
Implementation of heat countermeasures is recommended



WBGT (TANITA)

WBGT (°C)	Wet-bulb (°C)	Dry-bulb (°C)	Guidance for Sports
≥ 31	≥ 27	≥ 35	Cancel (Danger)
28–30.9	≈ 24	≈ 31	Severe Warning
25–27.9	≈ 21	≈ 28	Warning
21–24.9	≈ 18	≈ 24	Caution
≤ 20	≤ 17	≤ 23	Generally Safe

Heat Stress Management for Athletes



We have conducted research and provided support for the Summer Olympics based on these methods.

Environmental Differences by Olympic Host City

Tokyo 2020



- High temperature and humidity
- Evaporative heat loss via sweating is limited
- Beyond heat acclimation, active cooling to lower core temperature is important

Paris 2024



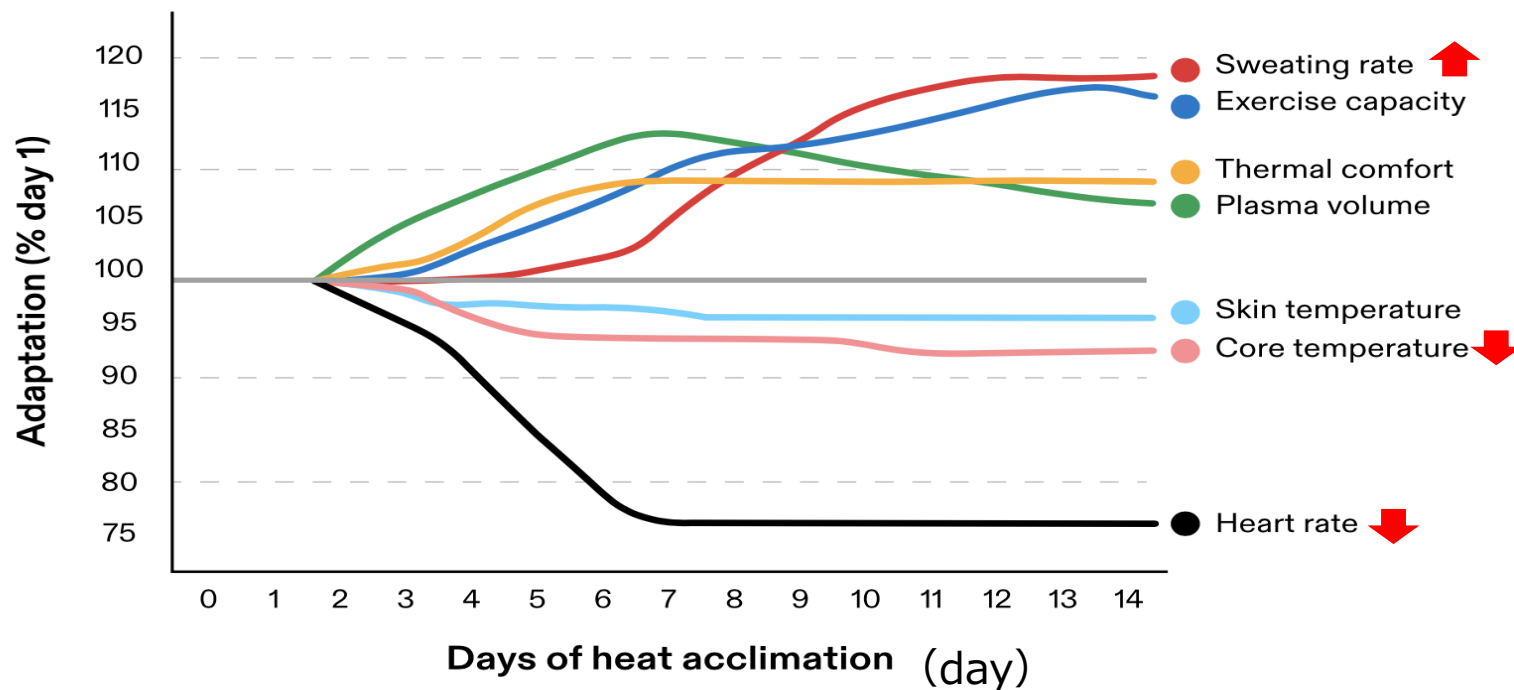
- High temperature and low humidity
- Evaporative heat loss via sweating is more feasible.
- Heat acclimation to promote sweating is important
- Heat waves can sometimes exceed 40 °C

Los Angeles 2028



- LA tends to be hot with lower humidity—so **heat acclimation training is important.**
- **Hydration is essential in any climate.**
- Consider **body-cooling strategies when WBGT ≥ 25 (°C).**

Heat Acclimation



Competitive athletes adapt faster than the general population.

Heat acclimation is the *only* heat management that can be prepared *in advance*.

Short term vs Medium-term heat acclimation

Short-term heat acclimation: **STHA**
≤7days

Medium-term heat acclimation: **MTHA**
8-14 days

	STHA	MTHA
Time to exhaustion	11 ± 8%↑medium(0.5)	31 ± 29%↑large(1.0)
Athletic performance	2.4 ± 3.5%↑small(0.3)	10.2 ± 14.0%↑medium(0.6)
Heart rate	-3.5 ± 1.8 %↓large(-1.0)	-7.0 ± 1.9%↓large(-1.0)
Core temperature	-0.7 ± 0.7 %↓large(-0.9)	-0.8 ± 0.3%↓large(-1.1)
Plasma volume	3.5 ± 2.6%↑	7.1 ± 3.7%↑

(Guy et al. 2015)

Both approaches improve exercise performance, but MTHA shows a larger effect size.
STHA is particularly practical for elite athletes with tight schedules

(Racinais et al. 2015)

Heat Acclimation Training for the Tokyo 2020 Games (3X3)

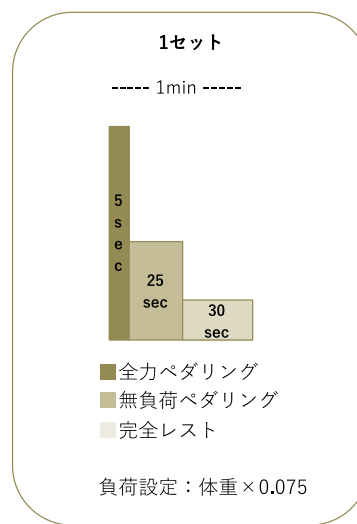


(2021 Getty Images)

<https://www.olympics.com/en/news/what-we-learned-3x3-basketball-tokyo-2020-olympics>

Heat acclimation training using high intensity intermittent exercise for 7 days

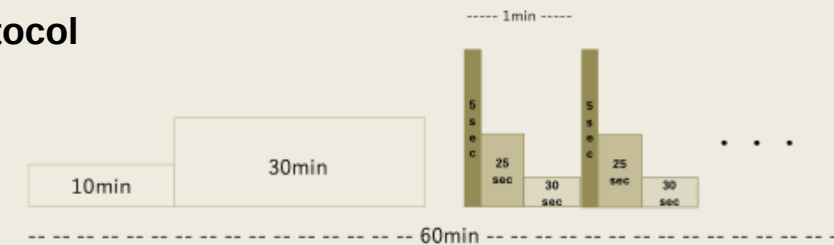
Subjects: 8 male, 6 female athletes



- Official event from the Tokyo 2020 Games
- Most of Japan's 3x3 players also play five-man/woman basketball
- They usually trained indoors and were not accustomed to a hot environment
- Matches were held from 10:00 to 16:00, the hottest time of the day
- Heat acclimation and other heat-related measures were an issue

Test Protocol

Bicycle

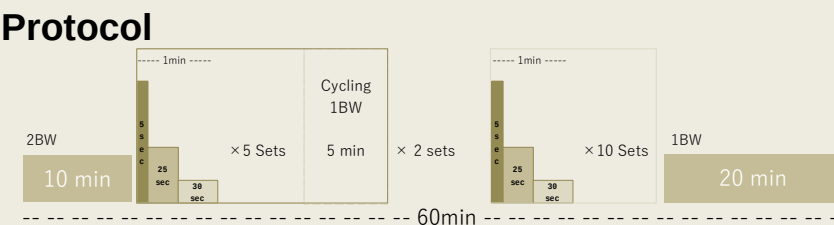


Training Protocol

Bicycle



回転数 70 rpm

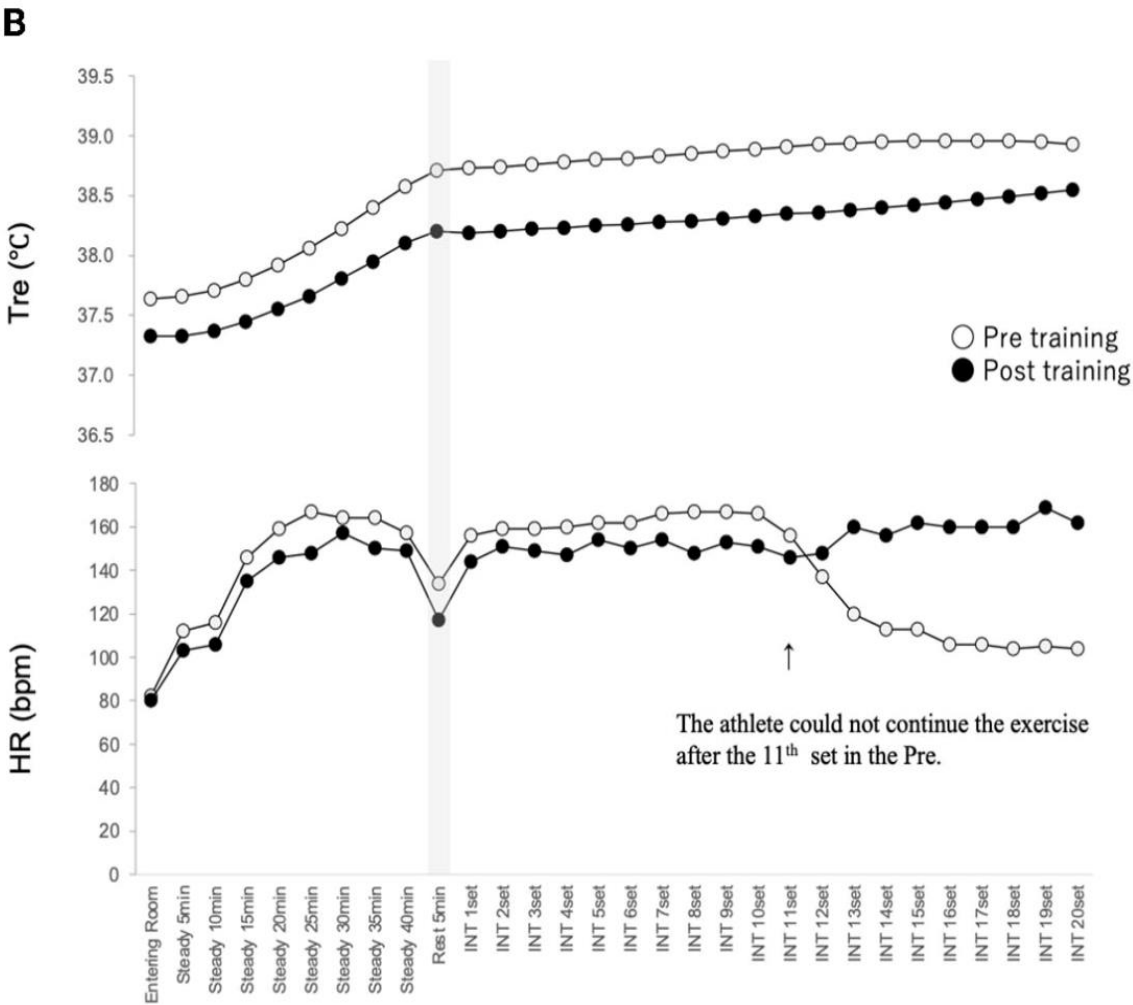


Heat Acclimation Training for the Tokyo 2020 Games (3X3)

Environment: Ta 33°C, Rh70%



Typical example data of core body temperature (Tre) and heart rate (HR)



Passive heat acclimation

Why this works

- ✓ Can be implemented without changing regular training.
- ✓ Especially useful for skill- or team-based sports: enables heat acclimation without adding fatigue.



Hot-water bathing



40~42°C



40~65 min



Sauna



70~90°C



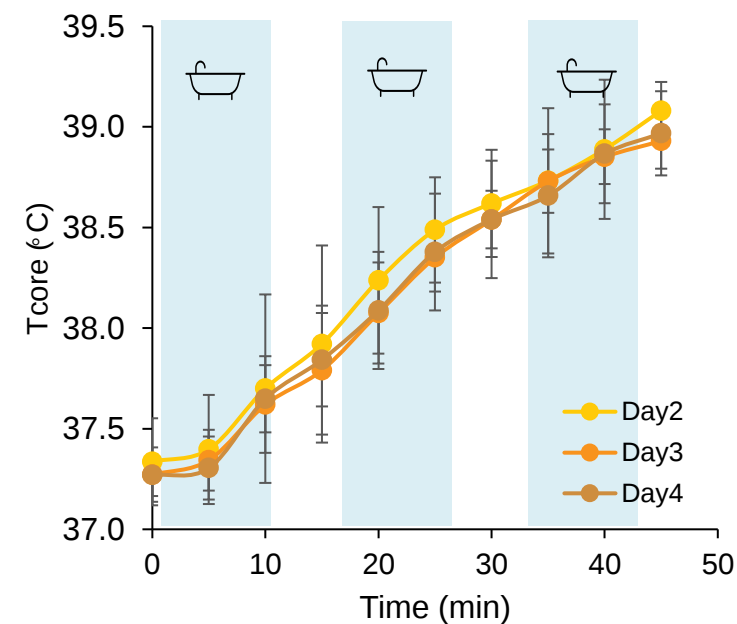
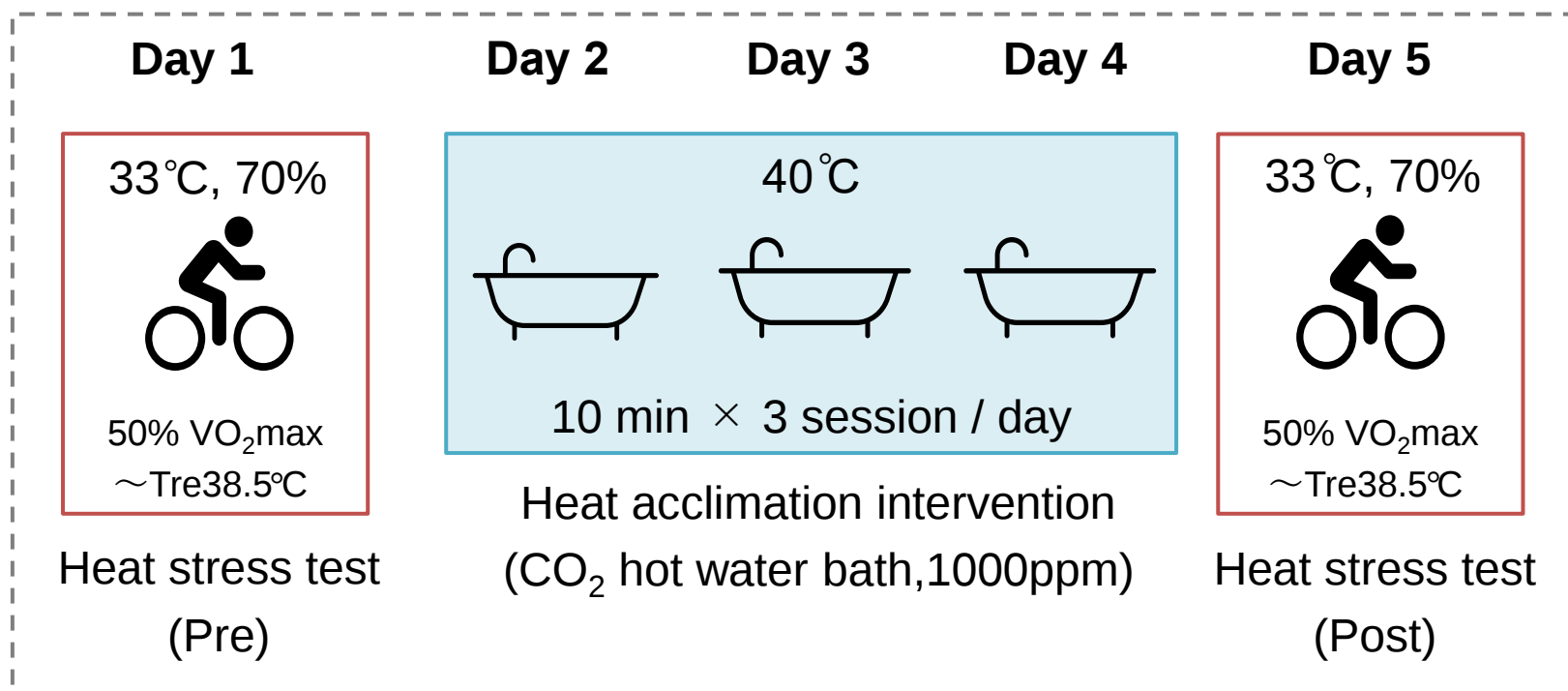
30 min, intermittent

Key point: In both methods, aim to raise core temperature to ~38.5 °C.

Passive Heat Acclimation Using CO₂ Baths

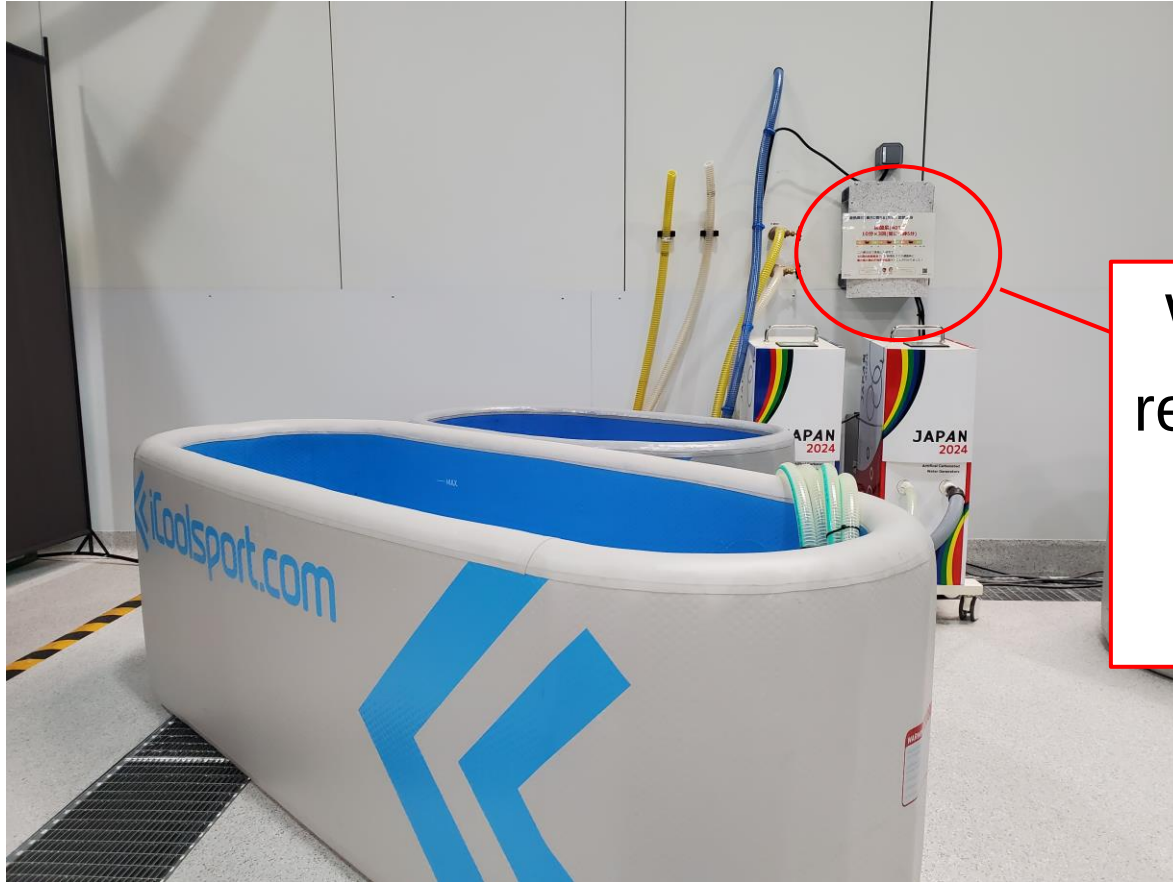
- Japanese people have a long tradition of bathing, and Japanese athletes are also familiar with it.
- Japanese athletes use CO₂ water baths at support sites more frequently than tap water baths (Shimizu et al., 2021).
- CO₂ hot water bath imposes greater thermal stress than tap hot water bathing (Iwata et al 2025).

We examined whether very short, 3-day CO₂ bathing could induce heat acclimation.

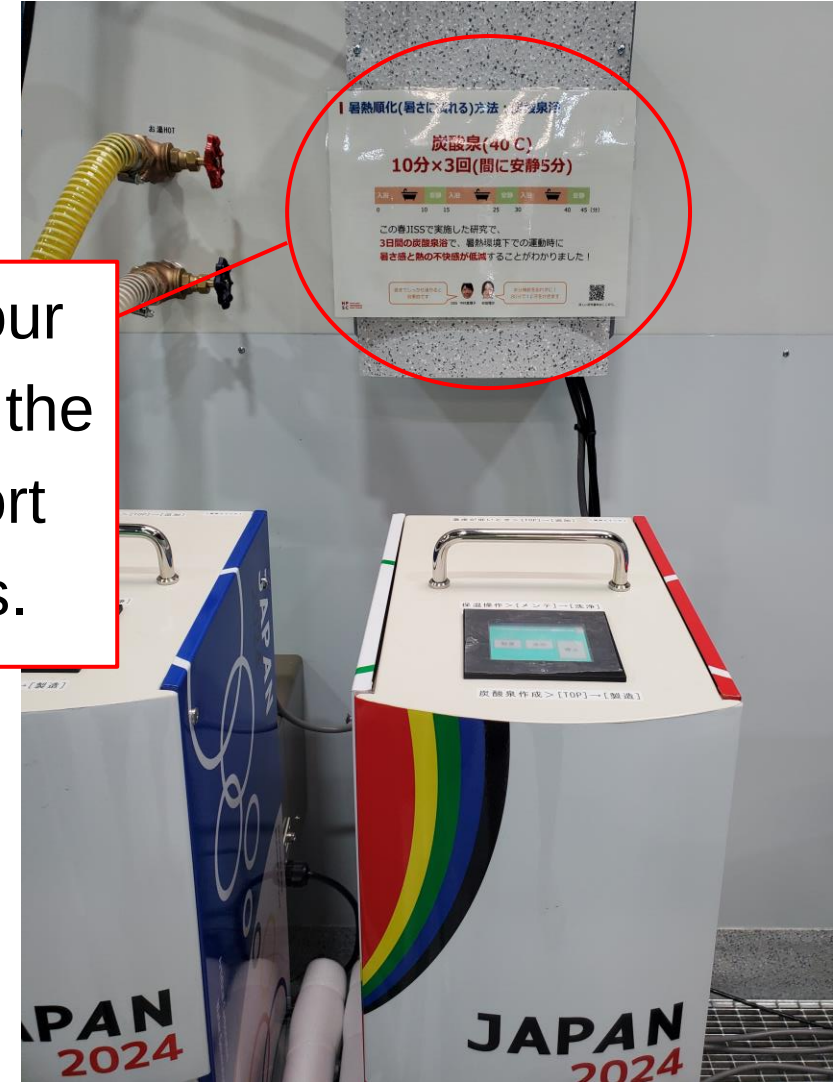


↑ Changes in core body temperature from Day 2 to Day 4

CO2 water bathing in Paris

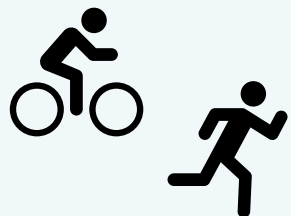


We presented our research data at the Olympic Support House at Paris.

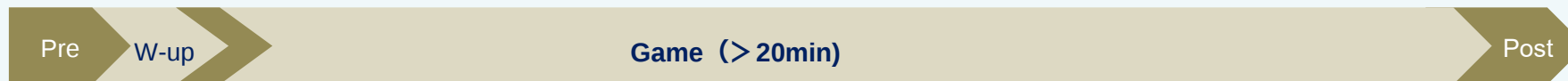


Timing of body cooling

➤ Cooling point

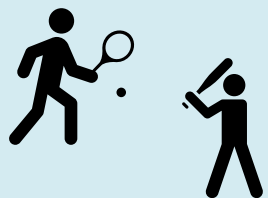


Pre-cooling



Typical sports : Marathon, cycling, triathlon

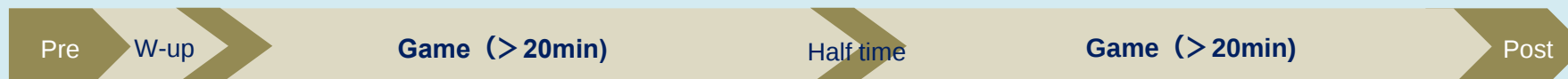
Common cooling methods: Ice slurry; palm cooling; ice vest etc..



Per-cooling/Mid-cooling



Typical sports : Tennis, baseball etc...

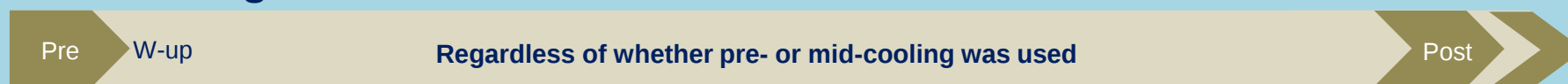


Typical sports : Football、 Rugby、 Hockey, etc..

Common cooling methods : Ice slurry; ice vest; mist + fans etc...



Post-cooling



Common cooling methods : Ice bath; ice vest; mist + fans; cryotherapy etc...

A sport-specific cooling strategy is required.

Pre Cooling (Slurry Ingestion)



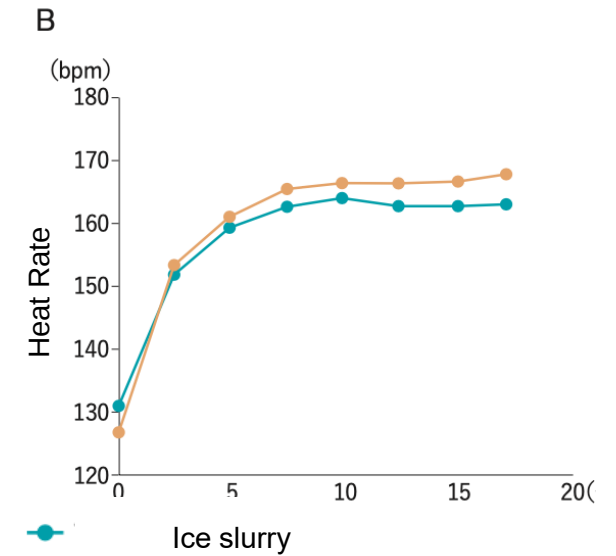
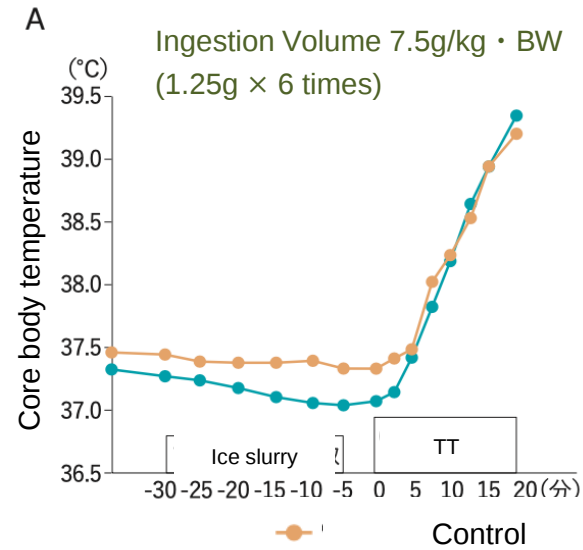
Cycling



WBGT, 27.9 °C
Ta, 33.1°C
Rh, 49.3%



Doshimichi Mountain Section



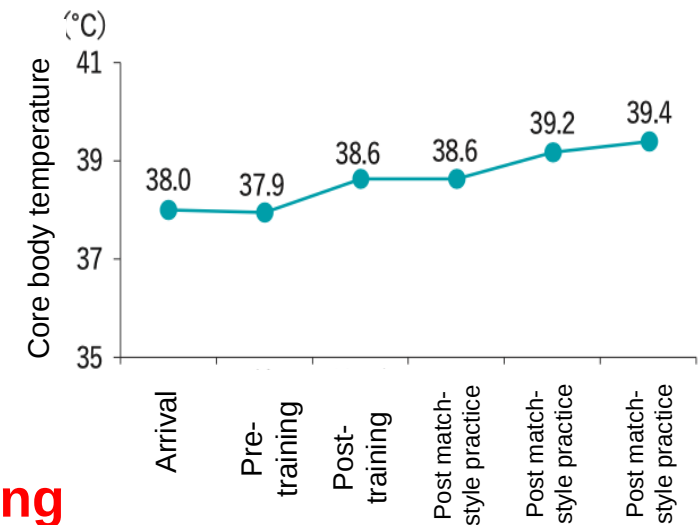
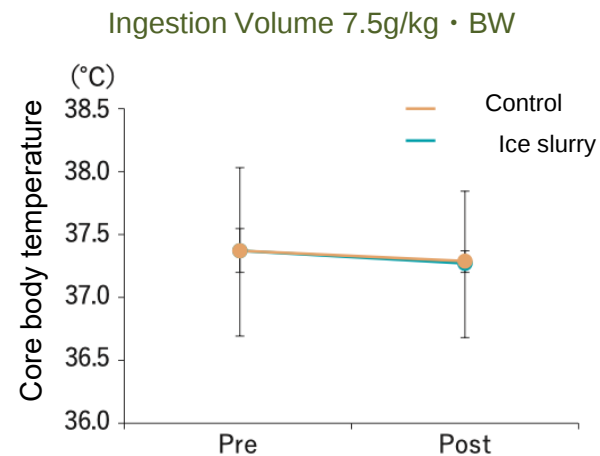
Beach Volleyball



WBGT, 27 °C
Ta, 31°C
Rh, 60 %



Kawasaki Marien



Requires combination with external cooling



Body Cooling Support in Tennis at the Tokyo 2020 Games



Pre

W-up

Game

Game

Game

Game

Game

Game

Game

Game

Post

Tennis



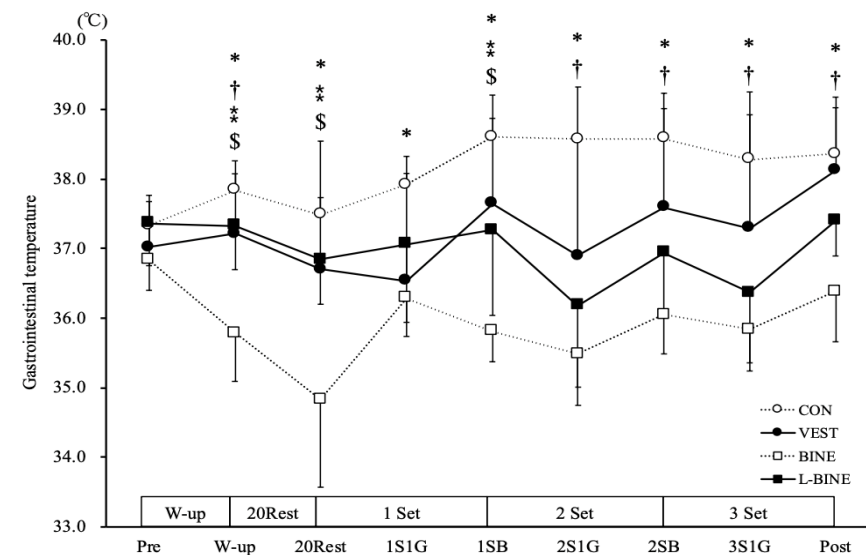
WBGT, 30.9 °C

Ta, 33.6 °C

Rh, 49.0 %



Intervention	Warm-up (30min)	Rest (20min)	Game break (90sec)	Set break (120sec)
CON	ad libitum fluid ingestion	ad libitum fluid ingestion	ad libitum fluid ingestion	ad libitum fluid ingestion
BINE	Ice slurry 200g	Ice slurry 200g Ice vest	Ice slurry 100g Ice vest	Ice slurry 100g Ice vest
L-BINE	Ice slurry 100g	Ice slurry 100g Ice vest	ad libitum Ice vest	Ice slurry 100g Ice vest
VEST	ad libitum fluid ingestion	ad libitum Ice vest	ad libitum Ice vest	ad libitum Ice vest



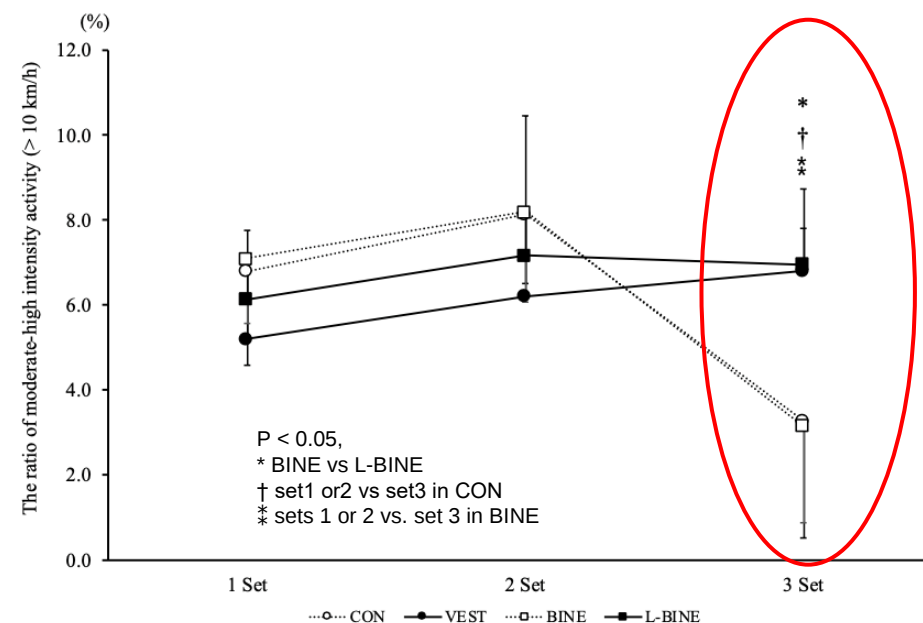
P < 0.05

*CON vs. BINE

†CON vs. L-BINE

‡VEST vs. BINE

§BINE vs. L-BINE



P < 0.05,

* BINE vs. L-BINE

† set1 or 2 vs set3 in CON

‡ sets 1 or 2 vs. set 3 in BINE

Heat Countermeasure Plan for Los Angeles

Pre-event prep in your country



Pre-event prep in Los Angeles

Game day

Heat Acclimation Training



Enhance sweating capacity
Increase plasma volume

Re-acclimation Training (on site)

Time-zone
adjustment;
confirm local
climate
conditions

In addition to regular training,
reacclimate on site using heat stimuli
(e.g., hot-water bathing, extra layers).

Decide on and
prepare cooling
methods

Decide use based on
game-day WBGT.

Body Cooling



Hydration



Ingest the required fluid volume according to body-mass change and urine color.

Estimate sweat loss.

Reconfirm sweat loss under
Los Angeles conditions.