HYDRATION ASSESSMENT & RECOMMENDATIONS

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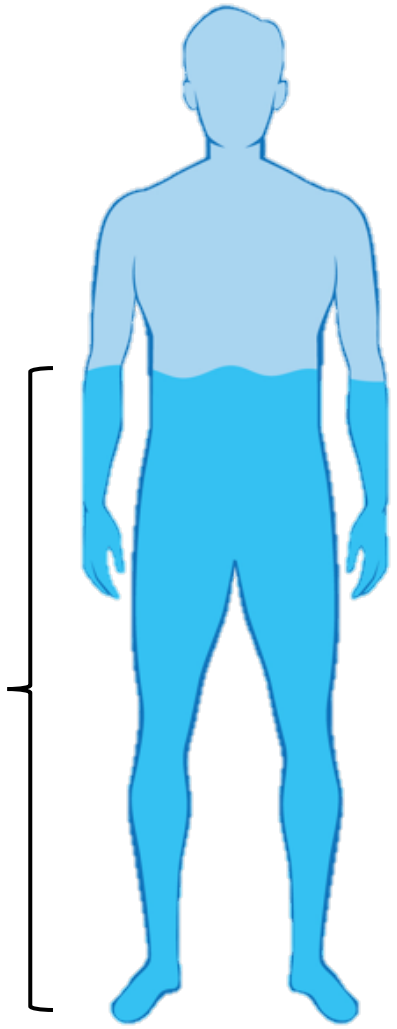
OVERVIEW

- Body water and electrolyte basics
- Assessment of hydration status and sweating rate
- Assessment of sweat sodium concentration and total sodium loss
- Example calculations
- Hydration recommendations

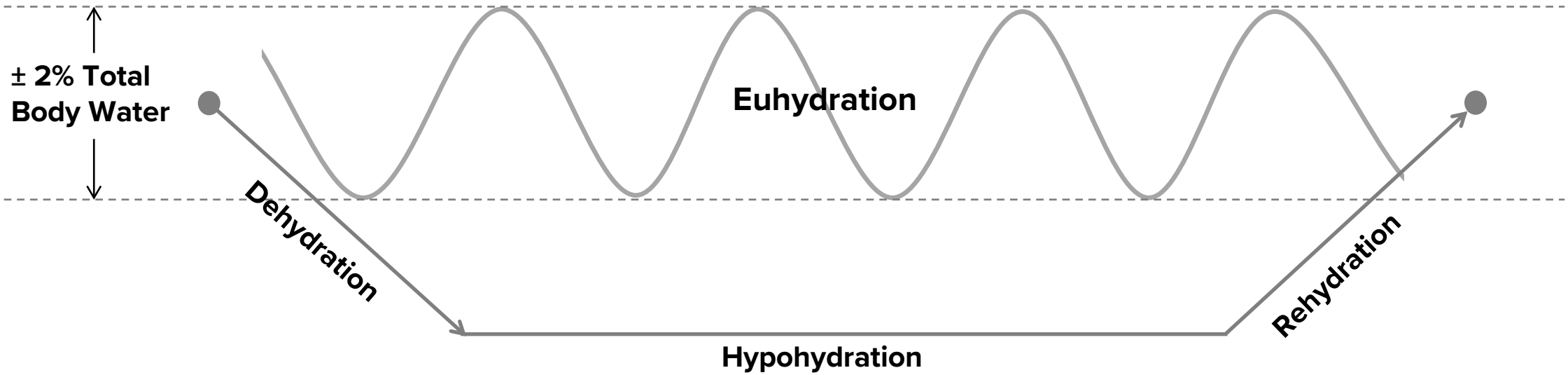
TOTAL BODY WATER

~50-70% of body mass

TBW = ~0.73 x fat free mass

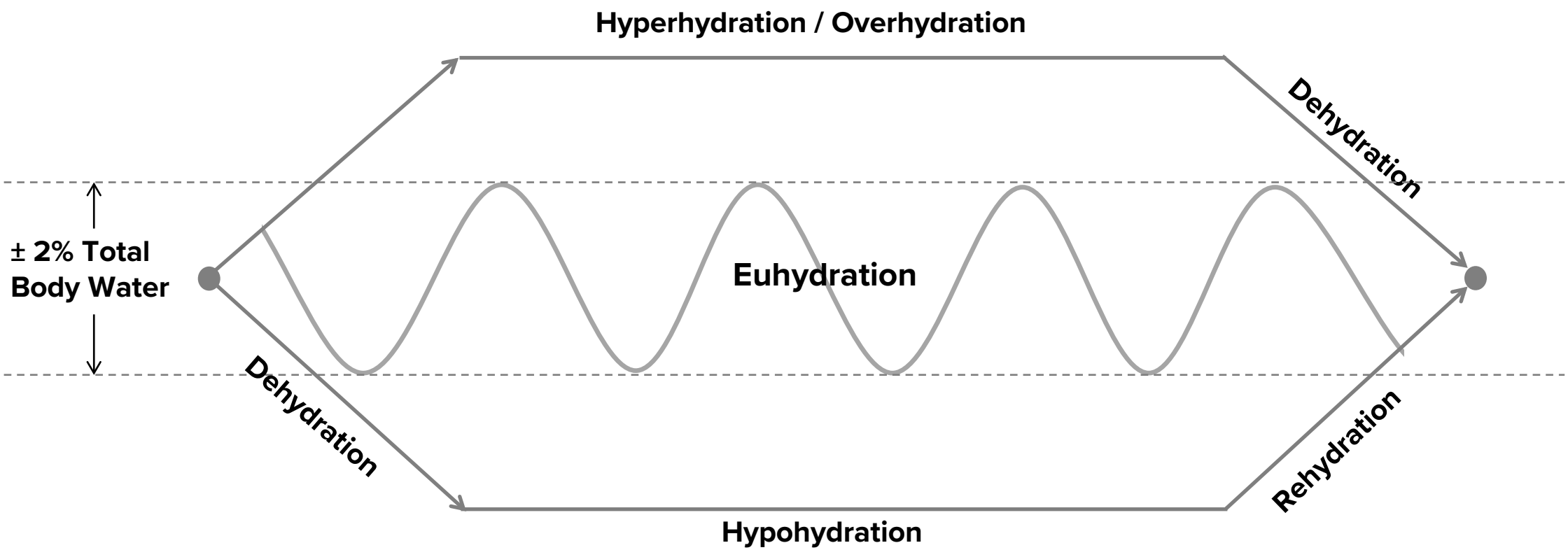


HYDRATION TERMINOLOGY



Greenleaf J. *Med Sci Sports Exerc.* 1992;24(6):645-656

HYDRATION TERMINOLOGY



HYDRATION TERMINOLOGY

Euhydration – “normal” body water content within homeostatic range

Dehydration – the process of dynamic loss of body water – e.g., the transition from euhydration to hypohydration

Rehydration – the process of dynamic gain of body water (via fluid intake) – e.g., the transition from hypohydration to euhydration

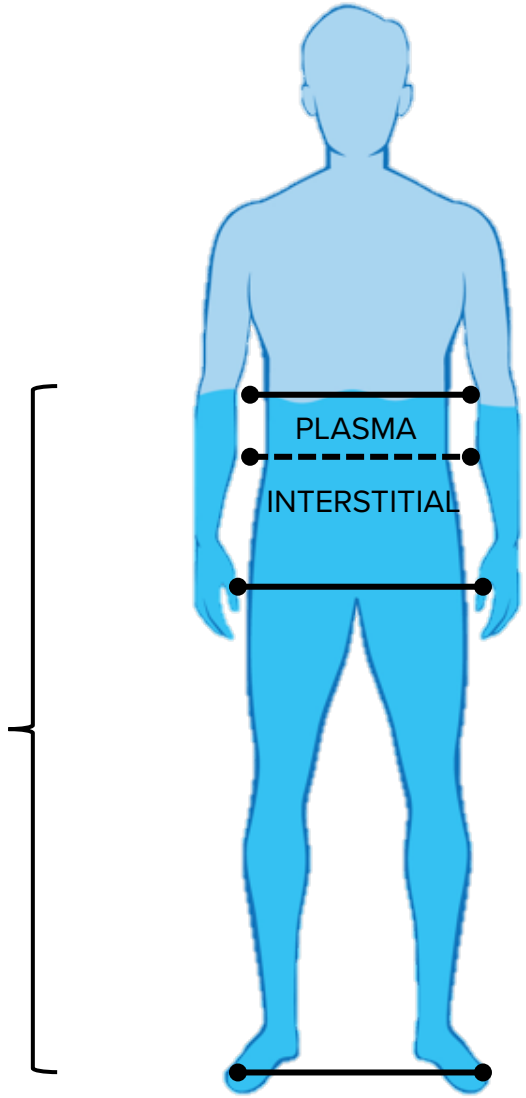
Hypohydration – state of body water deficit

Over- or Hyperhydration – state of body water excess

FLUID COMPARTMENTS

~50-70% of body mass

TBW = ~0.73 x fat free mass

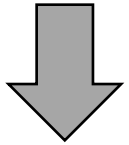


Extracellular Fluid (ECF)
35-45% of TBW

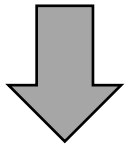
Intracellular Fluid (ICF)
55-65% of TBW

HYDRATION PHYSIOLOGY: HYPOHYDRATION

Hypohydration – body water deficit

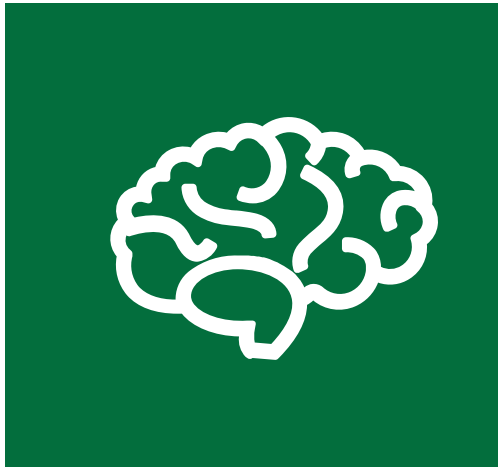


Hypovolemia – decreased plasma volume
Hyperosmolality – increased plasma osmolality (concentration of dissolved solutes, mostly sodium, in the blood)



- **Cardiovascular strain** – lower stroke volume and higher heart rate
- **Body core temperature** – decreased ability to dissipate body heat through sweating and skin blood flow
- **Fatigue** - early onset of fatigue leading to reduced performance

HYPOHYDRATION & PERFORMANCE



Cognition

Team Sports

Aerobic Exercise

Muscle Endurance, Strength, & Anaerobic Power

SSE #128,152, 165

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Hypohydration can impair performance, especially if exceeds 2-3% body mass loss and in hot/humid conditions

Laitano et. al. *Sports Science Exchange*. 2014;27(128)
Sawka et. al. *Sports Science Exchange*. 2015;28(152)
Baker. *Sports Science Exchange*. 2016;28(165)

McDermott BP, Anderson SA, Armstrong LE, et. al. *J Athl Train*. 2017;52(9):877-895
Thomas DT, Erdman KA, Burke LM. *Med Sci Sports Exerc*. 2016;48(3):543-568

HYDRATION PHYSIOLOGY: OVERHYDRATION

SSE #111, 122

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Overdrinking low or no sodium fluids

↓

Overhydration – body mass gain because of a fluid surplus

↓

+ prolonged exercise (>**4** hours)
+ smaller individual (low baseline total body water)
+ excessive sodium loss

} Additional risk factors

Exercise Associated Hyponatremia – dilution of plasma sodium concentration to < 135 mmol/L

↓

Water flux into the ICF –severity of symptoms related to cell swelling depends on how much and how fast plasma sodium [Na^+] decreases

Noakes TD, Goodwin N, Rayner BL, et. al. *Med Sci Sports Exerc.* 1985;17(3):370-375
Hew-Butler TD, Godek SF, Rosner M, et. al. *Br J Sports Med.* 2015;25:303-320

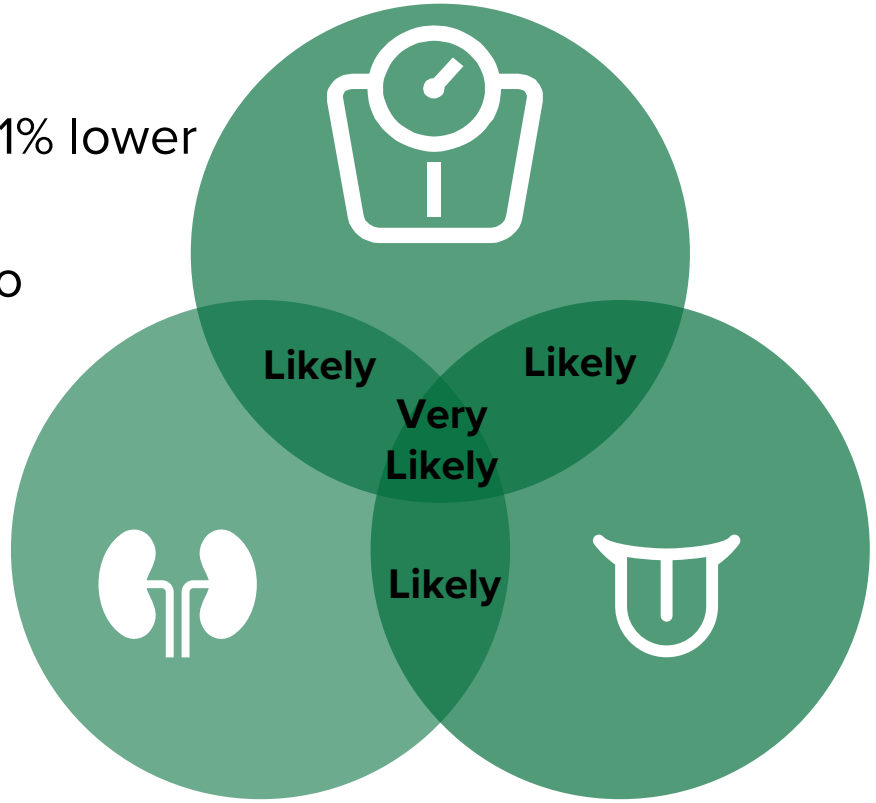
HYDRATION STATUS ASSESSMENT

PRE-EXERCISE HYDRATION ASSESSMENT

Are you hypohydrated?

Is my body mass >1% lower than normal?

(Yes) / No



Is my urine dark yellow?

(Yes) / No

Am I Thirsty?

(Yes) / No

Assess first thing in the morning (before breakfast)

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URINE COLOR

Urine color on a scale from 1 (very pale) to 8 (very dark) can be used to estimate hydration status

A urine color of ≥5 may be indicative of hypohydration

A urine color of 3 or 4 provides reasonable assurance the athlete is hydrated

Urine color can be monitored by the athlete or by the ATC

Post urine color charts in bathrooms

McKenzie AL, Muñoz CX, Armstrong LE. *J Athl Train*. 2015;50(12):1306-1309
Cheuvront SN and Kenefick RW. *J Am Coll Nutr*. 2016;35(2):185-192

URINE SPECIFIC GRAVITY (USG)

USG is a measure of urine concentration and is sensitive to changes in hydration status

ACSM & NATA suggest that a USG ≥1.020-1.025 is indicative of hypohydration

Best to use more than one measure (e.g., change in body weight, urine color or USG, and thirst) to assess hydration status

Sawka MN, Burke LM, Eichner ER, et al. *Med Sci Sports Exerc*. 2007;39(2):377-390
McDermott BP, Anderson SA, Armstrong LE, et al. *J Athl Train*. 2017;52(9):877–895

HYDRATION STATUS ASSESSMENT

Body mass loss

Sweat

Urine

Respiration
(fuel oxidation, water vapor)

Body mass gain

Drinking

Eating

Hydration status = % change in nude body mass

Calculation: [(Δ body mass) / baseline body mass]*100

Example: 2% hypohydration = 2% body mass deficit through fluid loss

HYDRATION STATUS ASSESSMENT

Using acute body mass change to estimate hydration status is appropriate for most individual and team sports, since practices and games are typically < 3 h

Using change in body mass to determine hydration status becomes less accurate with longer events

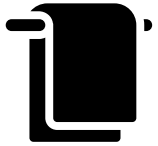
For example, during ultraendurance events ≥ 2% of body mass loss can occur through non sweat sources:

DATA COLLECTION

Change in Hydration Status

Supplies needed

Digital platform body weight scale with precision of 0.10 kg or better



Towels

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Instructions

Before Exercise

- ✓ Ask athlete to use restroom, void bladder and bowels
- ✓ Weigh athlete while they are wearing minimal clothing (e.g., compression shorts, sports bra)

After Exercise

- ✓ Ask athlete to towel dry thoroughly
- ✓ Weigh athlete while wearing the same minimal clothing as before exercise

EXAMPLE #1

Data

- Baseline body mass: 104.55 kg
- Post-exercise body mass: 101.00 kg

EXAMPLE #1

Calculate the athlete's % change in hydration status after practice

Body mass decreased from 104.55 kg to 101.00 kg, so Δ body mass = -3.55 kg

Hydration status = [(Δ body mass) / baseline body mass] * 100

(-3.55 kg / 104.55 kg) * 100

-3.4% change in body mass

EXAMPLE #2

Data

- Baseline body mass: 56.35 kg
- Post-match body mass: 55.45 kg

EXAMPLE #2

Calculate the athlete's % change in hydration status after the match

Body mass decreased from 56.35 kg to 55.45 kg, so Δ body mass = -0.90 kg

Hydration status = [(Δ body mass) / baseline body mass] * 100

(-0.90 kg / 56.35 kg) * 100

-1.6% change in body mass

EXAMPLE #3

Data

- Baseline body mass: 66.15 kg
- Post exercise body mass: 66.80 kg

EXAMPLE #3

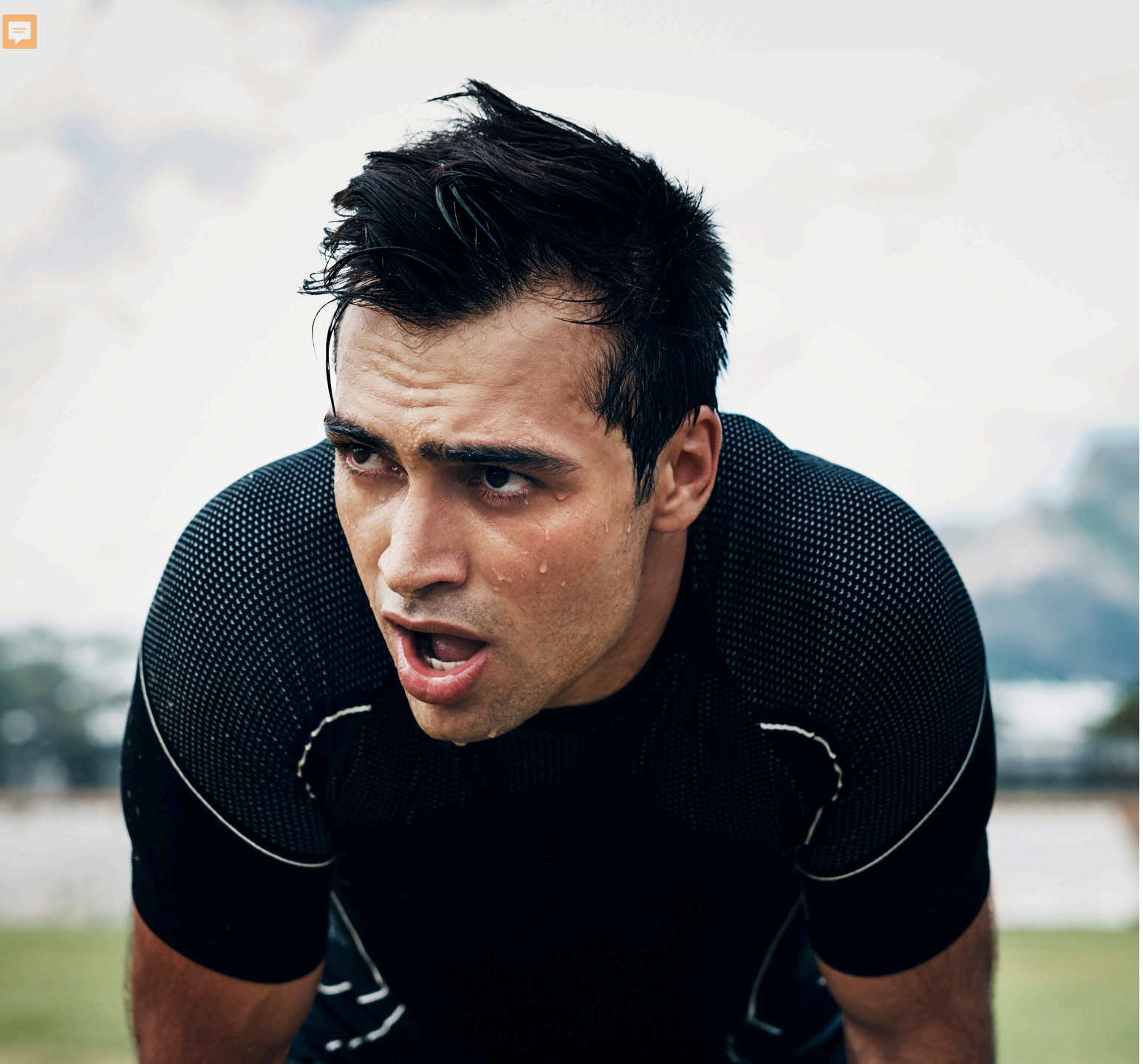
Calculate the athlete's % change in hydration status after exercise

Body mass increased from 66.15 kg to 67.00 kg, so Δ body mass = +0.65 kg

Hydration status = [(Δ body mass) / baseline body mass] * 100

(0.65 kg / 66.15 kg) * 100

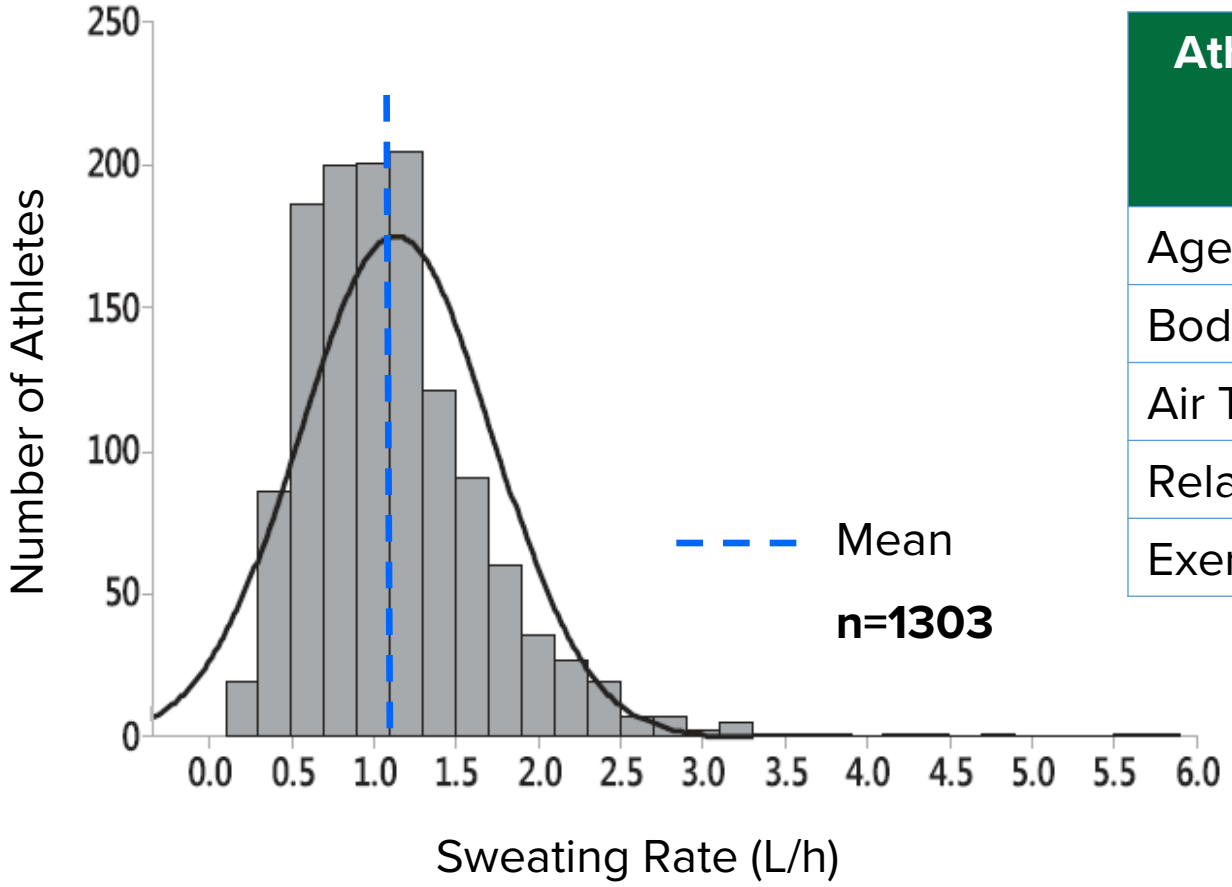
+**1.0% change in body mass**



MEASURING SWEATING RATE

SWEATING RATE

Normative Data in Athletes



Athlete, Environment, and Exercise Information	Mean ± SD (Range)
Age (years)	24 ± 9 (9-70)
Body Mass (kg)	84 ± 24 (23-178)
Air Temp (°C)	26 ± 5 (11-50)
Relative Humidity (%)	55 ± 17 (13-95)
Exercise Duration (h)	1.7 ± 0.7 (0.5-5.4)

Barnes KA, Anderson ML, Stofan JR, et. al. *J Sports Sci.* 2019;37(20):2356-2366

SWEATING RATE

Factors impacting the variability in sweating rate:

Exercise intensity
Body size
Environmental conditions
(temperature, humidity, solar load, wind)

Heat acclimatization
Fitness
Clothing/equipment worn
Body composition
Hydration status
Age (maturation)
Genetics

SWEAT LOSS CALCULATIONS

Sweat Loss = [Pre-Ex Body Mass – (Post-Ex Body Mass – Fluid & Food + Urine)]

Sweat Loss = [Pre-Ex Body Mass – (Post-Ex Body Mass – Fluid & Food + Urine & Resp)]

Respiratory losses = 0.2 g/kcal of energy expended during exercise. Because of the relatively small contribution of respiratory losses to total body mass loss and because energy expenditure is difficult to measure, this part of the equation is usually dropped for acute (up to 3 h) bouts of exercise.

Mass loss

Sweat
Urine
Respiration
(fuel oxidation, water vapor)

Mass gain

Drinking
Eating

Sawka MN, Burke LM, Eichner ER, et. al. *Med Sci Sports Exerc.* 2007;39(2):377-390
Cheuvront SN and Montain SJ. *Exp Physiol.* 2017;102:1047-1053
Cheuvront SN and Kenefick RW. *J Appl Physiol.* 2017;123(3):632-636

DATA COLLECTION

SSE #161

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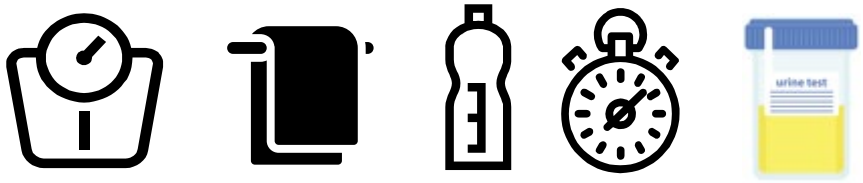
Supplies needed

- ✓ Digital platform body weight scale with precision of 0.10 kg or better
- ✓ Towels
- ✓ Clock or Stopwatch
- ✓ Drink Bottles
- ✓ Small digital scale
- ✓ Urine cup



Instructions

Before Exercise

- ✓ Ask athlete to use the restroom, void bladder and bowels
- ✓ Weigh athlete while he/she is wearing minimal clothing (e.g., compression shorts, sports bra)
- ✓ Weigh drink bottles and food (bars, gels, etc.), if applicable

During Exercise

- ✓ Collect urine loss in cup and weigh, if applicable

After Exercise

- ✓ Ask athlete to towel dry thoroughly
- ✓ Weigh athlete while wearing the same minimal clothing as before exercise
- ✓ Weigh drink bottles and food, if applicable

EXAMPLE #1

Data

- Baseline body mass: 104.55 kg
- Practice duration: 2.5 h
- Fluid consumed: 1.25 kg
- Food consumed: two 50-g energy bars
- Urine loss = N/A
- Post exercise body mass: 101.00 kg

EXAMPLE #1

Calculate the athlete's total sweat loss and sweating rate

Sweat Loss = [Pre-Ex Body Mass – (Post-Ex Body Mass – Fluid & Food + Urine)]

104.55 kg - (101.00 kg - 1.35 kg + 0 kg)

4.90 kg (or L) of sweat lost in 2.5 h

Sweating Rate = 4.90 L / 2.5 h = **1.96 L/h**

EXAMPLE #2

Data

- Baseline body mass: 56.35 kg
- Match duration: 1.5 h
- Fluid consumed: 0.85 kg
- Urine loss: N/A
- Post exercise body mass: 55.45 kg

EXAMPLE #2

Calculate the athlete's sweat loss and sweating rate

Sweat Loss = [Pre-Ex Body Mass – (Post-Ex Body Mass – Fluid & Food + Urine)]

56.35 kg - (55.45 kg - 0.85 kg + 0 kg)

1.75 kg (or L) of sweat lost in 1.5 h

Sweating Rate = 1.75 L / 1.5 h **= 1.17 L/h**

EXAMPLE #3

Data

- Baseline body mass: 66.15 kg
- Exercise duration: 2 h 20 min
- Fluid consumed: 2.05 kg
- Urine loss: 0.20 kg
- Post exercise body mass: 66.80 kg

EXAMPLE #3

Calculate the athlete's sweat loss and sweating rate

Sweat Loss = [Pre-Ex Body Mass – (Post-Ex Body Mass – Fluid & Food + Urine)]

66.15 kg - (66.80 kg - 2.05 kg + 0.20 kg)

1.20 kg (or L) of sweat lost in 2.33 h

Sweating Rate = 1.20 L / 2.33 h = **0.52 L/h**

HYDRATION RECOMMENDATIONS

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

SSE #182

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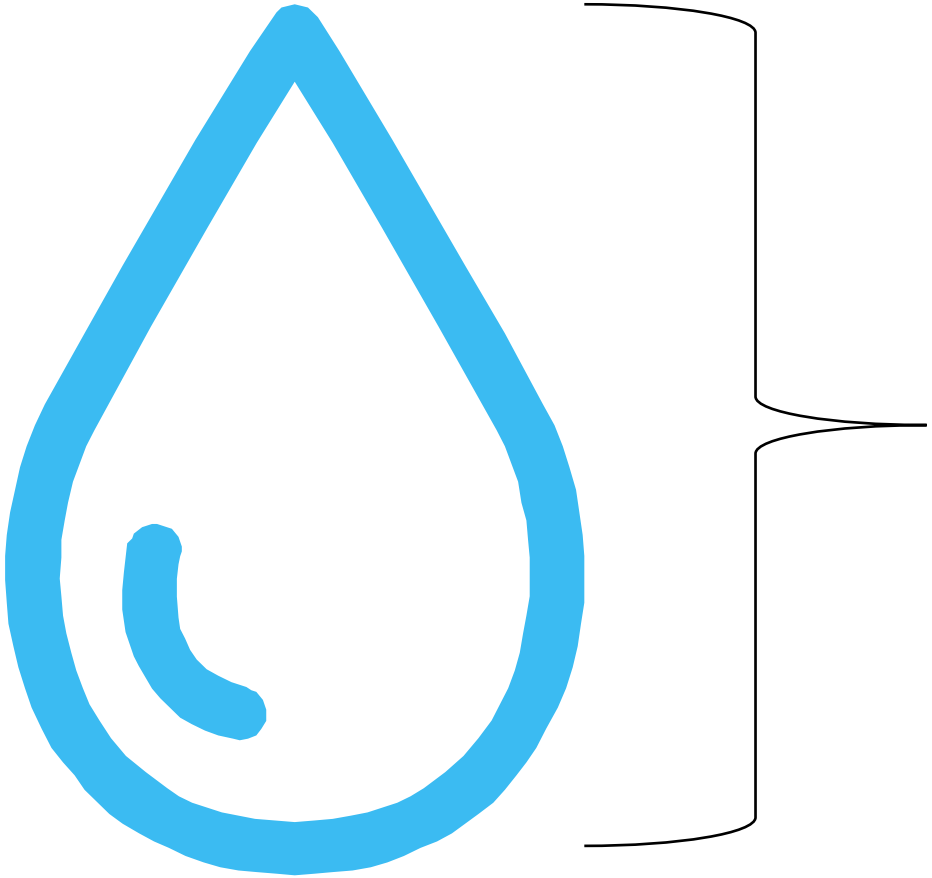
ASSESSING SWEAT SODIUM CONCENTRATION AND TOTAL SWEAT SODIUM LOSS

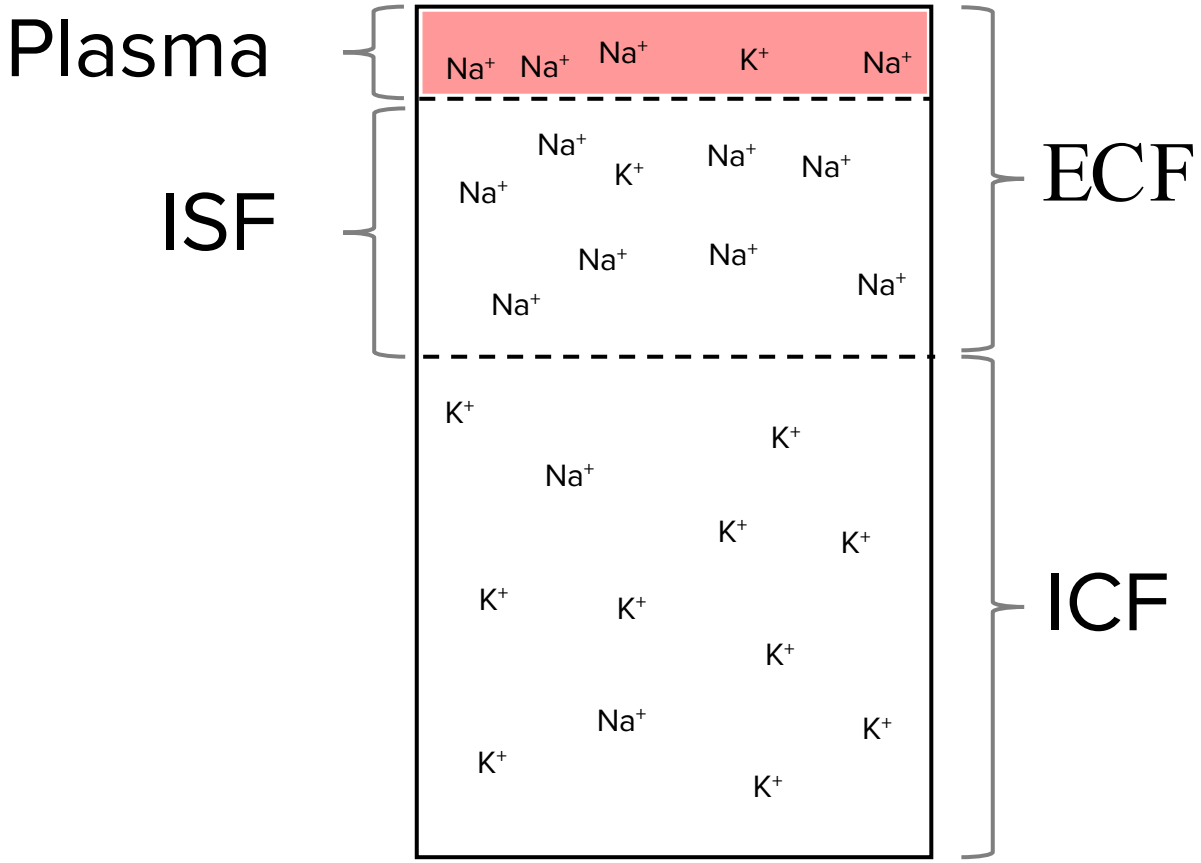
SWEAT COMPOSITION



	Concentration
Sodium	10-90 mmol/L
Chloride	10-90 mmol/L
Lactate	5-40 mmol/L
Urea	4-12 mmol/L
Potassium	2-8 mmol/L
Ammonia	1-8 mmol/L
Others (e.g., bicarbonate, calcium, magnesium, glucose, amino acids, iron, copper, zinc)	< 1 mmol/L each

Baker LB and Wolfe AS. *Eur J Appl Physiol.* 2019;120:719-752

SODIUM & FLUID BALANCE



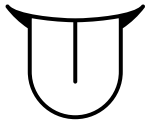
Sodium (Na^+) is the most abundant electrolyte in the extracellular space

Sodium controls water movement between fluid compartments

Water follows solute to maintain osmotic equilibrium

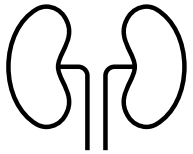
SODIUM & FLUID BALANCE

Helps maintain proper fluid and electrolyte balance among fluid compartments



Stimulates thirst – leading to increased fluid intake and better maintenance or restoration of euhydration

Supports cardiovascular function during exercise via better maintenance of plasma volume



Promotes whole body rehydration by stimulating renal fluid retention (decreased urine loss)

SSE#111, 122

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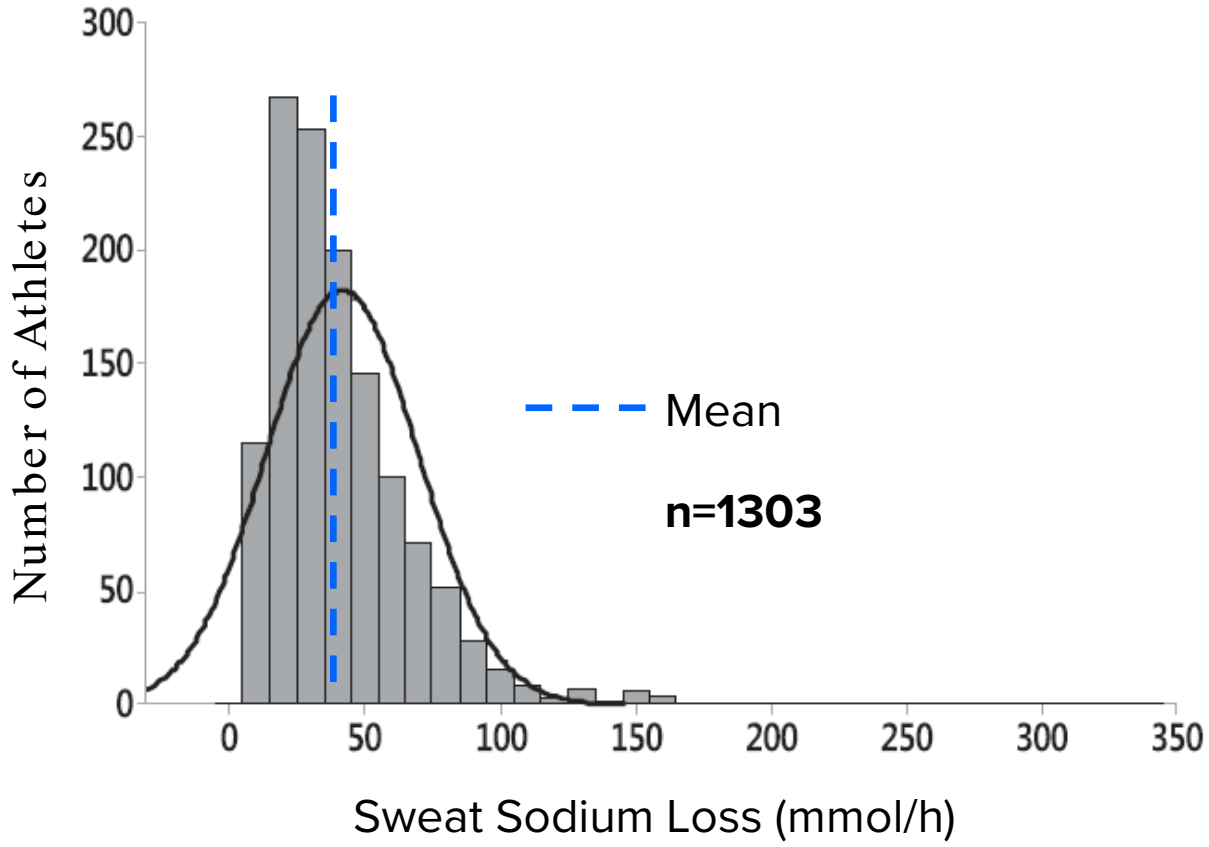
Stachenfeld NS. *Sports Science Exchange*. 2013;26(111)
Stachenfeld NS. *Sports Science Exchange*. 2014;27(122)

SWEAT SODIUM LOSS

Normative Data in Athletes



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Barnes KA, Anderson ML, Stofan JR, et. al. *J Sports Sci.* 2019;37(20):2356-2366

DATA COLLECTION

Sweat Sodium Concentration

SSE #161

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Supplies needed

- ✓ Absorbent sweat patch
- ✓ Forceps
- ✓ Alcohol wipes and/or deionized water
- ✓ Gauze or paper towels
- ✓ Gloves
- ✓ Storage tube
- ✓ Analytical device

Instructions

Before Exercise

- ✓ Clean the athlete's forearm with alcohol and/or deionized water, wipe dry
- ✓ Apply patch to mid-forearm

During/After Exercise

- ✓ Monitor patch via visual inspection
- ✓ Use gloved hands and clean forceps to remove patch upon moderate saturation
- ✓ Place absorbent pad into storage tube

Storage/Analysis

- ✓ If analysis is not done immediately, seal tube and store refrigerated for up to 1 week
- ✓ Measure sodium concentration using ion chromatography or ion selective electrode
- ✓ Use published regression equations to predict whole body sweat sodium concentration

EXAMPLE #1

Data

- Forearm sweat sodium concentration: 80 mmol/L
- Practice duration: 2.5 h
- Sweat loss: 4.90 L

EXAMPLE #1

Calculate the athlete's total sweat sodium loss:

Whole Body Sweat [Na^+] = 0.57 (FA sweat [Na^+]) + 11.05

Whole Body Sweat [Na^+] = 0.57 (80 mmol/L) + 11.05 = 56.65 mmol/L

Whole Body Sweat Sodium Loss = 56.65 mmol/L * 4.90 L = 277.59 mmol

= 277.59 mmol * 22.99 mg/mmol

= **6382 mg sodium**

EXAMPLE #2

Data

- Forearm sweat sodium concentration: 62 mmol/L
- Match duration: 1.5 h
- Sweat loss: 1.75 L

EXAMPLE #2

Calculate the athlete's total sweat sodium loss:

Whole Body Sweat [Na^+] = 0.57 (62 mmol/L) + 11.05 = 46.39 mmol/L

Whole Body Sweat Sodium Loss = 46.39 mmol/L * 1.75 L = 81.18 mmol

= 81.18 mmol * 22.99 mg/mmol

= **1866 mg sodium**

EXAMPLE #3

Data

- Forearm sweat sodium concentration: 38 mmol/L
- Exercise duration: 2 h 20 min
- Sweat loss: 1.20 L

EXAMPLE #3

Calculate the athlete's total sweat sodium loss

Whole Body Sweat [Na^+] = 0.57 (38 mmol/L) + 11.05 = 32.71 mmol/L

Whole Body Sweat Sodium Loss = 32.71 mmol/L * 1.20 L = 39.25 mmol

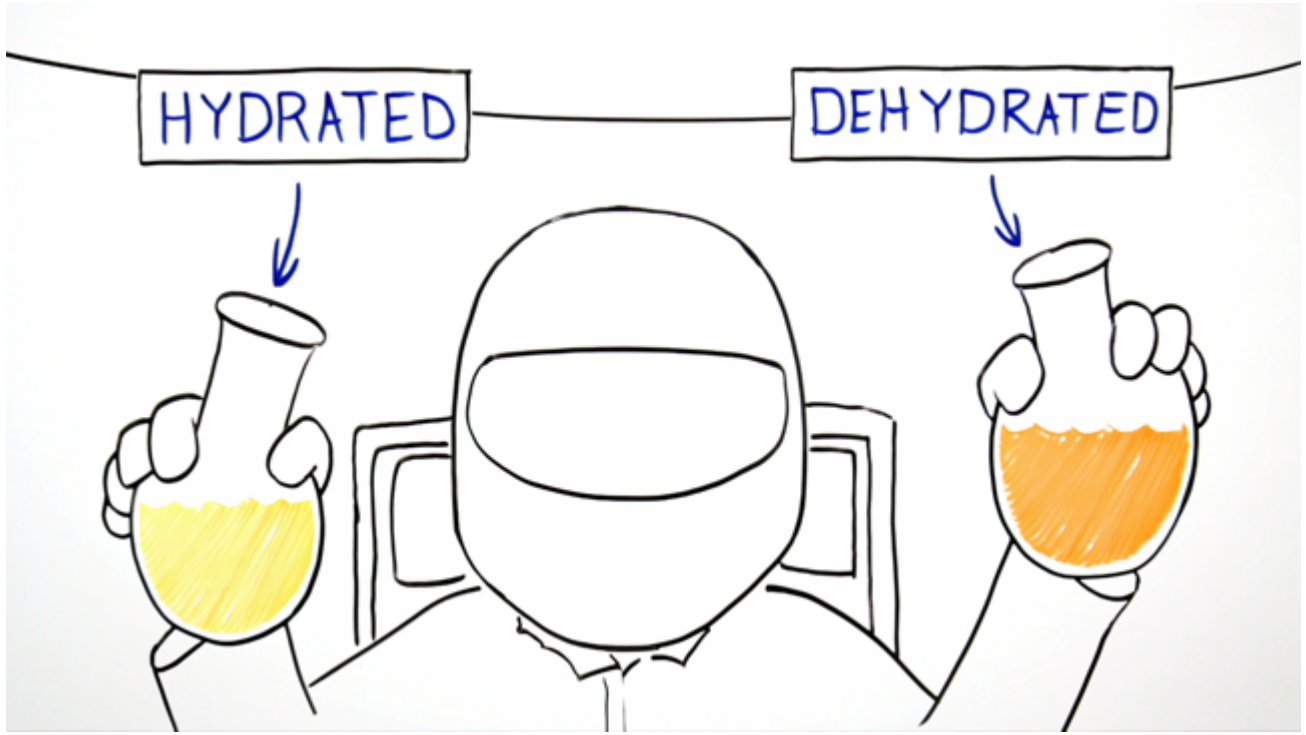
= 39.25 mmol * 22.99 mg/mmol

= **902 mg sodium**

KEY TAKEAWAYS

- ✓ Begin exercise properly hydrated
- ✓ Use a personalized fluid intake strategy based on sweat test results, exercise duration, and environmental conditions
- ✓ Drink enough fluid to prevent >2% dehydration, especially in warm weather
- ✓ Do not overconsume fluids during exercise
- ✓ Consume sodium with fluids if exercise is >2 h in hot weather and/or if sweat sodium losses are very high (> 3 g)

SUMMARY VIDEO



LINK TO VIDEO

Link to Video: https://www.youtube.com/watch?v=BtBhKPaqsJk

www.GSSIweb.org