Hydration

for Female Athletes

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Introduction

Body water is critical for many bodily processes such as regulating blood volume and blood pressure, and transporting oxygen and nutrients (Figure 1). Another key role is regulating body core temperature, which is important for athletes because during exercise, the working muscles generate heat which causes a rise in body temperature. In response, sweat production occurs and the evaporation of sweat from the surface of the skin cools the body. This bodily process prevents a sharp rise in body core temperature and in turn, reduces the risk of heat illness and any associated heat-related impairments in exercise performance.

Figure 1: The role of water in the body

On average, females have a smaller body size and a higher body fat percentage than males. As adipose (i.e., fat) tissue has a lower percentage of water (~10%) than fat-free mass (~74%), females have a lower overall percentage of body water (~55-60%).

Fluid balance

Sweat losses during exercise vary greatly between and within individuals due to factors such as body mass, exercise intensity and duration, environmental conditions, clothing and equipment, and training and heat acclimation status. Although in general females have lower sweating rates than males, this is usually attributed to their lower body mass and absolute exercise intensities.

Ingesting fluids can offset water losses experienced during exercise. However, when fluid intake is less than sweat loss, a body water deficit occurs, which is known as dehydration. On the other hand, if fluid intake exceeds fluid losses, the body will be in a state of hyperhydration (Figure 2).

Significant dehydration (> 2% body mass losses) has been found to impair aerobic performance in the heat, with greater levels of dehydration (3-4% body mass losses) found to impair aerobic performance in cooler conditions, as well as cognitive performance and technical skill in certain team sports. Therefore, it is important to ensure that athletes are adequately hydrating daily, as well as following sufficient hydration practices pre-, during and post-exercise.

Fluid balance terminology:

Hyperhydration
Excessive body water surplus

Euhydration
Normal baseline body water content

Hypohydration
Excessive body water deficit

Dehydration
Progressive body water loss

Rehydration
Progressive body water gain

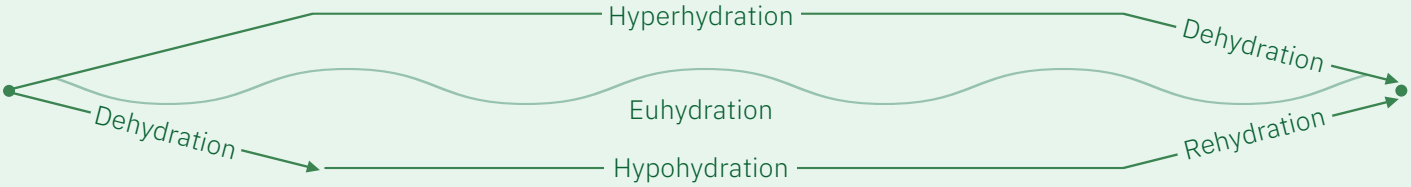

Figure 2: Fluid balance terminology (Greenleaf, 1992)

The information below provides a guide to understanding and meeting daily fluid requirements, spotting the signs of hypohydration, measuring sweat rate, and hydration recommendations for optimal performance.

Daily fluid requirements

Hydration is typically maintained through habitual eating and drinking habits. Both the European Food Safety Authority (EFSA) and the USA's Institute of Medicine (IOM) have published daily water intake recommendations, as shown in Table 1.

Table 1: Total daily water dietary reference intakes values (adequate intakes) for females set by the European Food Safety Authority (EFSA) and the Institute of Medicine (IOM).

Age	EFSA	IOM
9 – 13 years	1.9 L/day ~64 oz/day	2.1 L/day ~71 oz/day
14 – 18 years	2.0 L/day ~68 oz/day	2.3 L/day ~78 oz/day
19 years+	2.0 L/day ~68 oz/day	2.7 L/day ~91 oz/day

Dietary water consumption

In the diet, water is predominantly obtained through consumption of drinking water/beverages (80%) (Figure 3). Some water (20%) is also obtained through the consumption of water-containing foods (Figure 4).

Figure 3: Types of common beverages

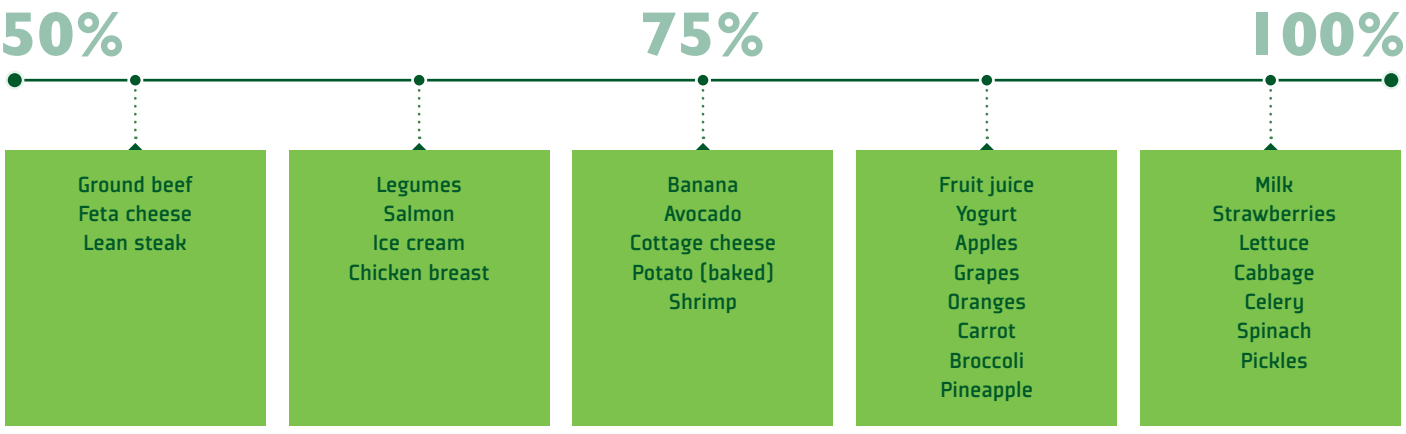

Figure 4: Approximate water content of foods

Important considerations for athletes

Daily fluid requirements may vary day-to-day depending on a variety of factors including how much the athlete sweats during exercise, daily life demands, and environmental conditions. Importantly for athletes, exercise type and intensity can alter fluid needs. Therefore, it is recommended to:

1. **Monitor the hydration status of athletes**
2. **Recognize and educate athletes on the signs of dehydration**
3. **Provide fluid recommendations depending on an athlete's individual needs**

Daily monitoring of hydration

Indicators of hydration status include changes in daily body mass, a measure of urine (i.e., color, volume or concentration), and feelings of thirst.

Specific guidelines for monitoring each indicator are outlined below:

Body mass (weight)

Take daily body mass measurement (ideally nude) at the same time of day on consecutive days, and ideally before any activity or consumption of food/drinks. If daily body mass loss is > 1%, compared to baseline euhydrated values, it may indicate a likelihood of dehydration.

A cost/benefit analysis should be performed before introducing daily measures of body mass. If implemented, female athletes should be educated on the reasons behind why this measurement is being taken.

Urine

Assessing urine volume and color offers a practical and cost-effective method to estimate hydration status. Reduced urine output and/or a darker urine color (indicative of higher concentration) can indicate dehydration. The urine color scale can help to categorize hydration status. Urine specific gravity (USG) and osmolality (UOsm) can also be used to estimate hydration status, as per Table 2.

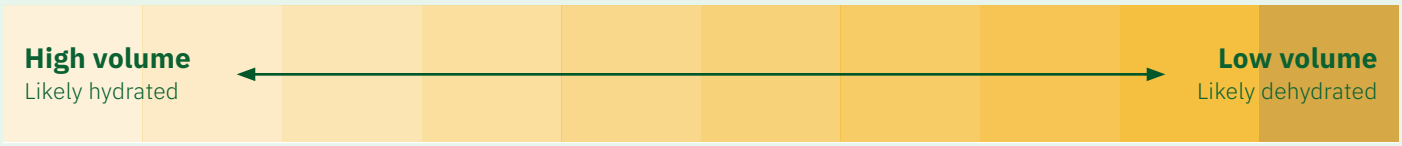

Figure 5: Urine color scale

Table 2: Hydration classification according to urine USG and UOsm values

Classification athlete likely:	Urine USG value	Urine osmolality value (mOsm/kg)
Euhydrated	<1.020	<700
Minimally dehydrated	1.020 – 1.024	700 – 900
Dehydrated	>1.024	>900

(Kenefick & Cheuvront, 2012)

Thirst

Thirst signals the body's need for fluids and can be an initial sign of dehydration. However, the absence of thirst doesn't guarantee the absence of dehydration. Menstrual cycle phase may alter thirst perception, during the luteal phase the rise in estrogen can decrease the osmotic threshold for thirst.

How thirsty do you feel now?

1	2	3	4	5	6	7
not thirsty at all	not thirsty	not very thirsty	neutral	thirsty	very thirsty	very, very thirsty

Figure 6: Thirst scale

Integrated methods for monitoring daily hydration status

Body mass (weight), urine and thirst measures in isolation cannot definitively prove if an athlete is hydrated or dehydrated. The weight, urine colour and thirst (WUT) venn diagram provides a practical hydration assessment tool. The presence of any two indicators suggests a potential for dehydration, while the presence of all three strongly indicates the likelihood of dehydration. Consistent tracking is needed to provide a more accurate picture of hydration status.

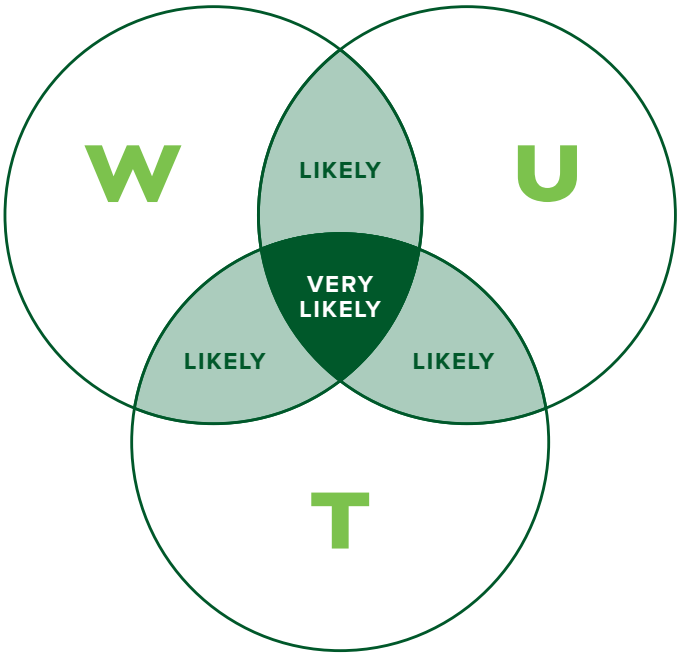

Figure 7: 'WUT' venn diagram (Cheuvront & Sawka, 2006)

W = Weight

U = Urine

T = Thirst

Hydration recommendations pre-, during and post-exercise

Pre-exercise

Athletes should begin any type of physical activity in a hydrated state, while also ensuring that they do not feel bloated, or the need to urinate frequently. It is recommended that athletes consume 5-7 milliliters (mL) of fluid per kilogram (kg) of body mass (mL/kg), 4 hours before the start of exercise. If no urine is produced, or if urine is dark in color, advise athletes to drink an additional 3-5 mL/kg in the 2 hours before exercise starts. A beverage containing electrolytes (i.e., a sports drink) will help the body to retain the fluids consumed.

Use the calculations below to determine pre-exercise fluid recommendations for individual athletes:

4 hours prior to exercise:

_____ body mass (kg) * 5 mL = _____ mL **70 kg = 350 mL**

TO

_____ body mass (kg) * 7 mL = _____ mL **70 kg = 490 mL**

2 hours prior to exercise:

(if needed, i.e., if urine is low in volume and/or dark in color)

_____ body mass (kg) * 3 mL = _____ mL **70 kg = 210 mL**

TO

_____ body mass (kg) * 5 mL = _____ mL **70 kg = 350 mL**

Orange = Example

During exercise

Acute changes in body mass over the course of exercise can be used to measure fluid loss, and in turn the rate of sweat loss per hour (i.e., sweat rate) can be calculated. This information will then inform fluid recommendations during exercise to prevent significant dehydration (> 2% body mass losses). Follow the steps below to calculate sweat rate.

Sweat rate calculator

Step 1: Calculate sweat loss

Pre-exercise body mass		Pre-exercise body mass		Fluid intake		Sweat loss
_____ kg	−	_____ kg	+	_____ L	=	_____ L
70 kg		**69.2 kg**		**0.5 L**		**1.3 L**

Step 2: Exercise time

_____ h

1 h

Step 3: Calculate sweat rate

Sweat loss		Exercise time		Sweat rate
_____ L	÷	_____ h	+	_____ L/h
1.3 L		**1 h**		**1.3 L/h**

Orange = Example

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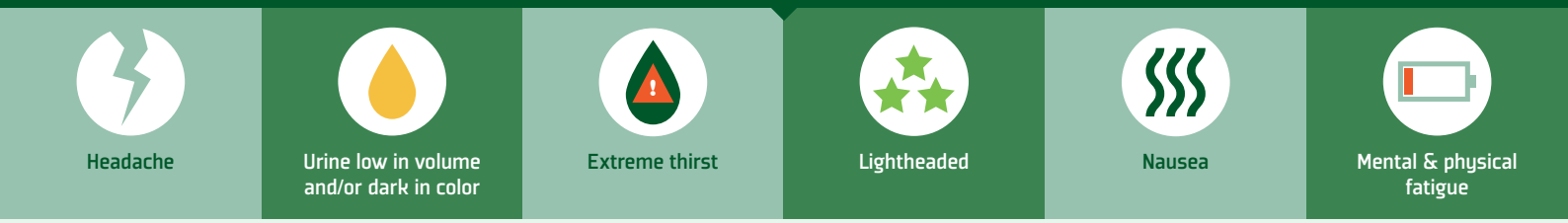
Recognizing dehydration

Due to the large variability in sweat rate between and within athletes, it is advised to measure sweat rates in different conditions to inform personalized fluid recommendations. Having personalized hydration plans will help prevent dehydration. However, it is always important for athletes and practitioners to be able to recognize the signs and symptoms of dehydration.

Recognize the signs of dehydration



To increase fluid intake during exercise, schedule regular fluid breaks (if possible), especially in sessions that are > 60 minutes, of high-intensity, and/or in hot and humid conditions.

High sweat sodium concentrations

When sweating occurs, electrolytes are also lost from the body. One electrolyte of interest is sodium because the concentration of sodium in sweat also varies between individuals. Athletes with high sweat sodium concentrations can often be identified if white salt stains appear on clothing during exercise, or they can be identified through measuring sweat sodium concentrations, however this requires specialist equipment. For athletes with high sweat sodium concentrations, consuming a beverage that contains sodium (such as a sports drink) will help to replace the sodium lost in sweat and it will also stimulate drinking. Sports drinks also contain carbohydrates which can help with the uptake of fluid in the gut, and support physical and cognitive performance.

The effect of both sex and menstrual cycle phase on sweating rate and composition

Both sex and menstrual cycle can have an impact on sweating rate and/or composition, which can be seen in Table 3.

Table 3: The effect of both sex and menstrual cycle phase on sweating rate and composition

	Sex differences	Menstrual cycle
Sweating rate	Women have a lower maximal sweating capacity (i.e., at very high workloads and in hot, dry environments). Otherwise, lower sweating rates observed in women can usually be attributed to lower body mass and absolute workloads. Women have lower output per gland and higher heat-activated sweat gland density. This translates to greater sweating efficiency, which may lead to less wasted sweat (drippage) in humid environments.	During the luteal phase there is an increase in the threshold (body core temperature set point) for the onset of sweating and/or decreased sweating sensitivity. However, there are no differences in whole body sweat rates during exercise across menstrual cycle phases.
Sweating composition	Women tend to have slightly lower sweat [Na^+] and [Cl^-] as a population, but no differences when accounting for absolute workload and/or sweating rate.	None

While there are some observed differences in sweating rate and composition between women and men, these variations are not significant enough to warrant different recommendations based on sex.

Post-exercise

Rehydration is an important part of the post-exercise recovery process. The aim is for athletes to replace any fluid and electrolyte losses that occurred during exercise, before the next exercise bout begins. In most situations, water and sodium can be replaced with normal eating and drinking practices. Drinking a beverage with sodium, or eating sodium-containing foods, will help replace sweat sodium losses, stimulate thirst, and retain the ingested fluids. Athletes are also advised to sip, and not chug, fluids. The replacement of both fluid and sodium should be combined with other recovery priorities (i.e., carbohydrate to replenish glycogen stores and protein to help muscles repair/adapt).

If dehydration is severe (> 5% body mass loses), or if rapid rehydration is needed (i.e., < 24 h before next exercise bout), the recommendation is for athletes to drink 1.2 - 1.5 L of fluid for each 1 kg of body mass loss.

Calculating post-exercise fluid requirements

Pre-exercise body mass		Post-exercise body mass		Body mass loss
_____ kg	−	_____ kg	=	_____ kg
70 kg		**69.2 kg**		**0.8 kg**

Body mass loss		120-150%		Fluid to consume post-excercise
_____ kg	×		=	_____ L
0.8 kg				**1-1.2 kg**

Orange = Example

Conclusion

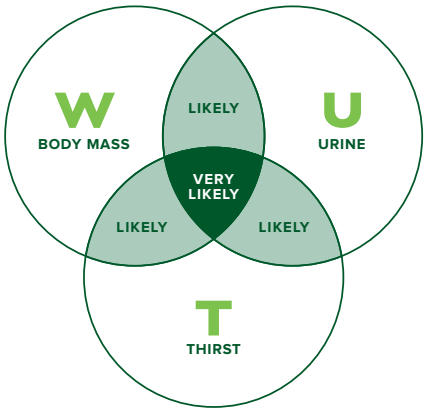
Optimal hydration is important for both health and performance. It is important to monitor the hydration status of athletes, incorporate personalized hydration plans, and enable strategic fluid intake pre-, during and post-exercise. Fluid intake can come from a variety of food and beverages. Table 4 provides practical advice which can be used with athletes on when to ingest different types of beverages. Finally, it is essential that practitioners and athletes recognize the signs of symptoms of dehydration.

Table 4: Practical advice regarding the use of common beverages

Common beverages	Practical advice to use with athletes
Water	• Drink water with all meals • Keep a drinks bottle with you throughout the day • Drink 5–7 ml of water per kg of body mass 4 hours before the start of exercise
Milk	• Avoid close to the start of exercise • Good option as a post-exercise recovery beverage
Sports Drink	• Good choice for before, during and after intense or prolonged exercise • Practice consuming during training sessions, prior to using during competition
Fruit Juices	• To reduce the risk of stomach upset, do not consume too close to exercise or during exercise
Soda	• Enjoy on social occasions • If the soda contains caffeine, avoid consuming late in the evening as it might negatively impact sleep • Zero sugar options recommended if body composition is a priority
Tea (hot/iced), coffee	• Consider coffee 1 hour before exercise to support performance benefits • Avoid after mealtime occasions because caffeine can inhibit iron absorption • Avoid late at night because sleep will likely be impacted by caffeine
Energy drinks (caffeinated, high sugar)	• Avoid drinking late in the evening because energy drinks may disturb sleep • Do not over consume • May be considered in the hour before exercise
Protein recovery shakes	• Ingest post-exercise to maximize adaptive response • Contributes to fluid, electrolyte, and muscle recovery

HYDRATION

Daily monitoring of hydration



Body mass
Daily body mass loss >1% may indicate likelihood of dehydration

Urine
Reduced urine output and/or a darker urine color can indicate dehydration

Thirst
Feelings of thirst may be an initial sign of dehydration

Presence of two indicators: Potential of dehydration

Presence of three indicators: Strong indication of dehydration

Hydration recommendations around exercise

4 hours before exercise	5–7 mL of fluid per kg of body mass
2 hours before exercise	3–5 mL of fluid per kg of body mass (if urine is dark and/or low volume)
During exercise	Use a personalized hydration plan to limit dehydration to 2% of body mass
After exercise	Replace fluid/electrolyte losses through normal drinking practices 120–150% body mass loss if dehydration is severe/if rapid rehydration is needed

Does sex or menstrual cycle phase influence sweating rate and/or composition?

	Sex differences	Menstrual cycle
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Sweating composition	Women tend to have slightly lower sweat [Na^+] and [Cl^-] as a population, but no differences when accounting for absolute workload and/or sweating rate.	None

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Hydration and thermoregulation: https://www.gssiweb.org/en/sports-science-exchange/All/hydration-thermoregulation

Online fluid loss calculator: https://www.gssiweb.org/toolbox/fluidloss/calculator