Module 2. Hydration in exercise

Unit 2.1 Dehydration and Performance

The relationship between a subject's dehydration and their physical performance can arise voluntarily or involuntarily. Dehydration refers to the loss of body water during a state where the body passes from hyperhydration to euhydration, or from euhydration to hypohydration.

We refer to voluntary dehydration when it is used intentionally by the athlete in an attempt to find some alleged athletic advantage (for example, to compete in a lower weight class), using techniques like saunas, steam, diuretics or sweating induced by exercise without ingesting liquids.

On the other hand, we talk about voluntary dehydration as a consequence of a greater loss of liquids due to perspiration in comparison to the amount of liquids ingested during the training session or competition in which the subject is performing.

Independently of how it is brought about, dehydration can affect various physiological processes and this, in turn, hinders the athlete's performance. Dehydration increases physiological tension, as the greater the body water deficit, the greater the increase in physiological tension for an exercise.

A state of dehydration greater than 2% of body weight reduces performance (above all in aerobic exercise) and to the extent that the percentage of weight loss becomes more evident due to lack of ingesting fluids, the decline in exercise can be even greater. We should consider, in any case, that the magnitude of the reduction in the task is probably related to the ambient temperature, the type of exercise and the unique biological characteristics of the individual (for example, their tolerance to dehydration). Some individuals, therefore, are more or less tolerant to dehydration (ACSM, 2007).

2.1.1 The Effects of Dehydration on Performance

During prolonged exercise, the resulting fatigue can be generated both by dehydration and by depletion of the energy substrates in order to carry out the challenge in question. Levels of dehydration greater than a loss of 2% of body mass were studied among soldiers and athletes, the effects of which showed a reduction in their cognitive performance (Grandjean, 2007, Lieberman, 2012, Masento, Golightly, Field, Butler & Van Reekum, 2014).

Armstrong, Costill & Fink (1985) demonstrated that the loss of 1.5 to 2% of body mass reduced performance in 1500 m, 5000 m and 10,000 m races, above all by reducing velocity during the final stages of the races; furthermore, the adverse effects were most evident in the longer races (Armstrong, Costill & Fink, 1985).

In his review, Coyle (2004) indicated that dehydration reduces performance during endurance exercise by means of various interrelated mechanisms, such as the increase of cardiovascular tension, due to hyperthermia and the reduction of blood volume, as well as the direct effects of hyperthermia on muscle metabolism and neurological function (Coyle, 2004).

A deficit of water, without the proportional loss of sodium chloride, is the most common form of dehydration during exercise. If there are greater deficiencies of sodium chloride during exercise, then the volume of extracellular fluid will contract, and this will cause dehydration due to the reduction of sodium reserves. Independent of the method of dehydration, in any deficit of water that are similarities in the alteration of physiological function and consequences in performance (ACSM, 2007).

Dehydration and hyperthermia have a great effect on the reduction of stroke volume and the flow of blood to the muscle, which limits the supply of oxygen to the muscles being exercised. It has been observed that dehydration increases the use of muscle glycogen during continuous exercise, which has a clear effect on performance.

The flow of blood through the skin decreases with dehydration and, the more this increases, the more core temperature and heart rate increase, which is why the reduction in systolic volume is greater (the quantity of blood pumped by the heart in one beat).

We can observe in the following table a summary of physiological factors that contribute to the decrease in performance.

Table 1: Physiological factors caused by dehydration

Increase in core body temperature
Elevated cardiovascular tension - Less blood volume - Less volume per beat - Less Blood flow to the muscle
Altered metabolic function
Altered CNS function
Greater use of glycogen

Source: Prepared by the author.

It is important to highlight that the capacity for endurance is much more effected when there is dehydration in hot environments than in cold environments, which implies that the reduction in thermoregulation function is a determining factor in the drop in performance, linked to a body water deficit.

One current topic of debate is if dehydration can also be an important factor in initiating gastrointestinal (GI) distress, like nausea, vomiting, bloating, gastrointestinal cramps and more.

2.1.2 Heat-Related Complications

High temperatures and physical activity are a combination that can generate lots of stress in the body. Considering that it is preferable to prevent this problem than to treat it, we should pay special attention during exercise to athletes who make up the risk group, like children, the elderly, or those who are in poor physical condition.

Attempting to order complications due to heat based on their seriousness, we can classify them into muscle cramps associated with exercise, heat exhaustion and heat stroke due to exercise.

Heat cramps

Cramps are basically a form of hyperactivity in the motor unit that provokes painful involuntary muscle contractions. Heat cramps are those cramps associated with loss of sweat and present a subtle difference with respect to cramps associated with exercise, as they are defined when they are resolved by replacing sodium.

People who present with this type of cramp tend to sweat extensively and, in turn, have elevated sodium concentration in their sweat. When heat cramps are present, body temperature does not necessarily increase. Their prevention implies two factors:

1) Ingesting liquids with an adequate amount of sodium.
2) Increasing daily salt consumption, before this tension due to heat is encountered (for example, extra salt during main meals).

Lack of ability to restore these minerals with proper frequency determines the pain and muscle spasms, generally in the abdomen and the extremities.

The exact etiology of heat cramps is unknown and is difficult to research, but, as we said before, sodium deficit seems to play an important role in their development.

Heat exhaustion

Heat exhaustion is defined as the inability to continue with the exercise. Heat exhaustion appears after suffering significant losses of liquids and electrolytes, and cardiovascular insufficiency. It is the most common heat-related complication among physically active people, above all among people who are dehydrated, poorly trained and not accustomed to the heat.

Heat exhaustion induced by exercise occurs due to a lack of effectiveness in the circulatory adjustments when the plasma volume reduces due to excessive sweating. Blood accumulates in the peripheral vessels and this significantly reduces the volume of blood required to maintain the cardiac output. This is known as a "brake" that protects the body during stressful conditions, so it deserves attention to avoid greater complications.

The main characteristics of heat exhaustion include weak and rapid pulse, hypertension, headache, dizziness and general weakness. The vast majority of athletes who present heat exhaustion recover at the competition site with adequate hydration or with intravenous treatment for greater effectiveness. In any case, after the event they should suspend the activity, as an immediate return to exercise is not viable (they should rest and properly hydrate during the following 24-48 hours).

Heat stroke due to exercise

As we said before, this is the most serious and complex of the possible complications, as it requires immediate medical attention.

The classic way it appears is expressed with a core temperature in excess of 40.5 °C (104.9 °F), with an altered mental state and an absence of perspiration. It is as though the thermoregulation system has stopped, which causes the temperature to rise.

In this state, immersion in cold water or ice-water is recommended, in order to produce more rapid cooling. The magnitude and length of the hyperthermia determine the damage to the organs and the consequent risk of death (the longer the body spends at an elevated temperature, the greater the damage to the central nervous system and the rest of the organs).

In these cases, oral temperature, in relation to rectal temperature, is not a precise measurement of core temperature after strenuous exercise. This is due to the fact that it depends on the effects that cooling by evaporation in the mouth and airways, derived from the increase in pulmonary ventilation during exercise, has on oral temperature.

2.1.3 Sweat Loss and Electrolyte Loss in Exercise

The human body has two different kinds of sweat glands. The apocrine glands are located in the hairy areas of the body (armpit, crotch, pubis, etc.) and are responsible for producing substances that, when decomposed by bacteria, are responsible for the characteristic odor of these areas. In any case, here we will pay special attention to the eccrine glands, which are principally involved in temperature regulation.

Then amount of liquids an athlete loses during exercise can vary significantly, and for this reason we should identify the external factors and the individual characteristics of the subject that predispose them to this variation:

1) **The external factors are the following:**

   - Duration and intensity of the exercise.
   - Clothing worn.
   - Environmental conditions.

2) **The characteristics of the subject are:**
   - Genetic predisposition.
   - Body weight.
   - Physical condition (more sweat is produced with better condition).
   - Acclimatization (better acclimatization produces more sweat in the subject).

While sweat is mainly water (around 99%), certain important electrolytes and other nutrients can be found in different quantities. Sweat is hypertonic in comparison to body fluids. This means that the concentration of electrolytes is less in sweat than in body liquids.

The composition of sweat can vary depending on the person in question, and can even be different for the same individual when he has adapted to the heat. The main electrolytes that are found in its composition are sodium and chloride, as sweat is derived from extracellular liquids, like plasma and intercellular liquids, which have a high content of these electrolytes.

As we detailed in table 2, the other minerals that are "lost" in small quantities – but to which we should pay attention – include potassium, magnesium, calcium, sodium and chloride.

Table 2: Concentration of electrolytes present in sweat

Electrolytes	Sweat (meq/L)	
	Average	Range
Sodium	35	10 – 70
Potassium	5	3 – 15
Calcium	1	0,3 – 2
Magnesium	0,8	0,2 – 1,5
Chloride	30	5 – 60

Source: Prepared by the author.

Special attention should be paid to those athletes who lose high quantities of sweat, as it could be necessary to increase their dietary intake of certain electrolytes as their losses will be higher during exercise. Prolonged sweating can reduce the concentration of sodium and chloride by between 5-7% and potassium by around 1%, so if this is not compensated for daily, this can cause a deficiency of these ions.

2.1.4 Guidelines of the American College of Sports Medicine (ACSM)

The American College of Sports Medicine proposes, in their last pronouncement (ACSM, 2007), maintaining adequate hydration in individuals carrying out physical activity. They also summarize exercise knowledge with respect to liquid and electrolyte needs and the impact of their imbalances on athletic performance and health. Among the main guidelines, they address the timing of liquid consumption, based on the moment of the exercise in which the athlete finds himself.

Replacing fluids before exercise

The pre-exercise hydration program will help ensure that any prior deficit in liquids and/or electrolytes is corrected before starting the activity.

They propose beverage intake of about 5-7 ml/kg of weight at least 4 hours before exercise, considering that if the individual does not produce urine, or if the urine is dark before the event, they should add another 3-5 ml/kg of weight 2 hours before the event in question.

The consumption of beverages with sodium (20-50 meq/L) and/or small quantities of salty snacks or foods that contain sodium during meals will help stimulate thirst and retain the consumed liquids.

The attempt to hyperhydrate oneself with liquids that expand the extracellular and intracellular spaces (for example, solutions of water and glycerol) will increase the risk of having to urinate during the competition, and does not provide physical advantages in performance in comparison with euhydration.

The preferred water temperature is frequently between 15 and 21 °C, but this factor and flavor preferences vary significantly among different individuals and cultures (Castaño, 2012).

The consumption of beverages with sodium and/or salty foods with beverages can help stimulate thirst and retain the liquids that are needed for the coming event.

Replacing fluids during exercise

It is difficult to recommend a specific program for replacing liquids and electrolytes due to the different characteristics of different types of exercise (metabolic requirements, duration, clothing, equipment), the weather conditions and other factors (for example, genetic predisposition, acclimatization to heat, and level of training), which all influence a person's sweat rate and the concentrations of electrolytes in the sweat (ACSM, 2012).

As we will see in the next chapter, obtaining the sweat rate of the athlete allows us to have a pattern in order to set a certain system for replacing liquids during the event. It is recommended, for example, that individuals be able to monitor the changes in body weight during training sessions or competitions to estimate their losses of sweat during an exercise task, in particular with respect to the weather conditions at that moment.

The composition of the liquids consumed could be important. According to the Institute of Medicine (1994), it is recommended that this type of beverage should contain approximately 20-30 meq/L of sodium, 2-5 meq/L of potassium and 5-10% carbohydrates (IOM, 1994). The need for these different components (carbohydrates and electrolytes) depends on the specific exercise task (for example, the intensity and the duration) and the climate conditions. The position of the ACSM also indicates that the sodium chloride ingested in a beverage consumed during exercise can help ensure an adequate fluid intake and stimulate a more complete rehydration after exercise. Both answers highlight the important role that sodium plays in maintaining the osmotic impulse to hydrate and in the osmotic stimulus to retain fluid in the extracellular space (ACSM, 2012).

With respect to carbohydrate consumption during high intensity exercise, that is, with a duration of 1 hour or more, this has been demonstrated to be beneficial. A rate of 30-60 g/h maintains the glucose levels in the blood and sustains performance during the exercise. Higher rates of carbohydrate delivery can be reached with a mix of sugars (for example glucose, sucrose, fructose, maltodextrin). If both replenishing liquids as well as carbohydrate delivery are to be covered in a single beverage, the concentration of carbohydrates should not exceed 8% and in fact should be slightly lower, as beverages with a high concentration of carbohydrates reduce gastric emptying.

Consumption of 500-1000 c.c. of sports drink (with 6-8% CHO) supplies between 30 to 80 grams/hour along with sufficient water. This consumption could avoid excessive dehydration and, in turn, over-compensate for the glycogen hole that occurs with the activity.

The ACSM also proposes that the consumption of caffeine in appropriate doses could help sustain performance in exercise and, probably, would not alter the state of hydration during exercise.

Replacing fluids after exercise

Ingesting fluids after physical activity could be a critical factor for aiding rapid recovery between each session of physical activity. Many athletes train more than once per day, which makes rapid rehydration an important consideration, especially if they are training in hot environments.

Maughan, Leiper & Shirreffs (1996) maintain that ingesting water is ineffective for producing normal hydration, as water absorption diminishes plasmatic osmolarity, so it suppresses thirst and increases urine production. When sodium is added, either in rehydrating beverages or in foods, the osmotic stimulus of thirst is maintained, and urine production is reduced (Maughan, Leiper & Shirreffs, 1996).

The main challenge, based on the ACSM's recommendations, is to completely replenish any deficiency of liquids and electrolytes that arises during training. The load of liquids depends on the speed with which rehydration needs to be completed and the magnitude of the deficiency of liquids and electrolytes. If the recovery time and circumstances permit, consuming food, along with a sufficient volume of water, will restore euhydration (using foods that contain sufficient sodium to replace the losses due to sweat). If dehydration is substantial with relatively short recovery periods (less than 12 hours), aggressive rehydration programs could be necessary (via intravenous methods).

Sodium losses are more difficult to quantify than water losses. If we know that individuals lose electrolytes through sweat at different rates, adding a little extra salt to their recovery foods and liquids could be beneficial when sweat loss is abundant.

To cover the losses incurred during exercise, the review indicates that an intake of 1.5 liters of liquids (or more) per kilogram of weight lost in training is required. Whenever possible, liquids should be consumed spaced apart in time (and with sufficient electrolytes), instead of being ingested in large quantities in a short time (Castaño, 2012).

Ingesting at least 150% of the weight lost during the first 6 hours after exercising is recommended, to cover the liquid eliminated both in sweat and in urine; in this way fluid balance is recovered.
For example: an individual who loses 1 kg of weight after their effort should ingest at least 1500 c. c. of liquids to compensate for the losses. In turn, rehydration should begin as soon as exercise has finished, even before the sensation of thirst appears.

Losses greater than 7% of body weight, with nausea, vomiting or diarrhea, or people who, for whatever reason, cannot ingest liquids orally, could justify intravenous liquid replacement. In other situations, this method does not provide any advantage over oral intake to replenish the deficiencies.

Unit 2.2 Assessing Perspiration Status

The perspiration pattern of each subject is very variable, so some individuals are more prone to dehydration than others. Establishing the pattern is complex, as there is not a consensus about the best way to determine it, and the most reliable methods, according to the literature, are not within the reach of athletes/evaluators. It is here where a combination of simple methods allows us to have a certain degree of certainty with regard to the athletes' needs.

As we saw in the beginning of the module, gains in water come from the total consumption of liquids/foods and from the endogenous metabolic production, while losses of water occur through respiratory, gastrointestinal and renal tracts, and through sweat.

As the American College of Sports Medicine proposes:

> When an individual's state of hydration is evaluated, there is not a single TBW (total body water) value that represents euhydration. The determinations need to be made on the basis of fluctuations beyond a range that has functional consequences. Ideally, the biological markers of hydration should be clear and sufficiently precise to be able to detect fluctuations in body water of approximately 3% of Total Body Water (or the change in water content sufficient to detect fluctuations of approximately 2% of body weight for the average person). Additionally, the biological marker should also be practical to use (time, cost and technical skill) for individuals and coaches (http://www.acsm.org/).

As a result of this proposal, we consider that both changes in the subject's body weight as well as urinary indicators are the most practical tools to develop on the ground in order to make a basic diagnosis of the situation.

The following table gives us a guideline with respect to the variety of biological markers of hydration, their use and variability in the face of acute or chronic changes in state.

Table 3: Biological markers of hydration state

Measurement	Practical Use	Validity	Euhydration Cut-point
Total Body Water	Low	Acute and chronic	<2%
Plasma osmolality	Medium	Acute and chronic	<290 mOsmol

Specific gravity of the Urine	High	Chronic	<1020 Usg
Urine Osmolality	High	Chronic	<700 mOsmol
Body weight	High	Acute and chronic	<1%

Source: http://www.acsm.org/

We will also develop these further in the module to understand their practicality and/or utility in different moments.

2.2.1 Total Body Water

The process of measuring water balance for data collection on intake and output has been modernized through the estimation of total body water (TBW), which requires measurements of the dilution of trace quantities of an isotope (generally deuterium oxide, $^{2}H_2O$).

A known volume and concentration of an isotope is introduced into the body, and later a determination is made of the new concentration of the isotope in a sample of body fluid (blood, saliva, etc.) after the marker has been able to distribute itself equally throughout the body's fluids. The unknown volume (TBW) is calculated, and we know that a low concentration of the isotope in the sample means that the body fluid volume should be relatively high and vice versa. Like quantitative techniques, isotope dilution does not permit the determination of a suitable baseline due to the wide variability in body composition and in the variability associated with normal total body water. All the same, the total measurement error of TBW using dilution of markers is as low as 1% (Ritz, 1998), so it permits the measurement of small changes in body fluids.

This model provides us with one of the most reliable possible measurements for determining the state of body hydration, but it is not useful for the majority of people due to its practicality.

2.2.2 Osmolality in the Plasma

Plasma osmolality is controlled around a fixed point of euhydration of approximately 285 mOsm/kg (DRI Panel 2015). If sweat losses due to exercise are not replaced, the volume of body water is reduced. The plasma volume and extracellular water diminish as they provide the liquid for the sweat, and plasma osmolality increases because sweat is hypotonic in relation to plasma. In other words, sweat removes relatively more water from the body fluids than solutes like sodium and chloride, and these osmatically active solutes increase in the blood plasma. The increase in osmotic pressure in the plasma is proportional to the decrease in total body water. Popowski et al (2001) demonstrated under well controlled conditions that plasma osmolality increases approximately 5 mOsm/kg for each loss of around 2% of body weight due to sweat. They also observed that plasma osmolality returns to normal values during rehydration, which is why it is one of the variables that is subject to short term changes.

This model, while it is less complicated than that of TBW, is also complex to measure and, for this reason, is not usually useful in the field.

2.2.3 Urinary Indicators (Color, Specific Gravity, and Osmolarity)

Urinary indicators of dehydration include an elevated specific gravity (USG) and osmolarity (UOsm) of the urine, along with a dark coloration (UCol). As we explained before, while not as reliable as the previous methods, in summary, with respect to what occurs with the athlete's weight, they allow us to observe and approximate the hydration status of the subject in question.

Urine is a solution of water and other substances, which increase or decrease their concentration with respect to the total volume. It is linked, additionally, with dehydration; thus, urine production varies to regulate the balance of liquids.

The production of urine is around 1 to 2 liters per day, but it can increase 10 times more when large amounts of liquid are consumed (Sawka, 2005). This great capacity for varying the production of urine represents the main method for regulating the net balance of body water through the broad range of volumes of liquid consumption and fluid loss through other means. Although it is not very practical to measure the volume of urine every day, quantitative (USG, UOsm) or qualitative (UCol) evaluation of its concentration is much more simple. As a research tool for differentiating euhydration from dehydration, the urine concentration indicated by USG, UOsm or UCol is a reliable evaluation technique with reasonably defined thresholds (Armstrong, 1994, Bartok, Schoeller, Sullivan, Clark and Landry, 2004, Shirreffs and Maughan, 1998).

In the following table we can observe reasonable values by category and consider that they are reliable indicators to orient ourselves with respect to chronic dehydration and not to acute dehydration, as the consumption of a large quantity of liquid could modify the evaluation of the state of hydration on the basis of these indicators. For this reason, we should use samples from the first urination of the day, or after several hours (at least 24) during which the hydration status has been stable.

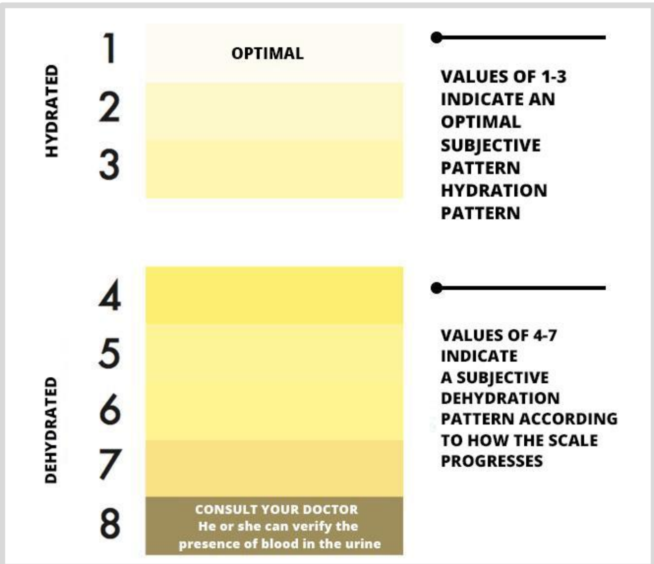
Table 4: Hydration categories (for a 75kg subject)

Hydration Category	USG on an empty stomach	24 hour USG	20 smolality on an empty stomach (mOsm)	24 hour osmolality (mOsm)
Extremely hydrated	<1017	<1012	<545	<377
Very well hydrated	1012- 1021	1012- 1014	545- 713	377- 345
Well hydrated	1022- 1023	1015- 1017	714- 817	476- 586
Normally hydrated	2014- 1026	1018- 1020	818- 924	587- 766
Slightly dehydrated	1027- 1028	1021- 1024	925- 999	767- 880
Very dehydrated	1029- 1031	1025- 1027	1000- 1129	881- 1013
Extremely dehydrated	<1031	<1027	<1129	<1013

Source: (Armstrong, Pumerantz, Fiala, Roti, Kavouras, Casa & Maresh, 2010).

Another tool that it is useful to consider, precisely for its practicality, is the Urine Chart, which consists of a scale of eight urine colors that get progressively darker as the dehydration present in the subject increases. On the basis of this scale, these specialists found that the color showed a high correlation with the specific gravity and the osmolarity of the urine and, thus, could be used to determine the state of hydration when high precision is not necessary (like, for example, for use with athletes in fieldwork, the use of which is not valid in research protocols). In any case, we should consider that it is a subjective tool and that, in turn, the color of the urine can change due to illnesses, vitamin or pharmaceutical consumption, certain foods and some food additives.

Figure 1: Urine Chart Scale



Source: (Armstrong et al., 1994)

2.2.4 Body Weight and Sweat Rate

A simple method to determine the level of dehydration reached during a physical activity consists in weighing the athlete before and after carrying out the exercise. When comparing the body weight of the athlete before and after, we can determine the level of dehydration provoked by the exercise, as we know that, for intermittent efforts lasting fewer than 3 hours and in non-extreme weather conditions (less than 35 °C and greater than 5 °C), the loss of water due to breathing is not significant with respect to that produced by sweating.

This tool is frequently used to evaluate rapid changes in an athlete's hydration, generally on the field. The use of this technique assumes that 1 gram of lost mass is equivalent to 1 ml of water lost.

In general, among well-hydrated people who have balanced energy, body weight (BW) on an empty stomach (after urinating) will be stable and fluctuate <1%. For active men who freely consume foods and liquids, they should, upon waking up in the morning and without clothing, take three consecutive BW measurements to establish a basal value, which will approximate euhydration. Women could need more BW measurements to establish a basal value, because their menstrual cycles influence the state of their body water.

Acute changes in BW during exercise can be used to calculate sweat rates and variances in hydration status that occur in different environments. This is achieved with measurements of BW before exercise in comparison with post-exercise BW, corrected for losses of urine and the volume of liquid drunk. Whenever possible, weight should be measured nude to avoid corrections for sweat trapped in clothing (goo.gl/CjmlKN)

Sweat rate

As we described before, using certain variables (weight at the beginning of exercise, weight after exercise, liquid ingested, urine excreted and minutes of activity) we can obtain the sweat rate for the subject in question. This rate allows us to obtain the sufficient quantity of liquid that should be replaced for each minute of the activity and the quantity that needs to be replaced based on their individual needs.

This calculation can be made using the formula taken from Murray (2007):

Sweat rate (ml/min) = (weight lost (g) + liquid ingested (ml) - urine (ml)) / minutes of activity (min).

Table 5: Example of how to calculate sweat rate

Variable	Value
Body weight before exercise	73%
Body weight after exercise	71,4%
Weight lost	1,6 Kg (1600 gr)
Beverage volume ingested	400 ml
Volume of urine in activity	200 ml
Time of exercise	60 min
Sweat rate= - 1600 gr + 400 mi – 200 mi / 60 min = 30 ml/min	

Source: Prepared by the author.

As we stated above, as it is a simple tool to implement, in scientific literature we often find different values of sweat rates (expressed in L/h or ml/min) and, on the basis of this, it is possible to figure out, in a global fashion, the needs of the sport in question.

Below we will look at one of the many tables available in the literature to be able to see the hydration profile that some sports require.

Table 6: Sweat rates, voluntary liquid consumption and % loss of BW in various sports

		Sweat Rate		Voluntary consumption of liquid (L-h"1)		Dehydration (%BW) (= change in BW)	
Sport	Condition	Average	Range	Average	Range	Average	Range
Water polo [41]	Training (males)	0.29	[0.23-0.35]	0.14	[0.09-0.20]	0.26	[0.19-0.34]
	Competition (males)	0.79	[0.69-0.88]	0.38	[0.30-0.47]	0.35	[0.23-0.46]
Netball [16]	Training in summer (females)	0.72	[0.45-0.99]	0.44	[0.25-0-63]	0.7	[+0.3-1.7]
	Competition in summer (females)	0.98	[0.45-1.49]	0.52	[0.33-0.71]	0.9	[0.1-1.9]
Swimming [41]	Training (males and females)	0.37		0.38		0	(+1.0-1.4 kg)
Rowing [22]	Training in summer (males)	1.98	(0.99-2.92)	0.96	(0.41-1.49)	1.7	(0.5-3.2)
	Training in summer (females)	1.39	(0.74-2.34)	0.78	(0.29-1.39)	1.2	(0-1.8)
Basketball [16]	Training in summer (males)	1.37	[0.9-1.84]	0.80	[0.35-1.25]	1.0	[0-2.0]
	Competition in summer (males)	1.6	[1.23-1.97]	1.08	[0.46-1.70]	0.9	[0.2-1.6]
Soccer [130]	Training in summer (males)	1.46	[0.99-1.93]	0.65	(0.16-1.15)	1.59	[0.4-2.8]
Soccer [89]	Training in winter (males)	1.13	(0.71-1.77)	0.28	(0.03-0.63)	1.62	[0.87-2.55]
American Football [62]	Training in summer (males)	2.14	[1.1-3.18]	1.42	[0.57-2.54]	1.7 kg (1.5%)	[0.1-3.5 kg]
Tennis [15]		1.6	[0.62-2.58]	~1.1		1.3	[+0.3-2.9]
Tennis [14]	Competition in summer (males)		[0.56-1.34]	~0.9		0.7	[+0.9-2.3]
	Competition in summer (females)	2.60	[1.79-3.41]	1.6	[0.80-2.40]		
Squash [18]	Competition in summer (males prone to cramping)	2.37	[1.49-3.25]	0.98		1.28 kg	[0.1-2.4 kg]
Half marathon T911 [Z1J]	Competition (males)	1.49	[0.75-2.23]	0.15	[0.03-0.27]	2.42	[1.30-3.6]
Cross-country running LDZJ	Competition in winter (males)						
	Training in summer (males)	1.77	[0.99-2.55]	0.57	[0-1.3]	~1.8	
Ironman Triathlon [133]	Competition in temperate climate (males and females)						
	Swimming segment					1 kg	(+0.5-2.0 kg)
	Cycling segment	0.81	(0.47-1.08)	0.89	(0.60-1.31)	+0.5 kg	(+3.0-1.0 kg)
	Running segment	1.02	(0.4-1.8)	0.63	(0.24-1.13)	2 kg	(+1.5-3.5 kg)
	Full competition			0.71	(0.42-0.97)	3.5%	(+2.5-6.1 %)

Source: (ACSM, 2007)

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