Nutrición Hospitalaria

Nutr Hosp. 2014;29(1):21-25
ISSN 0212-1611 • CODEN NUHOEQ
S.V.R. 318

Revisión

From dehydration to hyperhidration isotonic and diuretic drinks and hyperhydratant aids in sport

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Abstract

The needs of water and electrolytes are quite variants, depending on age, physiological or environmental conditions. In most long-term sports, usual weight loss of 3-6%, affect in athletic performance. The effects of a 6% dehydration could be improved with individualized diet-specific nutritional strategies and allow only a 2-3% dehydration, which affect metabolic efficiency but will not risk the health. On the contrary, hyperhydration can be dangerous and is associated with hyponatremia that can cause cerebral edema or respiratory failure. Sports drinks should moisturize, providing minerals and carbohydrates and increase the absorption of water by an ideal combination of salts and sugars. Therefore, it is important to provide correct hydration -protocols before, during and after physical activity, as well as know possible limitations of the sport.

(*Nutr Hosp.* 2014;29:21-25)

DOI:10.3305/nh.2014.29.1.6775

Key words: *Hydration. Dehydration. Sport. Diuretic drinks. Hyperhydration.*

DE LA DESHIDRATACIÓN A LA HIPERHIDRATACIÓN; BEBIDAS ISOTÓNICAS Y DIURÉTICAS Y AYUDAS HIPERHIDRANTES EN EL DEPORTE

Resumen

Las necesidades de agua y electrolitos son variantes, según la edad, estado fisiológico o condiciones ambientales. En la mayoría de deportes de larga duración, es habitual una pérdida de peso de un 3-6%, que repercutirá en el rendimiento deportivo. Los efectos de un 6% de deshidratación podrían mejorarse con estrategias dietético-nutricionales específicas e individualizadas y permitir únicamente un 2-3% de deshidratación, que afectará a la eficiencia metabólica pero no tendrá riesgo para la salud. Al contrario, la hiperhidratación también puede ser peligrosa, asociándose a hiponatremia que puede provocar edema cerebral o insuficiencia respiratoria. Las bebidas isotónicas deben hidratar, aportar sales minerales e hidratos de carbono y aumentar la absorción de agua mediante la combinación de sales minerales y azucares. Por ello, es importante aportar correctos protocolos de hidratación antes, durante y después de la actividad física, así como conocer las limitaciones a las que la práctica deportiva nos pueda llevar.

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Palabras clave: *Hidratación. Deshidratación. Deporte. Bebidas diuréticas. Hiperhidratación.*

Introduction

The need of water and electrolytes vary according to age, physiological or environmental conditions. Up to 50-65% of total body weight is water and if this ratio is out of limits, it can reach states of dehydration or overhydration, which could endanger the health of the athlete.[1]

Water is an essential part of the body fluids and the means of transport of substances, is part of various bodily secretions and is the medium where biochemical reactions occur. From the standpoint of digestive physiology it attends multiple processes and regulates body temperature. The main functions of water in relation to physical activity are: transport of

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Recibido: 14-IX-2013.
Aceptado: 6-XII-2013.

Table I
Physiological effects of dehydration according to the degree of dehydration (own elaboration)

Dehydration levels	*Physiological effects*
1%	Increase of 0.3º C and about 6 pul/min at the same load of exercise[8].
2%	**Affectation at level of thermoregulation.** Tbody increases (0.6-1º C) and HR.
3%	Decreases muscle strength due to loss of bioenergetic efficiency. Hyperthermia, headache and disorientation can occur.
4%	Loss of endurance and strength. Muscle cramps due to loss of electrolytes. Risk of freezing to altitude and below 0º C.
5-6%	Exhaustion. Increases body temp (39-41º C).

T: temperature; HR: heart rate.

oxygen to tissues, hormones and nutrients as well as carbon dioxide and other metabolic wastes; containing blood pH buffering agents, and helps dissipate heat. Individuals with less body water (women, obese, elderly) have increased risk of dehydration and should control more their hydration.[2] The amount of water varies greatly depending on the tissue: blood containing 80%, 70% muscle and adipose tissue of 20-25%. Thus, subjects with more fat, less water will. Athletes who have more blood volume and muscle, have high levels of body water (60-65%), if they are hydrated.[3] This decreases their susceptibility to dehydration.

However, long-term sports (marathon, triathlon ...) of more than 4 hours, the usual 3-6% loss of body weight, which will impact on the health and is a limiting factor in athletic performance.[4] The effects of 6% dehydration could be improved with specific dietary and nutritional strategies and individualized, and allow only 2-3% dehydration, which affect the metabolic efficiency but will not pose a health risk.[5]

Method

A search was made on the basis of Pubmed, Scirus, SciELO, SportDiscus, Embase and Scopus data. We have also obtained documents with the search engine "Google Scholar" and a snowball strategy, in order to get more items.

Keywords coincide with the descriptors of Medical Subject Headings (MeSH) ("sport" OR "hydration" OR "replacement fluid" OR "isotonic drinks" OR "sport drinks" AND "recovery drinks" AND "nutritional aids" AND settled "hyperhidration" in both English and Castilian). Search was done between the years 2006-2013, integrating other relevant articles through the snowball search strategy.

Studies on dehydration and hyperhydration

A mild dehydration (2%) is the limit in which the decay of physical and cognitive performance begins. It reduces plasma volume, increases heart rate (HR) decreases blood flow to the skin, sweating and heat dissipation is reduced and body temperature increases by 1° C, and when it reaches 39° C, performance fell drastically by a malfunction of energy production and neuropsychological impairment.[6] This causes dehydration concentration in sports (motorcycling, formula 1)[7] to reduce the performance.

Thus we can classify the effects of dehydration levels (table I).

The 5% dehydration exercises which exceed the anaerobic threshold for 10', affects the anabolic/catabolic state. It increases cortisol and consequently the same load of exercise may prove more fatiguing.[9]

On the other hand, hyperhydration (common in endurance races) can also be hazardous,[10] being associated with hyponatremia. It can cause cerebral edema or respiratory failure.[11] Dilutional hyponatremia is characterized by a plasma concentration of sodium (Na) less than 135 mEq/L. The incidence increases from 6-8 hours (> 30° C and relative humidity 55%), it is associated with a lack of heat acclimatization, Na loss by excessive intake of water or hypotonic beverages. It is treated with hypertonic beverages, as those used after sporting events[12] and with proper heat acclimatization for 7-14 days (training in hot and high humidity environments).

In Athletics ultra-marathon races (120-160 km), because of the difficulty of ingesting adequate amounts of liquids, states of dehydration (3-6%) occur in 50% of marathoners and 30% suffer from hyponatremia.[13] However, cyclists in races of ultra-endurance can ingest a larger amount of beverage, as there is less

Table II
Functions of the main electrolytes (own elaboration)

SODIUM (Na)	Regulates the amount of water in the body and intervenes in the muscle excitability and cell permeability.
POTASIUM (K)	Regulates the intracellular water content by intervening in protein and carbohydrate synthesis, neuromuscular excitability, etc.
CHLORINE (Cl)	Maintains osmotic pressure and acid-base balance and is essential in the gastric juice.

stomach movement. Knechtle B et al.,[14] studied ultra-endurance "non-stop" races of more than 1 day. Cyclists ingested 0.7 l/h of isotonic beverage and increased the density of the urine and 1.4% weight loss was observed.

In sports of short duration, such as those of high intensity force, dehydration reduces the ability of the central nervous system to stimulate muscle contraction.[15] Thus, 3% dehydration reduces strength in the upper body by 8% and 19% of the lower body.[16]

In turn, in swimmers, we observe differences in respect to other water sports. If the water temperature is below that of the body, sweat loss is smaller. Therefore, despite the high relative humidity (indoor) (65-80%), the rate of sweating barely reaches 0.5-0.7 l/hour, 1-2% weight loss competitions of 2 hours and up to 2.5% in 3 hour competitions.[17] During training high water losses (0.5-l/h) have not been observed, and these are compensated with an intake of sports drinks during the workouts.[18]

Water and electrolyte needs in sport

It is important to know where the hydric losses and intakes come from. Among the daily losses we have urine (1-2 L), sweat (0,1 L), transpiration (0,3 L) and faeces (0,1 L). Water taken (2-4 L), comes from drinks (1-3 L), food (1,6 L) and metabolic water (0,4 L).[19] In sport, through breathing and sweating losses may reach 2-4 l/h. The water needs depend on the intensity of the activity and thermal stress, 0.7-1 l/h of isotonic drink during activity should be taken.[20] The drink should contain 0.5-0.7 g Na/l in sports of 2-3 hours and Na 0.7-1.2 g/l in ultra-endurance.[21]

It is difficult to assess the needs of each group or individual, as they vary a lot even in the same individual depending on several factors such as environmental conditions and physical activity.[22]

In sports, to dissipate heat it occurs mainly through sweating, not to mention losses due to hyperventilation.[23] Thus, it is considered normal for someone sedentary the intake of 2 l/d[24] 3 l/d[20] in an active person.

In the sporting context electrolytes are critical (table II).

Characteristics of isotonic drinks

Sports drinks should: hydrate and prevent dehydration during sports activity, provide mineral salts (mainly Na and Cl and P); provide carbohydrates (HC) increase the absorption of water by the combination of mineral salts and sugars (fast and slow absorption in a ratio of 3/1).

For hydration to be adequate, drinks during the competition must be isotonic (200-320 mOsm/kg water). During physical activity, in sports with a duration of less than 1 hour, international institutions recommend not exceeding 6-9% in the concentration of HC.[21]

Some authors recommend a maximum intake of 90 g/h HC in ultra-endurance competitions, but these amounts may cause gastrointestinal discomfort.[25] Despite this, athletes who tolerate HC more during the competition, are those with the highest performance. So the latest recommendations on long-term athletes are 60-90 g of HC/h, especially after 4 h.[26]

Optimal amounts of intestinal absorption are 600-800 ml/h water, 60 g glucose[27] and up to 90 g of maltodextrin and fructose,[28] the latter can give gastrointestinal problems. Therefore it is not recommended that the beverage contains more than 20-30% fructose.

Lower temperatures (10° C) slow the absorption of the beverage and above 20° C are not desirable. It is important to maintain proper temperature of the drink, especially in hot environments being able to use ice cubes and keep it cool and appetizing as well.[29]

Diuretic drinks and their effects on hydration

There are diuretic beverages, such as alcohol. So if the alcohol is 2% it can hydrate but 4%30 dehydrates (beer, cider, wine). As beer has a high glycemic index, it could help the recovery of muscle glycogen post-exercise, but sports drinks are more appropriate to have a correct osmolarity, salt concentration and optimal HC.

There has also been controversy about taking high doses of caffeine (300 mg/d), for their diuretic effects. However, according to Maughan et al.,[31] the diuretic effect of caffeine can be significant in unaccustomed sportsmen. According to Del Coso et al.[32] in cyclists accustomed to 63% heat VO_2max 2 h with 6 mg caffeine/kg, it was observed that it increased diuresis (28%) and loss of electrolyte (14%). But these effects diminished if taken with isotonic drink, not affecting an exercise of 2 h at 36º C, thus its

Table III
Hydration protocol and fluid replacement (own elaboration)

	Before	*During*	*After*
Recommendation of hydration	Drink 5-7 ml/kg 4 h before exercise. If you can not urinate or its dark (concentrated), you should add 3-5 ml/kg over the last 2 h. On very hot days ensure an intake of 0,5L in the last hour.	Drink every 15-20' 150-250 ml of isotonic drink with 6-8% mixture of sugars. Drink 0.6-1l/h, depending on sport. Ensure taking Na 0.5-0.7 g/l. On hot days and in ultra endurance increase Na 0.7-1g/l.	Ingesting at least 150% of the weight loss (1.5 l/kg lost weight) the first 6 h post-exercise, with Na 1-1.5 g /l.[35,36]
Characteristics of the beverage	Isotonic 0.5-0.7 g Na/l. 4-6% sugars	Isotonic 0.5-0.7 g Na/l. 6-8% sugars	Hypertonic 1-1.5 g/l Na. 9-10% sugars[35,37]
Other nutrients for sports recovery		The taking of protein hydrolyzate of rapid absorption (2-4%) in ultra-endurance races can be effective to improve recovery[38,39].	Aa branched: help muscle recovery and improve the immune system[40]. It has been seen immunomodulatory role of sugars[41]. Drink HC 1.2 g/kg helps restore muscle glycogen, more if we add hydrolyzed protein ratio HC/P, 3-4/1[42].
Observations	Drinks with high amounts of Na (above 1 g/l) and salty foods stimulate thrist and retain fluid. In competitions longer than 1 h, take isotonic drink.	In modalities with great stomach movement it will be difficult to take more than 0.6 l/h. In modalities such as cycling or when competing at irregular intensities it an increase the volume.	If you have lost more than 2% of body weight you shoud be drinking even if there is no thirst and provide more Na, even if its with salty foods.
Other aids	Glycerol or combination with creatine may help as hyperhydrant.	The use of drums or camelback and carrying ice cubes.	Salty foods.

Na: sodium; AA: amino acids; HC: carbohydrates; P: protein.

Table IV
Hyperhidrants ergonutritional aids (own elaboration)

	Effects	*Intake protocol*	*References*
Glycerol	Decreases body T, FC and perceived exertion. Weight loss < 2%.	1-1.5 g/kg in 1.5-2 L of fluid 2.5-4 h before AF.	[43-45]
Creatine	Responsible for the synthesis of ATP proton buffering and muscle enhancer FC and T decreases in the body during exercise.	20 g/d (500 mL water) 5-7 days, 2 g/d 2 months and a half. Shoud intake with HC (100 g/5 g creatine), it retains 60% more.	[46,47]
HC lost	Helps retain creatine	4.8% HC (sports drink) 300-500 mL 6-10% in 15 min before the AF. During 6-8% HF 800-1,500 mL/h.	[47,48]
Sodium	Retains liquids	23-69 mg/100 mL (sports drink). During AF 10-30 mmol/L.	[48]

T: temperature; HR: heart rate; AF: physical activity; HC: carbohydrates.

effects could only be observed in very long distance races and not exposed to heat. Nor has the diuretic effect of tea on regular users been found, and yet it seems to improve mood.[33]

The hydration protocol (table III) must be individualized to each sport, environmental conditions and needs. This should be investigated in each team-athlete the loss of water and Na, under given conditions.[34]

Hyperhidrant ergonutritional aids

Another strategy is to increase the use of Hyperhidrant moisturizing agents (table IV).

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