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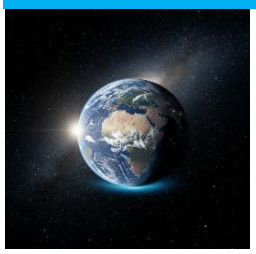

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Hydration Strategies and Their Impact on Physical Performance - A Systematic Review

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Abstract

Background.

Adequate hydration is one of the fundamental factors necessary for maintaining physiological homeostasis and optimal physical performance. Disturbances in water-electrolyte balance may occur during physical exercise, when increased fluid loss takes place through sweating and respiratory pathways. Dehydration negatively affects thermoregulatory mechanisms, cardiovascular function and overall exercise capacity. In recent years, hydration strategies have become one of the key areas of research in exercise physiology and sports science.

Aim.

The aim of this systematic review is to analyze the current scientific evidence regarding hydration strategies and their impact on physical performance in athletes and physically active individuals.

Materials and methods.

A systematic review of the scientific literature was conducted using the PubMed, Web of Science and Scopus databases. Publications published between 2016 and 2026 were included in the analysis. The inclusion criteria comprised original studies, randomized controlled trials and systematic reviews evaluating the effects of hydration on parameters of physical performance.

Results.

The analysis of the literature indicates that even mild fluid loss may lead to increased perceived fatigue, a significant reduction in aerobic performance and impairments in cognitive function. Studies suggest that beverages containing electrolytes may be more effective than water in maintaining electrolyte balance and plasma volume during prolonged physical exercise.

Conclusions.

Hydration strategies play a crucial role in maintaining optimal physical performance. Individualization of hydration plans, taking into account environmental conditions, exercise intensity and individual sweating rate may represent the most effective approach to supporting athletic performance.

Key words: hydration, dehydration, physical performance, sport, water-electrolyte management, exercise physiology

1. Introduction.

Adequate hydration is one of the key factors determining the proper functioning of the human physiological system. In the context of physical exercise, hydration plays a particularly important role in maintaining exercise capacity and the efficiency of metabolic processes. Water participates in the transport of nutrients, regulation of body temperature, maintenance of electrolyte balance and the removal of metabolic by-products. These processes are directly related to physical performance and post-exercise recovery [1]. During intense physical exercise, significant fluid loss occurs, primarily through sweating, which may lead to disturbances in water-electrolyte balance and gradual deterioration of the body's physiological functions [2].

Studies have shown that even moderate dehydration may negatively affect exercise capacity, including muscle strength, endurance and the ability to perform repeated high-intensity efforts. It is estimated that fluid loss corresponding to approximately 2% of body mass may lead to noticeable decline in physical performance, particularly during prolonged exercise or in conditions of elevated ambient temperature [3]. The mechanisms responsible for this phenomenon include disturbances in thermoregulation, increased cardiovascular strain and impaired neuromuscular function [4].

Dehydration may influence the perception of fatigue and the perceived level of exertion during physical activity. Studies have shown that hypohydration contributes to an increased subjective perception of exercise intensity, which may limit the ability to maintain high training or competitive intensity. Numerous observations indicate that a substantial proportion of athletes begin competition or training in state of suboptimal hydration, which increases the risk of impaired athletic performance [5].

Increasing attention has been devoted to the development and implementation of effective hydration strategies aimed at minimizing fluid and electrolyte losses and maintaining physiological homeostasis during physical exercise. These strategies include adequate hydration before the onset of physical activity, as well as fluid replacement during and after exercise. Depending on environmental conditions, the characteristics of the physical effort and individual athlete-specific factors, different approaches are applied, such as drinking according to thirst, planned fluid intake or the use of beverages containing electrolytes and carbohydrates [6].

Despite the growing number of studies examining the effects of hydration on exercise capacity, the findings are not always consistent and the effectiveness of different hydration strategies may depend on multiple factors, such as ambient temperature, exercise intensity and the level of athletes' training. For this reason, a systematic review of the current scientific evidence regarding the impact of hydration strategies on physical performance is necessary [7].

Research objective.

The aim of this review is to systematize knowledge about dehydration among adult athletes, both endurance and recreational. The compilation and analysis of available scientific research allows for the presentation of hydration strategies and their impact on physical performance and cognitive function in athletes.

Research problems.

1. Does the intensity of hydration affect physical performance during exercise?
2. What are some effective hydration strategies for maintaining exercise capacity?
3. Do multi-electrolyte fluids provide more effective hydration than plain water?
4. Do environmental and individual factors influence fluid requirements during exercise?

2. Research materials and methods.

This review included analyses of articles published between 2016 and 2026. Studies examined fluid management strategies for athletes or physically active individuals during exercise. They focused on hydration and dehydration. Publications were sourced from journals indexed by PubMed, Scopus, or Web of Science. The literature search aimed to obtain the most current and reliable understanding of the impact of hydration on physical performance. Data are based on original studies, randomized controlled trials, and systematic reviews. The collected information was collated and compared to determine the relationship between hydration strategies and physical performance. Due to the diversity of the studies analyzed, including the type of sports, various physical activities, and various hydration methods, a qualitative analysis of the available data was conducted. The focus was on how physiological

exercise parameters change during dehydration, the effectiveness of various hydration strategies, the impact of electrolyte drinks on the human body, and the importance of an individualized approach to hydration strategies. Most of the analyzed studies included athletes practicing endurance sports, including: long-distance runners, cyclists, triathletes, and team sports players.

3.Research results.

3.1. Pathophysiology of dehydration.

In adults, dehydration is a clinical condition caused by an imbalance between fluid intake and loss, ultimately leading to electrolyte imbalance. This serious condition can lead to multiple organ dysfunction and hypovolemic shock. Dehydration is typically caused by insufficient fluid intake, excessive fluid loss, or a combination of both. Factors that can increase the risk of dehydration include physiological degenerative processes such as decreased thirst and fatigue. Medications, acute illnesses, and economic and social conditions also contribute. Dehydration is a common cause of hospitalization [8].

Clinical symptoms of dehydration vary depending on the degree of dehydration, ranging from mild to life-threatening. Mild symptoms include increased thirst, chronic fatigue, and confusion, while severe symptoms include hypovolemic shock, leading to multiple organ failure, neurological dysfunction, and death [9].

Dehydration diagnosis typically includes an assessment of the patient's clinical condition and symptoms, supplemented by laboratory testing. Blood electrolyte concentrations are assessed, as well as renal function (creatinine levels), and serum osmolality. Treatment typically begins with oral or, in more severe cases, intravenous fluid therapy, considering the cause of fluid imbalance and treatment of the underlying condition. Plasma electrolyte concentrations are also monitored [10].

The human body defends itself against dehydration and has mechanisms that regulate electrolyte imbalances and protect against excessive fluid loss. Mechanisms that maintain homeostasis include:

- Hypothalamic regulation of thirst, which involves the presence of osmoreceptors in the hypothalamus. As a result of increased plasma osmolality, these receptors trigger the thirst response and encourage the individual to drink water. Due to senile degeneration, this regulation is weakened [11].

- Renal regulation via antidiuretic hormone causes water reabsorption in the kidneys. As plasma osmolality increases, vasopressin is secreted from the posterior pituitary gland, which increases water reabsorption in the renal collecting ducts. As a result, primary urine is concentrated and water is conserved, which is essential for maintaining euvolemia [12].
- Hormonal regulation through activation of the renin-angiotensin-aldosterone system, which is stimulated by a decrease in intravascular volume. The sympathetic nervous system stimulates the kidneys to secrete renin, which converts angiotensinogen to angiotensin I. Angiotensin-converting enzyme then converts angiotensin I to angiotensin II, which directly causes vasoconstriction, helping to maintain normal blood pressure during dehydration [12].

3.2. Types of drainage.

The type of dehydration is differentiated based on the relative proportion of water loss to sodium ion loss. It is important to correctly recognize the clinical symptoms of a given type of dehydration, as this will determine the consequences of dehydration, the treatment method, and subsequent management.

3.2.1. Isotonic Dehydration.

A disturbance in fluid and electrolyte balance, in which water and sodium ions are lost in equal proportions. Therefore, this type of dehydration is accompanied by normal body fluid molality, i.e., isotonic fluids. The main causes include loss of isotonic fluids through the gastrointestinal tract through vomiting, diarrhea, and bleeding. Increased loss through the kidneys and skin due to extensive burns can also occur. In other pathological conditions, water can enter the so-called third space. Isotonic dehydration leads to a deficit of body fluids, leading to hypovolemia or reduced circulating plasma volume. In extreme cases, it can lead to hypovolemic shock. Depending on the severity, symptoms include dry skin and dry mucous membranes, tachycardia, hypotension, organ ischemia, or oliguria. Diagnosis is based on a creatinine laboratory test and clinical findings. A definite diagnosis is confirmed by an increase in creatinine concentration in the presence of a normal total electrolyte balance, including sodium ion concentration. Treatment primarily involves oral fluid administration to alleviate

symptoms and the increased blood pressure, as well as treating the underlying cause of dehydration [13].

3.2.2. Hypotonic Dehydration.

A disturbance in water and electrolyte balance in which sodium ion loss exceeds water loss, leading to hyponatremia. Water deficiency occurs in the body, leading to reduced body fluid molality. It often occurs in individuals chronically taking diuretics or suffering from chronic kidney disease or adrenal insufficiency. It can also be an iatrogenic consequence of treating isotonic dehydration with electrolyte-free fluids, which are hypotonic solutions relative to body fluid molality. As a result, fluid shift into cells can lead to symptoms such as muscle weakness, cerebral edema, or even coma. Clinical symptoms typically include increased thirst, decreased blood pressure, and oliguria. Treatment focuses on intravenous saline administration, and in chronic dehydration, correction of other electrolyte imbalances, including potassium ion concentration [14].

3.2.3. Hypertonic Dehydration.

A disturbance in water and electrolyte balance, in which water loss exceeds sodium ion loss, leading to hypernatremia. Pathophysiologically, it occurs with increased molality of body fluids, i.e., hypertonia. The most common causes are insufficient fluid intake, excessive sweating, and the loss of hypotonic fluids, such as diabetes insipidus. Insufficient water intake can occur in unconscious individuals or those with swallowing disorders. Water loss can also occur with hyperventilation. Clinical symptoms will depend on the degree and rate of cellular dehydration. This is most evident in dehydration of central nervous system cells. Confusion, hallucinations, and seizures may occur, and in extreme cases, lead to coma. Additionally, symptoms include intense thirst, significant dryness and loss of skin elasticity, tachycardia, oliguria, and hyperthermia. Treatment begins with oral electrolyte-free fluids, and in severe cases where oral administration is impossible, parenteral fluids are used, such as 0.45% sodium chloride solution [14].

3.3. The impact of dehydration on physical performance.

Physical performance declines with dehydration because the body struggles to maintain proper body thermoregulation. Oxygen and nutrient transport to muscles is impaired due to

reduced circulating blood volume and increased osmolarity. Even mild dehydration can lead to accelerated fatigue during physical activity. Fluid and electrolyte imbalances can contribute to painful muscle cramps and dizziness. A particularly significant decline in performance in athletes has been observed with fluid losses exceeding 2% of total body weight. Furthermore, a dehydrated human body exhibits increased heart rate, increased body temperature, and decreased maximum exercise capacity during exercise. In endurance sports, dehydration leads to an increased perception of physical exertion and a shorter time to exhaustion of energy reserves [15].

3.4. The effect of hydration on endurance performance.

In endurance sports, maintaining adequate blood volume and electrolytes is particularly important, enabling efficient transport of respiratory gases and muscle function. This allows muscles to work longer with the same force without early fatigue. Adequate fluid intake during endurance sports improves the maintenance of applied force and body temperature, and limits the decline in circulating blood volume. It influences body temperature regulation through constant sweating. Regular fluid intake before, during, and after physical activity can be crucial to maintaining high endurance levels in athletes [16].

3.5. Types of electrolyte drinks.

Electrolyte beverages used during physical activity differ in their composition and osmolality. These differences influence the rate of fluid absorption and their effectiveness in replenishing water and electrolyte losses. The scientific literature distinguishes hypotonic, isotonic and hypertonic beverages, whose use depends on environmental conditions and the characteristics of the physical effort [17].

Hypotonic beverages contain lower concentrations of carbohydrates and electrolytes than blood plasma, which promotes efficient water absorption in the gastrointestinal tract and rapid gastric emptying. For this reason, they are particularly useful during prolonged exercise in high temperatures, where the primary goal is rapid fluid replacement [18].

Isotonic beverages are the most commonly used drinks in sport, as they contain both electrolytes and a moderate amount of carbohydrates. Their composition allows for simultaneous energy supply during endurance exercise and effective fluid replacement. Studies

have shown that isotonic beverages may support the maintenance of physical performance and improve water-electrolyte balance during exercise lasting longer than 60 minutes [19].

Hypertonic beverages contain a higher concentration of carbohydrates, therefore, their primary function is to provide energy. They are less frequently used during exercise due to their higher osmolality, which may slow gastric emptying and fluid absorption. Hypertonic drinks are more commonly utilized in the post-exercise period, when, in addition to fluid replacement, the restoration of the body's energy reserves is also important [20].

3.6. Effective irrigation strategies.

3.6.1. Pre-exercise hydration strategy

The pre-exercise hydration strategy aims to achieve a state of euhydration before onset of physical activity. It also serves to reduce the risk of an early decline in plasma volume during training or competition. Not only the volume of fluid intake is important, but also its composition, particularly the content of sodium and carbohydrates, which influence gastrointestinal tolerance and fluid retention in the body. This strategy is particularly important before prolonged exercise, especially when performed in high temperatures or in individuals with high sweating rates [21].

3.6.2. Intra-exercise hydration strategy

Hydration during exercise should stabilize the thermoregulatory response, support the maintenance of exercise capacity and limit the progression of dehydration. During continuous exercise, hypotonic beverages containing carbohydrates and electrolytes may be particularly beneficial for central hydration parameters, as they facilitate more efficient water delivery compared with more concentrated solutions. At the same time, the choice of an intra-exercise hydration strategy should depend on sweating rate, exercise duration, work intensity and environmental conditions [22].

3.6.3. Post-exercise hydration strategy

The aim of the post-exercise hydration strategy is to restore fluid and electrolyte losses as quickly as possible, particularly when the next training session or competition occurs within a short period of time. Studies indicate that beverages containing sodium and carbohydrates

may improve fluid retention compared with water alone. The composition of the beverage is also important for the effectiveness of rehydration. This means that after more substantial dehydration, preparations with an appropriately adjusted sodium content may provide better results than fluids low in electrolytes [23].

3.6.4. Individualized hydration strategy

An increasing number of authors indicate that a universal hydration model has limited particular value. Fluid requirements vary depending on training status, body mass, gastrointestinal tolerance, sweating rate, ambient temperature and the type of exercise performed. Therefore, an individualized hydration strategy should take into account both the characteristics of the activity and the individual athlete's response to a specific type of beverage and fluid intake protocol. This approach reduces the risk of both inadequate hydration and excessive fluid intake, which may also be detrimental [24].

4. Discussion.

Summarizing the collected data and research findings, it can be concluded that proper hydration is a key factor influencing physical performance and cognitive function in athletes. Adequate hydration is a key factor in determining the body's exercise capacity in both competitive sports and recreational activities. Analysis of available research confirms that dehydration leads to a number of physiological changes that negatively impact circulatory system function, thermoregulation, and muscular performance.

The study by Deshayes et al. emphasized that even mild dehydration can lead to impaired physical performance, particularly during endurance exercise, leading to impaired concentration and delayed reaction time. In this systematic review, the authors emphasize that adequate rehydration after dehydration restores the ability to continue exercise and improves cognitive function. The process of full recovery from pre-dehydration function takes time, and optimal performance is not always achieved [15].

The problem of insufficient hydration is similar and remains common among athletes across various disciplines. At the same time, the study by Magee et al. indicates that this problem affects athletes at various levels of advancement. Despite abundant scientific evidence clearly demonstrating the need for adequate hydration during sports, few athletes still employ

optimal fluid intake strategies. Due to insufficient nutritional education regarding hydration, a high incidence of dehydration is observed among university and club athletes [8].

The study by Adams et al. assessed the negative impact of insufficient fluid intake on athletes' performance. It clearly indicated that dehydration significantly impaired performance in cyclists, even in the absence of intense thirst. The authors concluded that relying solely on an athlete's sense of thirst may not be sufficient to assess dehydration and maintain optimal hydration levels during a race [10].

Endurance performance can be significantly impaired with a weight loss of approximately 2% due to dehydration, as indicated by the findings of a study by Cheuvront et al. This decrease in performance was demonstrated by up to 8% compared to properly hydrated individuals. Hypohydration has been shown to increase the physiological load during exercise, causing increased body temperature and a higher heart rate during exercise [24].

Dube et al. focused their research on the impact of hydration on cognitive function in athletes. They confirmed that dehydration negatively impacts attention, working memory, and decision-making, especially during prolonged exercise or at higher environmental temperatures. However, the impact of dehydration on cognitive function varies, depending on the athletes' training level and the intensity of the physical activity [25].

A review of the available literature reveals the need for increased nutritional education regarding hydration strategies among athletes. It is recommended to introduce more effective methods for monitoring athletes' physical hydration status to help them achieve better athletic performance. It is important that the hydration strategy be personalized for each athlete. The need for individualization stems from differences in sweat rate and intensity, environmental conditions, and the nature of the sport. Developing original hydration plans based on fluid loss assessment and training needs analysis is increasingly recommended. These interventions lead to improved athlete performance and improved safety during sports [26].

5. Conclusions.

Based on the collected research, the following conclusions can be drawn:

1. Adequate hydration significantly improves physical performance compared to dehydration.
2. Rehydration strategies in sports encompass comprehensive pre-, intra-, and rehydration.

3. Electrolyte-containing beverages are more effective in maintaining fluid and electrolyte balance during prolonged exercise than water.
4. Individualizing hydration strategies based on sweat rate and environmental conditions increases the effectiveness of maintaining physical performance.

Disclosure:

Author Contributions

Conceptualization: Natalia Kałwa,
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Project Administration: Agnieszka Janaszek,
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Conflicts of Interest

The authors declare no conflict of interest.

Supplementary Materials.

No additional materials.

Declaration of Generative AI and AI-Assisted Technologies

During the preparation of this work, the authors used ChatGPT-5.2 to improve grammar and language clarity. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

References.

1. Judge LW, Bellar DM, Popp JK, Craig BW, Schoeff MA, Hoover DL, et al. Hydration to maximize performance and recovery: knowledge, attitudes, and behaviors among collegiate track and field throwers. J Hum Kinet. 2021;79:111-122. https://doi.org/10.2478/hukin-2021-0065
2. McCartney D, Desbrow B, Irwin C. The effect of fluid intake following dehydration on subsequent athletic and cognitive performance: a systematic review and meta-analysis. Sports Med Open. 2017;3:13. https://doi.org/10.1186/s40798-017-0079-y
3. Deshayes TA, Pancrate T, Goulet EDB. Impact of dehydration on perceived exertion during endurance exercise: a systematic review with meta-analysis. J Exerc Sci Fit. 2022;20(3):224-235. https://doi.org/10.1016/j.jesf.2022.03.006
4. Elliott KB, Keefe MS, Dunn RA, Palmer TB, Lepley AS, Sekiguchi Y. Hypohydration decreases neuromuscular performance prior to and following intermittent exercise in the heat. Med Sci Sports Exerc. 2026 Jan 23. https://doi.org/10.1249/MSS.0000000000003938
5. Goodman SPJ, Moreland AT, Marino FE. The effect of active hypohydration on cognitive function: a systematic review and meta-analysis. Physiol Behav. 2019;204:297-308. https://doi.org/10.1016/j.physbeh.2019.03.008
6. Pałka T, Rydzik Ł, Koteja PM, Piotrowska A, Bagińska M, Ambroży T, et al. Effect of various hydration strategies on work intensity and selected physiological indices in young male athletes during prolonged physical exercise at high ambient temperatures. J Clin Med. 2024;13(4):982. https://doi.org/10.3390/jcm13040982

7. Francisco R, Armstrong LE, Silva AM. Recommendations for optimizing research regarding the effects of dehydration on athletic performance. Sports Med. 2026;56:23-34. https://doi.org/10.1007/s40279-025-02310-6
8. Magee PJ, Gallagher AM, McCormack JM. High prevalence of dehydration and inadequate nutritional knowledge among university and club level athletes. Int J Sport Nutr Exerc Metab. 2017.
9. Irwin C, Desbrow B, Leveritt M. Effects of acute exercise, dehydration and rehydration on cognitive function in well-trained athletes. J Sports Sci. 2018.
10. Adams JD, Sekiguchi Y, Suh HG, Seal AD, Sprong CA, Kirkland TW, et al. Dehydration impairs cycling performance, independently of thirst. Med Sci Sports Exerc. 2018.
11. Li S, Xiao X, Zhang X. Hydration status in older adults: current knowledge and future challenges. Nutrients. 2023;15(11):2609. https://doi.org/10.3390/nu15112609
12. Cuzzo B, Padala SA, Lappin SL. Physiology, vasopressin. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026. Available from: https://www.ncbi.nlm.nih.gov/books/NBK526069/
13. Lacey J, Corbett J, Forni L, Hooper L, Hughes F, Minto G, et al. A multidisciplinary consensus on dehydration: definitions, diagnostic methods and clinical implications. Ann Med. 2019;51(3-4):232-251. https://doi.org/10.1080/07853890.2019.1628352
14. Frith J. New horizons in the diagnosis and management of dehydration. Age Ageing. 2023;52(10):afad193. https://doi.org/10.1093/ageing/afad193
15. Barley OR, Chapman DW, Blazevich AJ, Abbiss CR. Acute dehydration impairs endurance without modulating neuromuscular function. Front Physiol. 2018;9:1562. https://doi.org/10.3389/fphys.2018.01562
16. Pérez-Castillo IM, Williams JA, López-Chicharro J, Mihic N, Rueda R, Bouzamondo H, et al. Compositional aspects of beverages designed to promote hydration before, during, and after exercise: concepts revisited. Nutrients. 2023;16(1):17. https://doi.org/10.3390/nu16010017
17. Rowlands DS, Kopetschny BH, Badenhorst CE. The hydrating effects of hypertonic, isotonic and hypotonic sports drinks and waters on central hydration during continuous exercise: a systematic meta-analysis and perspective. Sports Med. 2022;52(2):349-375. https://doi.org/10.1007/s40279-021-01558-y

18. Armstrong LE. Rehydration during endurance exercise: challenges, research, options, methods. Nutrients. 2021;13(3):887. https://doi.org/10.3390/nu13030887
19. Ly NQ, Hamstra-Wright KL, Horswill CA. Post-exercise rehydration in athletes: effects of sodium and carbohydrate in commercial hydration beverages. Nutrients. 2023;15(22):4759. https://doi.org/10.3390/nu15224759
20. Jardine WT, Aisbett B, Kelly MK, Burke LM, Ross ML, Condo D, et al. The effect of pre-exercise hyperhydration on exercise performance, physiological outcomes and gastrointestinal symptoms: a systematic review. Sports Med. 2023;53(11):2111-2134. https://doi.org/10.1007/s40279-023-01885-2
21. Périard JD, Eijsvogels TMH, Daanen HAM. Exercise under heat stress: thermoregulation, hydration, performance implications, and mitigation strategies. Physiol Rev. 2021;101(4):1873-1979. https://doi.org/10.1152/physrev.00038.2020
22. Kenefick RW. Drinking strategies: planned drinking versus drinking to thirst. Sports Med. 2018;48(Suppl 1):31-37. https://doi.org/10.1007/s40279-017-0844-6
23. Li H, Early KS, Zhang G, Ma P, Wang H. Personalized hydration strategy to improve fluid balance and intermittent exercise performance in the heat. Nutrients. 2024;16(9):1341. https://doi.org/10.3390/nu16091341
24. Cheuvront SN, Kenefick RW. Dehydration: physiology, assessment, and performance effects. Compr Physiol. 2014;4(1):257-285. https://doi.org/10.1002/cphy.c130017
25. Dube A, Gouws C, Breukelman G. Effects of hypohydration and fluid balance in athletes' cognitive performance: a systematic review. Afr Health Sci. 2022;22(1):367-376. https://doi.org/10.4314/ahs.v22i1.45
26. Maughan RJ. Investigating the associations between hydration and exercise performance: methodology and limitations. Nutr Rev. 2012;70(Suppl 2):S128-S131. https://doi.org/10.1111/j.1753-4887.2012.00536.x