REVIEW ARTICLE

ENGLISH VERSION

Hydration in soccer: a review

Cristiano Ralo Monteiro[1], Isabela Guerra[2] and Turíbio Leite de Barros[3]

ABSTRACT

Hydration should be considered before, during and after the exercise. This review intends to approach the main points of hydration process in soccer. The replacement of fluids during exercise is proportional to some factors, such as: exercise intensity; climatic conditions; the athlete's acclimatization; the athlete's physical conditioning; physiologic individual characteristics and the player's biomechanics. Performance is improved when players ingest not only water but also carbohydrate. The rates that carbohydrate and water are absorbed by the organism are limited by the rates of gastric emptying and intestinal absorption. The composition of drinks offered to the players should be influenced by the relative importance of the need of supplying carbohydrates or water; it should be remembered that the depletion of carbohydrate can result in fatigue and decrease of performance, but it is not usually a life-threatening condition. The addition of carbohydrate in these drinks increases the concentrations of blood glucose, increases the use of external fuel through the increase of the glucose oxidation in the muscles and it spares muscle glycogen. So, the ingestion of carbohydrate before and during the exercise can delay the emergence of fatigue and increase the players' performance. Several tactics can be used to avoid dehydration, like hyperhydration before exercise and player's acclimatization. The ideal situation to restore the player's fluid losses is between the sessions of exercises. Since soccer is a sport with quite peculiar characteristics related to hydration, the players should be concerned and educated about the importance of fluid ingestion before, during and after the exercise.

Key words: Soccer. Hydration. Carbohydrate. Performance.

INTRODUCTION

Hydration or fluid replacement is an important aspect to be considered before, during and after the practice of exercises[1].

Hydration before and during exercise enhances performance, particularly if the beverage to be taken has carbohydrates[2].

Maughan & Leiper (1994)[3] suggest dehydration takes place due to the need of the body to keep its temperature close to resting values, of about 37º C. In high-temperature environments, the single mechanism that causes body to lose heat is water evaporation at skin surface. This allows body temperature to be maintained, but leads to dehydration and loss of electrolytes.

According to those authors, fluid replacement should be proportional to some factors, such as intensity of exercise; climatic conditions; adjustment of athlete to the weather; athlete's physical fitness; individual physiologic and biomechanic features of the athlete.

It is also reported that performance in exercise is impaired by dehydration at 2% of body weight, and, if dehydration increases to 5%, it may decrease work capability in about 30%[4]. Cognitive function is an important aspect for team sports, such as soccer, and it is impaired by presence of dehydration and hyperthermia[5].

The level of dehydration may be assessed by weighting the athlete before and after training and/or competition, but the amount of information about weight loss (sweat) of soccer players during training and competition is limited[1]. Some studies report that loss of fluid through sweat during a soccer match ranges from 1 to 3.5 liters[6-8].

In this study we are going to review issues related to hydration in soccer, such as gastric emptying, fluid and carbohydrate replacement strategies before, during and af-

1. Physical education teacher. Master Science student – Unifesp/Escola Paulista de Medicina.
2. Nutritionist. PhD student – Nutrição Humana Aplicada, USP.
3. Associate Professor – Department of Physiology, Unifesp/Escola Paulista de Medicina

Received in 18/9/02

Approved in 19/5/03

Correspondence to:
Rua Sebastião Lacerda, 32 – Laranjeiras
22240-110 – Rio de Janeiro, RJ
E-mail: isabelaguerra@hotmail.com

ter soccer practice and/or match, as this sport presents very particular features related to this matter, such as lack of interruption for fluid intake.

FACTORS THAT INFLUENCE FLUID AND CARBOHYDRATE REPLACEMENT RATE

Performance is optimized by intake of both, water (lessens dehydration effects) and carbohydrate. However, the rates at which substratum and water are absorbed by the body are limited by gastric emptying and intestinal absorption rates[5].

Gastric emptying is controlled by a number of factors, such as intensity, type of exercise, volume of intake, energetic density, osmolality, temperature, and type of carbohydrate in the solution[2,9-13].

The volume of ingested fluid impels gastric emptying, but carbohydrate increase in the fluid delays it. Fluid osmolality, temperature and pH have less influence in gastric emptying. The amount of fluids ingested by athletes is typically smaller than the one they can tolerate, and to increase ingestion, it is basic to intake fluid at training[2].

Some factors, including exercise intensity, also affect the rate of gastric emptying. Exercises performed at an intensity of 70 to 75% of maximum $\dot{V}O_2$ have little or no effect on gastric emptying rate, but exercises performed at an intensity higher than or equal to 80% of maximum $\dot{V}O_2$ seem to make this rate decrease, but this is not much of a problem, as these types of exercise are not performed long enough to cause limitation in fluid availability[1,2,9-11,14,15].

One can say that in soccer, where these high-intensity activities better mark the strain from the sport, the amount of ingested fluid should be emptied from the stomach more slowly. Emptying occurs probably more swiftly in low-intensity exertion, and fluid should be taken whenever possible during exercise, to prevent nauseas or any other type of gastric discomfort.

An increase of carbohydrate content in fluids will increase the rate of this substratum available in the small intestine, but it will decrease the volume of gastric emptying. Each solution of diluted glucose (40 g/l or more) slows emptying rate down, but absorption of glucose that is transported with sodium in the small intestine fasters water absorption[11].

High glucose-concentration solution will cause high osmolality, stimulating high water-secretion rates towards the intestinal tract, contributing to dehydration. When water provision is of utmost priority, the amount of carbohydrate in fluids must be low, about 30-50 $g.l^{-1}$. In cold climates, or for players of low sweat rate, a higher carbohydrate concentration may be more suitable (more than 100 $g.l^{-1}$).

The contents of fluids to be taken should be influenced by the relative importance of the need to supply substratum or water. This depends, in part, on the rate of individual work of the player, temperature and humidity of the environment, and the individual's physiologic and biomechanic features.

Carbohydrate depletion may result in fatigue and performance decrease, but it is not, typically, a life-threatening condition. But disorders in fluid balance and temperature regulation are potentially more serious conditions, and for this reason players in warm countries should focus in keeping fluid and electrolyte balance.

In longer-lasting exercises in which substratum depletion takes place and/or during exercise performed under heat, leading to dehydration, regular intake of hydro-electrolytic fluid with carbohydrate will attenuate these undesirable factors that impair performance[11,16,17].

FLUID REPLACEMENT STRATEGIES BEFORE A SOCCER MATCH

1. Practice and competition under heat – acclimatation

Warm and humid environments may pose an obstacle for players, and for an adequate acclimation process to occur in this type of climate, one must be exposed to it for about 10 days. Higher adaptation to heat exposure leads to higher sweat in response to exercise.

Players may adjust their body to hot climate by practicing moderate to intense exercises under these temperatures. After training from 1 to 4 hours for 5 to 15 days, the body will be adjusted to warm weather. Under these conditions, warm-up prior to competition or practice should be short and in aired places. One should avoid the use of heavy or rubber-made clothes.

Thus, temperature at rest will decrease, temperature of the skin and body will be lower during exercise, heart beats will be lower during exercises, and sweat rate will increase. All these changes will help players to improve their performance under a warm climate.

During competition, where matches are carried out in succession, there might be problems.

One should pay heed to a proper fluid intake between soccer practice and/or matches carried out in successive days under a warm weather, or else there will not be a full recovery, as the player will not be fully re-hydrated.

2. Hyper-hydration in soccer

Volunteer hyper-hydration during the week before competition seems to increase body reserve of fluids and improve temperature regulation. Such hyper-hydration should

be done through the intake of 300-600 ml of fluids at pre-competition meals, and an extra 150 to 300 ml of fluids at every 15-20 minutes, until 45 minutes prior to the beginning of the competition event, for the athlete to have time to eliminate the excess through the urine before competition. Fluid intake during a soccer match should be encouraged by providing individual bottles, that should be left close to the goal or the field, so that the player can quickly leave the field and drink, during the "informal" interruptions during the match, and each player should be aware of his/her fluid loss at training and/or matches[3,5,13].

In a study carried out by Rico-Sans *et al.* (1996)[19], eight young players (17 ± 0.6 years), of the Porto Rico team, well-fit, as shown by their maximum aerobic power of 69.2 ± 0.7 $ml.kg^{-1}.min^{-1}$, were investigated.

The goal of the study was to check if hyper-hydration would increase the total amount of body water, thus reducing the stress from the increase of body temperature during a match and, therefore, enhancing performance.

Hyper-hydration was done one week before a competition, and showed to provide positive results in increasing the total amount of body water of 1.1 liter when compared to voluntary hydration. In this study, it was observed that body temperature during a soccer match increased 2.04 ± 0.31º C and 1.71 ± 0.17º C for voluntary hydration and hyper-hydration, respectively. When the stress from the heat was considered, curves of temperature lines were significantly different, indicating a smaller increase in hyper-hydration ($R2 = 0.01$) and a higher increase in voluntary hydration ($R2 = 0.72$; $P < 0.01$) during the match.

FLUID REPLACEMENT DURING A SOCCER MATCH

Both soccer rules and gastric tolerance do not allow suitable hydration for soccer players[20]. During the match, it is difficult to intake fluids; therefore, its ingestion should be enough to replace loss from sweat, the amount of carbohydrate should be enough to provide substratum and not to limit rate of gastric emptying, fluids should be ingested regularly to keep gastric volume, and finally, players should be aware of their fluid needs[1,21,22].

If regulation allowed a regular intake of fluids during a match, there would be higher voluntary intake by and better fluid balance in soccer players. Typically, fluid replacement in soccer corresponds to some 50% of the loss. It is believed a requirement to improve fluid intake in soccer would be to increase availability and/or chances for players to be able to drink during matches[5]. In soccer, as there are no breaks for fluid intake during a match, the players can only do it before the match and during the interval[19].

Additional beverages should be offered at the end of the first half, with volume and contents known by players and based in individual requirements and preferences[3]. These beverages should have a carbohydrate concentration of 6 to 8%, and should be provided at a temperature of 15 to 20º C at every 15-20 minutes, in a volume of 150 to 300 ml.

FLUID REPLACEMENT IN RECOVERY FROM PRACTICE AND MATCHES

Replacement of water and electrolytes at the post-exercise period is fundamental for the recovery process.

The success of a proper hydration after practice and matches depends on the balance between fluid intake and urinary losses. The ideal for a player is to replace fluid loss between exercise sessions, for a new event to be started under a normal hydration condition (euhydration). However, this is difficult in situations in which moderate to high dehydration occurred, or when interval between training sessions is less than 6-8 hours. A good re-hydration requires planning for fluid intake, to overcome both physiological and practical problems, such as difficulties in getting fluids[23].

Immediately after the exercise, athletes should intake enough hydro-electrolytic fluid with carbohydrate to replace fluid loss during the exercise. To ensure full hydration, beverages should contain sodium, and the ingested amount should be 150% of loss through sweat[2,17,22]. This is because typically it is necessary for one to replace 50% more than the amount of fluid lost at the exercise, for a proper re-hydration to take place[1,24].

The need for fluid replacement depends not only on the extent of the loss through the sweat, but it is also influenced by the period of time before the next match or training session[3].

Post-exercise water intake leads to a swift decrease in sodium concentrartion and plasmatic osmolality, thus reducing the urge to drink and fostering fluid elimination through the urine, both factors that interfere in the re-hydration process[21].

According to Mack (1998)[25], fluid intake was significantly higher when added to a sodium chloride solution. Furthermore, sodium-free solutions cause a swift fall in serum sodium levels and osmolality[11,26,27].

Alcoholic beverages and those with caffeine should be avoided during the re-hydration period, as they have a diuretic action[21,27].

Considering that dehydration often occurs in athletes, and has a hazardous effect both in health and performance, coaches and athletes should be educated on this issue[27].

CONCLUSION

Soccer is a sport of very particular features regarding hydration, particularly as it does not have regular breaks for players to drink fluids during matches. Fluid intake during exercise is quite beneficial for players, as it minimizes dehydration effects. Dehydration may cause performance to decrease. To prevent that from taking place, players must be educated as to the importance of fluid intake before, during and after the practice of exercises.

All the authors declared there is not any potential conflict of interests regarding this article.

REFERENCES

1. Galloway SD. Dehydration, rehydration, and exercise in the heat: rehydration strategies for athletic competition**.** Can J Appl Physiol 1999;24: 188-200.
2. Maughan RJ, Leiper JB. Limitations to fluid replacement during exercise. Can J Appl Physiol 1999;24:173-87.
3. Maughan RJ, Leiper JB. Fluid replacement requirements in soccer. J Sports Sci 1994;12:S29-S34.
4. Horswill CA. Effective fluid replacement. Int J Sports Nutr 1998;8:175-95.
5. Burke LM, Hawley J. Fluid balance in team sports – Guidelines for optimal practices. Sports Med 1997;24:38-54.
6. Ekblom B. Applied physiology of soccer. Sports Med 1993;3:50-60.
7. Leatt PB, Jacobs I. Effect of glucose polymer ingestion on glycogen depletion during a soccer match. Can J Sports Sci 1989;14:112-6.
8. Bangsbo J. Energy demands in competitive soccer. J Sports Sci 1994; 12:S5-12.
9. Brouns F. Gastric emptying as a regulatory factor in fluid uptake. Int J Sports Med 1998;19: S125-8.
10. Epstein Y, Armstrong LE. Fluid-electrolyte balance during labor and exercise: concepts and misconceptions. Int J Sports Nutr 1999;9:1-11.
11. Maughan RJ. Fluid and electrolyte loss and replacement in exercise. J Sports Sci 1991;9:117-42.
12. Murray R, Bartoli W, Stofan J, Horn M, Eddy D. A comparison of the gastric emptying characteristics of selected sports drinks. Int J Sports Nutr 1999;9:263-74.
13. Shepard RJ. Biology and medicine of soccer: an update. J Sports Sci 1999;17:757-86.
14. American College of Sports Medicine. Position Stand: Exercise and Fluid Replacement. Med Sci Sports Exerc 1996;29:i-vii.
15. Gisolfi CV, Duchman SM. Guidelines for optimal replacement beverages for different athletic events. Med Sci Sports Exerc 1992;24:679-87.
16. Kirkendall DT. Effects of nutrition on performance in soccer. Med Sci Sports Exerc 1993;25:1370-4.
17. Shi X, Gisolfi CV. Fluid and carbohydrate replacement during intermittent exercise. Sports Med 1998;25:157-72.
18. Elias SR, Roberts WO, Thorson DC. Team sports in hot weather. Guidelines for modifying youth soccer. Phys Sportsmed 1991;19:67-78.
19. Rico-Sanz J, Frontera WR, Rivera MA, Rivera-Brown A, Molé PA, Meredith CN. Effects of hyperhydration on total body water, temperature regulation and performance of elite young soccer players in a warm climate. Int J Sports Med 1996;17:85-91.
20. Broad EM, Burke L, Cox GR, Heeley P, Riley M. Body weight changes and voluntary fluid intake during training and competition sessions in team sports. Int J Sport Nutr 1996;6:307-20.
21. Maughan RJ. Fluid and carbohydrate intake during exercise. In: Burke L, Dekin V, editors. Clinical sports nutrition. Australia: McGraw-Hill, 2000;369-90.
22. Hawley J, Dennis S, Noakes T. Carbohydrate, fluid and electrolyte requirements of the soccer players: a review. Int J Sport Nutr 1994;4:221-36.
23. Burke L. Nutrition for recovery after competition and training. In: Burke L, Dekin V, editors. Clinical sports nutrition. Australia: McGraw-Hill, 2000;396-423.
24. Maughan RJ, Shirrefs SM. Dehydration, rehydration and exercise in the heat – Concluding remarks. Int J Sports Med 1998;19:S167-8.
25. Mack GW. Recovery after exercise in the heat – Factors influencing fluid intake. Int J Sports Med 1998;19:S139-41.
26. Maughan RJ. Restoration of water and electrolyte balance after exercise. Int J Sports Med 1998;19:S136-8.
27. Murray R. Fluids needs of athletes. In: Berning JR, Steen SN, editors. Nutrition for sport & exercise. Maryland: Aspen Publication, 1998;143-53.