RBCDH Brazilian Journal of KINANTHROPOMETRY and Human Performance

DOI: http://dx.doi.org/10.5007/1980-0037.2012v14n3p276

original article

Evaluation of hydration status following soccer matches of different categories

Avaliação de parâmetros de hidratação após jogos de futebol de diferentes categorias

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Abstract – The purpose of this study was to evaluate the hydration status and thermoregulatory responses, during official soccer matches, of soccer players in different categories. The participants of the under-15 (U-15, n=36) and of the under-17 category (U-17, n=14) were placed into different groups according to the amount of time spent in the field: Main group; Partial group; Intermediate group; Control group. The thermoregulatory responses and hydration status were measured. The Main group and the Partial group presented significantly higher water intake, weight loss and sweat rate compared with the Intermediate and Control group ($p<0.05$). The under-17 players of the Main group had a larger weight difference pre and post match compared with the under-15 players of the same group ($p<0.05$). It was concluded that an official soccer match altered significantly the hydration status of the players, and it was related with the time spent in the match.

Key words: Body water; Dehydration; Environment; Sports.

Resumo – *Objetivo do presente estudo foi avaliar o padrão de hidratação e respostas termorregulatórias de jogadores de futebol de diferentes categorias ao longo de um jogo oficial. Participaram desse estudo jogadores de futebol das categorias sub-15 (N 36) e sub-17 anos (N 14). Os jogadores foram divididos em grupos de acordo com o tempo de atuação em nos jogos: grupo principal, o grupo parcial, grupo intermediário grupo controle. As respostas termorregulatórias decorrentes dos jogos e o estatus de hidratação foram determinados e comparados entre os grupos apresentados. Os grupos principal e parcial apresentaram maiores valores de consumo de água, perda de peso e taxa de sudorese em comparação aos grupos intermediário e controle ($p<0,05$). A diferença de peso pré e pós-jogo entre as categorias foi maior nos atletas da categoria sub17 em comparação com os atletas sub 15 no mesmo grupo ($p<0,05$). Conclui-se que um jogo de futebol foi capaz de alterar de forma significativa os parâmetros de hidratação dos jogadores de futebol tendo relação direta com o tempo de atuação em campo.*

Palavras-chave: *Água corporal; Ambiente; Desidratação; Esporte.*

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Received: 17 June 2011
Accepted: 03 January 2012

INTRODUCTION

During a soccer match, players can run distances of approximately 10 to 13 km at intensities near their anaerobic threshold, at an average around 85% maximum heart rate (%HRmax) and 75% of maximum oxygen consumption (%VO_{2max})[1]. This is equivalent to a total energy expenditure of approximately 1700 kcal, with a range of 6.5 to 16.9 kcal.min^{-1} [2]. Most of this energy is transformed into heat, with a consequential increase in body temperature, sweat rate and need for fluid ingestion[3].

When physical activity is performed in the heat, the combination of high sweat rate with inadequate fluid replacement or carbohydrate drinks can increase the risk of hyperthermia. During a soccer match, the players only have access to fluid when there are interruptions during the game, at half-time, or at the end of the match. According to Saltmarsh[4] this can limit the players' fluid intake; thus, affecting their hydration status. As a consequence, there are thermoregulatory and cardiovascular alterations which can lead to deterioration in players' performance[5-9].

There are various studies analysing players' hydration and soccer, be it during training sessions[9], friendly matches[6,10-12], with amateur players[13] or in low level divisions[12]. Nevertheless, there has not been to date a study that comprises different high level category players during official matches in a hot environment with an *ad libitum* hydration strategy. Therefore, the aim of the present study was to evaluate the hydration status and thermoregulatory responses of soccer players of different categories during official matches.

METHODS

Thirty six male soccer players of the under-15 (U-15) category (mean ± SD = 14.2 ± 0.8 years; 176.1 ± 6.5 cm; 64.5 ± 7.6 kg; 15.7 ± 2.6% body fat; 54.2 ± 3.0 VO_{2max}) and fourteen male players of the under-17 (U-17) category (mean ± SD = 16.2 ± 1.2 years; 181.4 ± 7.6 cm; 71.5 ± 7.1 kg; 10.7 ± 2.3% body fat; 52.7 ± 1.9 VO_{2max}) took part in this study. Both teams were in the first division of the Brazilian soccer series. The participants signed an informed consent form and ethical approval by Ethics Committee in Research of the Federal University of Minas Gerais (ETIC-1291/2010). For inclusion in the study, the athlete should be registered with the Brazilian Football Confederation (CBF) and fit to play. The injured players throughout the game were excluded from the study.

The Official Soccer Matches

Two official matches corresponding to the third round of the state championship were analysed. The first one was an U-15 game that took place from 2 to 4pm. Soccer players from both teams took part in this study. The other game was an U-17 one that took place after the previously-mentioned game at the same stadium, from 4:30 – 6:30pm. From this match, only the

home-team players took part in this study. Therefore, a total of 3 soccer teams were tested on the whole.

Both soccer matches took place on an official sized field. The U-15 match allowed for 5 player substitutions and was composed of two 35 min halves with a 15 min break. The U-17 match had two halves of 40 min each, also with a 15 min interval and the same number of substitutions. Apart from these changes, the matches were played according to the rules set by the International Federation of Association Football (FIFA) for these categories.

Experimental group composition

Within each team, the players were placed into different groups according to the amount of time spent in the field. Main group (MAIN) played between 51 min - 80 min; Partial group (PAR) played 31 min - 50 min; Intermediate group (INT) played 10 min - 30 min; Control group (CON) players that remained on the bench throughout the entire match and didn't played.

Pre and Post Matches Procedures

Body composition of the players was determined with skin folds measurement and players' VO_{2max} was tested with the *Yoyo Endurance Test* – specific for soccer and intermittent sports players[14]. This test was applied at the beginning of the tournament. Immediately before and after the matches, urine sample was collected from each player. Urine specific gravity was measured by placing a small sample (0.05 mL) on a refractometer (503 Nippon Optical Works®, Japan), and urine osmolality was analysed using an osmometer (5004 MicroOsmette™, Precision Systems Inc., USA). The samples were measured in duplicate.

The players were weighed before (Wb) and after (Wa) the match (Filizola® scale - MF 100, Brazil), while wearing just their shorts and football socks - these were also weighed and their values were subtracted from the total weight. Weight loss was calculated as Wb – Wa. Sweat rate ($mL \cdot min^{-1}$) was calculated using the following equation: Wb - (Wa - Water intake) / total activity time[15]. In this case, the activity time considered here were 70min (U-15) and 80min (U-17). We used the total time of play for the calculation of sweat rate because the sampling occurred before the game and only at the end of the game, even the player acted less time. This was because the researchers could only make measurements at these times. This fact can be considered a limitation of the study.

The players' tympanic temperature was measured (infrared thermometer, G-TECH, IR1DB1, USA), as well as their skin temperature (infrared thermometer, FLUKE®, USA) through the use the following equation[16]: (0.43 chest temperature ºC) X (0.25 arm temperature ºC) X (0.32 thigh temperature ºC). Mean body temperature was calculated according to Consolazio et al.[17] body temperature = (0.67 Core temperature ºC) + (0.33 skin temperature ºC). Only the players from the MAIN group had their body temperature analysed. This was due to the fact that the temperatures could only be measured at the start and end of the game; thus, if a player left before the match finished, his temperature would have decreased if measured at the end of the match.

The official players' heart rates (Polar® Team System®, Finland) were monitored during the warm-up and during the match. Data are presented as absolute values in beats per minute (bpm) and percentage of maximum heart rate (HRmax). Each player's HRmax was defined as the highest HR measured during the analysed match or during other games that were routinely monitored by the soccer team's Physiology Department. The purpose of HR monitoring was to present data of effort intensity from the match.

Each player had his own bottle being allowed to drink *ad libitum*. The amount ingested was then measured. Players were instructed to not wet their heads with their water nor throw it away. During previous training sessions and friendly matches, they had the opportunity to familiarize themselves with this procedure.

Environmental conditions

Dry temperature (DT), humid temperature (HT) and wet globe bulb temperature (WGBT) were measured (RS214, WIBGET®, USA) and relative humidity (RH) was calculated. These measures were made every 5 min throughout both matches (1st and 2nd match). Mean temperatures and RH were compared between each half –time of the matches (1st and 2nd half)

Statistical Analysis

Differences between pre and post match variables were analyzed using paired *student t test*. The ANOVA two-way test was used to analyze difference between the groups and categories (Sigma Stat 2.0.15 statistical software). When a significant F value was found, the post-hoc of Tukey was used. All measures compared show a normal distribution. Statistical significance was accepted at $p<0.05$.

RESULTS

Fluid intake

No difference in the volume of water intake was observed between categories. However, there was a difference between the groups (Table 1, Figure 1A). Players of the MAIN and PAR groups ingested significantly more water compared with both the INT and CON groups ($p<0.05$). In addition, the players from the INT group ingested significantly more water compared with the CON group ($p<0.05$).

Weight loss, sweat rate and HR

It was only possible to analyse the weight loss between categories of players from the MAIN group due to the reduced number of measurements taken from the other groups. Players of the U-17 category presented a significantly higher weight loss when compared with the players from the younger category ($p<0.05$) (Figure 2). When the athletes were grouped together, according to the time of action on game and not considering their categories, the weight loss were higher in the MAIN comparing to the INT

group ($p<0.05$) (Table 1, Figure 1B). The same pattern could be seen when the dehydration on percentage was analysed (Table 1, Figure 1C).

About the sweat rate, a significant difference was observed for both the MAIN and PAR groups when compared with the INT and CON groups ($p<0.05$), as shown in (Table 1, Figure 1D)

Table 1. Water intake, weight loss, dehydration percentage and sweat rate of each group.

	MAIN (n=24)	PAR (n=8)	INT (n=13)	CON (n=5)
Water intake (L)	1.39 ± 0.06 *#	1.69 ± 0.34 *#	0.74 ± 0.05 *	0.47 ± 0.07
range	0.75 - 1.70	1.17 - 3.00	0.3 - 0.95	0.17 - 0.60
Weight loss (kg)	0.49 ± 0.12 #	0.21 ± 0.13	0.07 ± 0.10	0.32 ± 0.11
range	1.72 - (+0.42)	0.62 - (+0.2)	0.72 - (+0.32)	0.76 - (+0.02)
Dehydration (%)	0.80 ± 0.20	0.35 ± 0.20	0.08 ± 0.15	0.54 ± 0.10
range	3.00 (+0.60)	1.00 (+0.30)	1.10 (+0.50)	1.20 (+0.01)
Sweat rate (mL/min)	25.58 ± 1.52 *#	27.17 ± 5.39 *#	10.51 ± 1.03	10.51 ± 2.11
range	13.57 - 40.33	21.20 - 46.85	5.28 - 17.85	7.20 - 16.53

Main group (MAIN) n=24, Partial group (PAR) n=8, Intermediate group (INT) n=13, Control group (CON) n=5. *Significantly different compared with CON group ($p<0.05$). #Significantly different compared with INT group ($p<0.05$), (mean ±SE).

The HR of the players recorded during the matches were; Main group 172 ± 8.6 bpm, PAR group 175 ± 6.3 bpm, INT group 174 ± 7.5 bpm and CON group 78 ± 10.3 bpm. There were no differences between categories or the groups of soccer players who played. The CON group present lower HR than another group ($P<0.05$).

Urine osmolality and specific gravity

No difference for urine osmolality was found either between categories, groups or when pre and post match samples were compared. As for urine specific gravity, there was a significant increase at the post-match time-point compared with the pre-match time point ($p<0.05$) for the MAIN and PAR groups (Table 2).

Table 2. Urine specific gravity and osmolality.

	MAIN (n=24)	PAR (n=8)	INT (n=13)	CON (n=5)
Specific gravity (mg/DI)				
Pre	1020.3 ± 0.8	1021.2 ± 1.6	1023.1 ± 1.9	1019.3 ± 3.1
Range	1012-1032	1018-1026	1014-1028	1010-1028
Post	1023.7 ± 0.7*	1025.3 ± 1.3*	1021.1 ± 2.8	1022.1 ± 2.3
Range	1015-1030	1022-1030	1008-1028	1014-1030
Osmolality (mOsm/kg)				
Pre	817.2 ± 168.6	865.5 ± 58.1	853.2 ± 61.3	753.8 ± 126.1
Range	520-1117	659-1102	698-1023	378-1036
Post	795.6 ± 100.6	738.3 ± 89.4	811.8 ± 52.9	841.6 ± 79.4
Range	958-496	536-1069	755-931	522-1090

Main group (MAIN), partial group (PAR), intermediate group (INT), control group (CON). Pre (pre match) and Post (post match).*Significantly different compared to pre match values ($p<0.05$), (mean±SE).

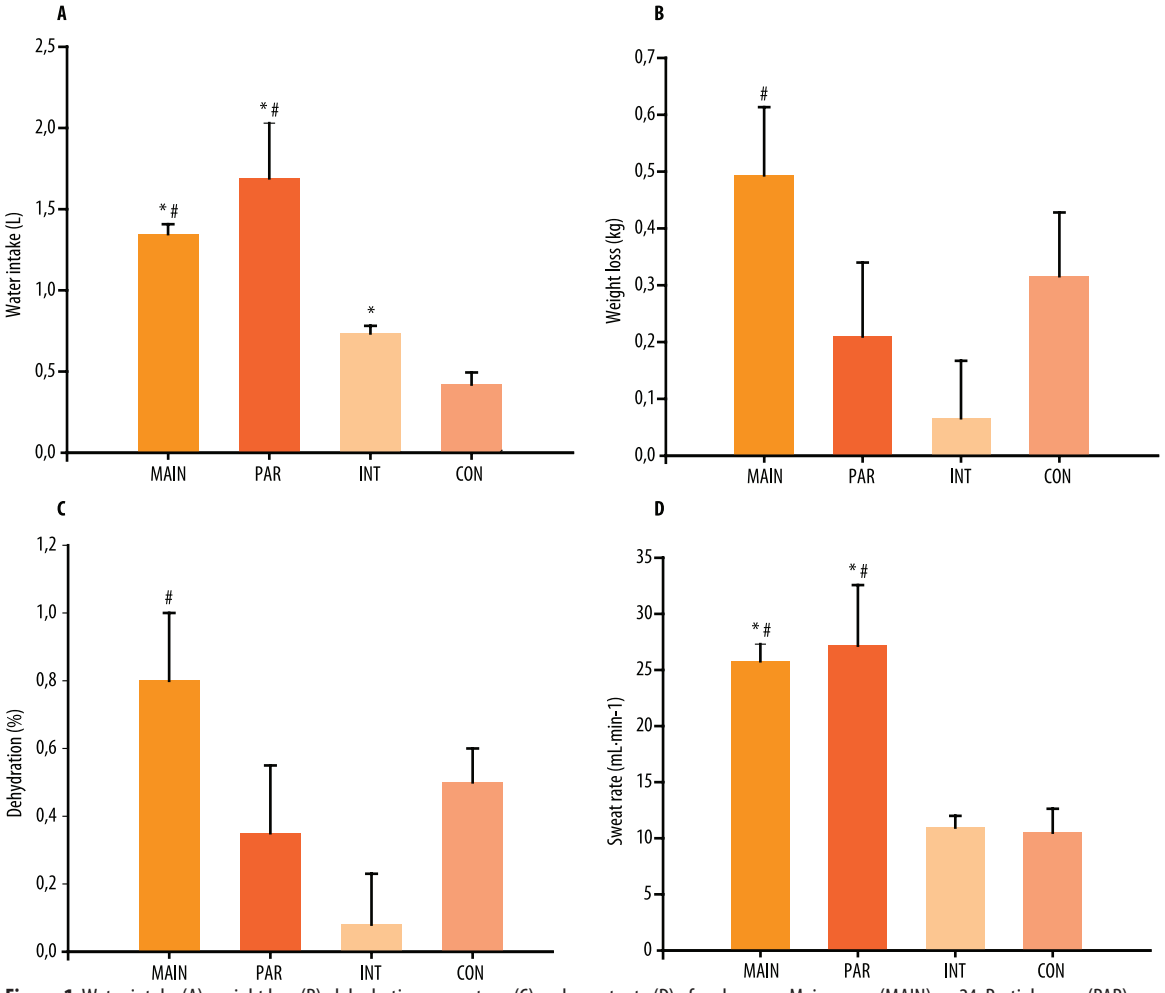

Figure 1. Water intake (A), weight loss (B), dehydration percentage (C) and sweat rate (D) of each group: Main group (MAIN) n=24, Partial group (PAR) n=8, Intermediate group (INT) n=13, Control group (CON) n=5. *Significantly different compared with CON group ($p<0.05$). #Significantly different compared with INT group ($p<0.05$), (mean ±SE).

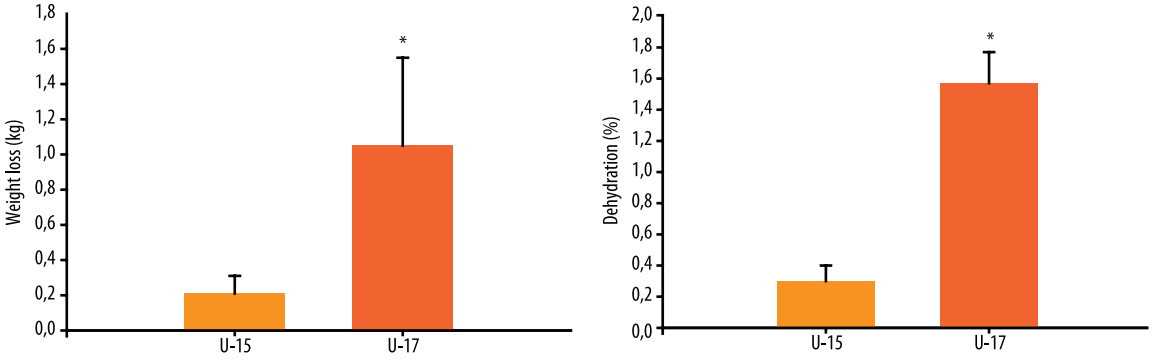

Figure 2. Weight loss and dehydration percentage measured post match in main group (MAIN) group of under-15 (U-15) and under-17 (U-17) categories. *Significantly different (mean±SE) ($p<0.05$).

Body temperature and environmental conditions

Body temperature was only measured from the players in the MAIN groups (n=24) of both categories. No difference was observed between the pre and post match values for either category. In addition, there was no difference between the categories (table 3).

The environmental conditions for both matches are presented in Table 3.

Table 3. Environmental conditions of both matches.

Time matches		DT (C°)	HT (C°)	WBGT (C°)	RH (%)
1st match	1stH	24.6 ± 2.2 * #	22.2 ± 1.1 # †	23.6 ± 1.6	80.7 ± 6.2
	2ndH	21.8 ± 0.3 **	21.3 ± 0.3 # †	21.7 ± 0.5 *	91.5 ± 0.0 *
2nd match	1stH	22.8 ± 0.1 * #	21.5 ± 0.2 # †	22.1 ± 0.1 *	91.0 ± 0.0 *
	2ndH	23.5 ± 0.2 # †	22.1 ± 0.1 # †	22.7 ± 0.2 # †	87.4 ± 4.2 * # †
Body temperature (C°)		U-17		U-15	
		Pre	Post	Pre	Post
		35.40 ± 0.5	35.20 ± 0.7	35.50 ± 0.4	35.18 ± 1.0

Dry temperature (DT), humid temperature (HT), wet globe bulb temperature (WGBT) and relative humidity (RH). First half (1stH) and second half (2ndH), Pre (pre match), Post (post match), U-17 (under-17) and U-15 (Under-15). *Significantly different compared with the 1st match 1stH ($p<0.05$). #Significantly different compared with the 1st match 2ndH ($p<0.05$). †Significantly different compared with the 2st match 1stH ($p<0.05$), (mean ±SD).

DISCUSSION

The main finding of the paper was the increase in water intake and sweat rate with the higher time spent in field during soccer matches (figure 1). Players of the MAIN and PAR groups ingested higher volumes of water compared with the other groups. This result was expected because these players spent more time playing. Nevertheless, there was no significant difference in this variable between the MAIN and PAR groups, even though the last group spent less time in field. This result can be explained by the accessibility of the athletes to hydration stations[4,18]. The athletes of the PAR group could have ingested more water during the first half of the match, before entering the match, or after they were substituted in the second half because they had easy access to their water bottles.

Krustrup et al.[6] observed an average water intake of 0.69 L in a friendly match. The present study found higher values: 1.39 ± 0.06 L and 1.69 ± 0.34 L for the MAIN and PAR groups respectively. This difference can be due to the higher intensity of the matches analysed. In addition, the volume of water ingested and sweat rate were higher in the groups that played during a longer period of time.

In the present study, a weight loss of 0.49 ± 0.12 kg (MAIN group) was observed. These results were lower than those reported by Guerra et al.[11] when evaluating the carbohydrate supplementation in an experimental group and in a control group. The latter presented a mean weight loss of 1.75 ± 0.47 kg, but they did not have access to water during the match, only at half-time. Shirreffs et al.[9] also reported lower values of weight loss (1.23 ± 0.50 kg) in a study analysing 26 professional soccer players during a 90 min training session in a warm and dry environment (30°C, RH 20%). Considering that the presented study evaluated a training session and not a competitive game, lack of motivation could have hindered the performance of the players, as shown by Antonacci et al.[19]. Thus, we expected a greater response to weight loss in this study, unlike what was found.

Maughan et al.[18] reported a higher weight loss (0.84 ± 0.52 kg) compared with the present study. Although the authors used a similar methodology, as well as professional soccer players, the environmental conditions were very different: temperatures between 6 and 8º C, RH between 50 and 60%.

Al-Haazza et al.[13] compared the dehydration percentage between children and young soccer players and reported that the groups presented a loss of 2.35% and 3.62% of their body weight respectively. Similar to this study, the authors found a relationship between parameters of hydration and time of performance of athletes. The dehydration percentages in the present study were smaller than values compared with the ones presented by Al-Haazza et al.[13]. It is important, however, to take into account that the effort intensity presented as HR (172 ± 8.6 bpm and 87.2 ± 2.6 %HRmax) during the matches of the present study were similar, not only compared with that reported by Al-Haazza et al.[13], but also compared with those of other studies evaluating competitive situations reporting average values of 165 bpm or 85%HRmax [20,21].

Shephard[8] reports that soccer players can lose between 3.5 and 4 L of sweat during a match in a warm environment. This might represent a 5% decrease in body weight which can decrease performance. According to Murray[7], physical activity performance is negatively influenced by dehydration above 3% of body weight. The present study showed lowers values than present by Murray[7]. Casa et al.[5] suggest that body weight loss ≥2% can be associated to a decrease in performance. Nevertheless, it is important to point out that fatigue during exercise can be explained by a combination of factors, such as metabolic, cardiovascular and respiratory factors, and not dehydration alone[6; 22].

Sweat rate was higher in both the MAIN and PAR groups compared with INT and CON groups. Although the MAIN group played longer than the PAR group, no difference between sweat rates was found between them. This might have happened due to higher effort intensity on behalf of the players that spent less time in field. This behaviour was not found in the INT group – here players did not present higher sweat rate values compared with the CON group. The CON group was composed of athletes who did just the warm up routine. This step consisted of displacement and intense exercise of short duration. Due to this fact the players in the group CON presented low sweat rates.

Additionally, the similarity between the INT and CON groups could be due to individual variation, sweating during resting condition throughout the game or the low number of players analysed in the CON group.

The sweat rate results, found in the present study for the MAIN (25.58 ± 1.52 mL/min, 1.53 ± 0.09 L/h) and PAR groups (27.17 ± 5.39 mL/min, 1.63 ± 0.32 L/h), represented in mL/min and L/h, are different from the values reported by Reis et al.[12]: 8.8 ± 6.6 mL/min with a large variation of 1.7 to 28.3 mL/min. These authors, however, evaluated a 60 min training session at a lower temperature (14°C) and RH (70%). Another study[23] evaluating two 90 min female soccer training sessions reported sweat rates of 0.49 and

0.44 L/h in environmental conditions of 14.1°C and 71% RH (1st session) and 6.2°C and 74% RH (2nd session). Moreover, McGregor et al.[24] presented the following sweat rate results from a soccer specific performance test in environmental conditions of approximately 20° C and RH 57%: 1.4 L/h for the group which ingested liquid throughout the test and 1.2 L/h for the group which ingested no liquids. The sweat rates reported in the present study are higher than those mentioned in the studies above probably because of the competitive situation that was analysed.

The U-17 athletes lost more weight compared to the younger category possibly due to the longer game duration and the unfavourable heat dissipation in the environmental conditions during their match: higher dry temperature. Additionally, the RH was higher during the 1st and 2nd halves of the U-17 match compared with the 1st half of the U-15 match. It has been well established that a combination of elevated temperature and RH results in higher losses of body fluids. Nevertheless, no differences in sweat rate were observed between the categories despite the different environmental conditions, game durations (35 and 40 min) and players' age (U-17 and U-15). Another point that must be considered is the absence of differences among the body temperatures of the athletes.

Besides dehydration percentage, other variables, such as urine specific gravity and osmolality, can be used to verify an individual's hydration status. Harvey et al.[25] analysed players' urine specific gravity before and after two soccer matches and showed an increase from 1.012 to 1.020 g/mL. This corroborates the present study that found an increase after the match for both the MAIN and PAR groups. Except for the CON group, classified by the ACSM[26] the players started the activity with higher values of considered euhydrated (≤ 1,020 g/mL). However Armstrong et al.[27] consider a variation from 1010 to 1030 g/mL, to classify individuals as euhydrated.

Players in this study, even showing no difference in osmolality in relation to pre and post and between both groups could be considered dehydrated because they had values below 700mOsm/kg[26]. This is in accordance with the study of Maughan et al.[18] who investigated a soccer match in a cold environment. Ali et al.[10], on the other hand, did show that there is a reduction of urine osmolality after specific training of female soccer players. Taking into account characteristics of soccer matches (i.e intermittent, high intensity, long duration), together with adverse environmental conditions, efficient hydration strategies are important to avoid dehydration during the match.

It has been suggested that blood analysis (plasma volume and osmolality) provide better indication of the hydration status because urine parameters can indicate a false-positive result[28]. The shifts evaluation in plasma volume and osmolality weren´t did. This can be one limitation of the present study.

Field research present difficulties of standardization of data . Researches on sports in competitive situations are difficult to perform due to interference in the routine of athletes. Outdoor team sports like Soccer have great difficulties to be searched. All these aspects can be highlighted as difficulties

or limitations of scientific research. Nevertheless, field researches in the sports in real situations have a high ecological validity and applicability in sports training science.

CONCLUSION

In summary, the present data showed that football matches were capable of altering significantly some parameters hydration status of players taking into consideration the time spent in the field. Better hydration strategies are needed, especially in warm condition, because the ones used during the official matches analysed here were to fulfil hydration needs.

Acknowledgements

We thank CAPES, CNPq, FAPEMIG and BRAZILIAN MINISTRY OF SPORTS for their financial support.

REFERENCE

1. Stolen T, Chamari K, Castagna C, Wisloff U. Physiology of soccer: an update. Sports Med 2005;35(6):501-36.
2. Silami-Garcia E, Espirito Santo LC, Garcia AMC, Nunes VNG. Energy expenditure of professional soccer players during official games. Med Sci Sports Exerc 2005; 37(5):S87.
3. Sawka MN, Montain SJ, Latzka WA. Hydration effects on thermoregulation and performance in the heat. Comparative Biochemistry and physiology. Part A, Mol inte physiol 2001;128:679-90.
4. Saltmarsh M. Thirst: why do people drink? Nutr Bul 2001;26:53-8.
5. Casa DJ, Armstrong LE, Hillman SK, Montain SJ, Reiff RV, Rich BS, Roberts WO, Stone JA. National Athletic Trainers' Association Position Statement: fluid replacement for athletes. J Athl Train 2000;35:212-24.
6. Krustrup P, Mohr M, Steensberg A, Bencke J, Kjaer M, Bangsbo J. Muscle and blood metabolites during a soccer game: Implications for sprint performance. Med Sci Sports Exerc 2006;36(8):1-10.
7. Murray B. Hydration and physical performance. J Am Col Nutr 2007; 26: 542s-548s.
8. Shephard RJ. Biology and medicine of soccer: An update. J Sports Sci 1999;17: 757-86
9. Shirreffs SM, Aragon-Vargas LF, Chamorro M, Maughan RJ, Serratosa, L, Zachwieja JJ. The sweating response of elite professional soccer players to training in the heat. Inter J Sports Med 2005;26(2):90-5.
10. Ali A, Gardiner R, Foskett A, Grant N. Fluid balance, thermoregulation and sprint and passing skill performance in female soccer players. Sca J Med Sci Sports 2010;21(3):437-45.
11. Guerra I, Soares E, Burini R. Nutritional aspects of competitive soccer. Rev Bras Med Esporte 2001;7(6):200-6.
12. Reis V, Azevedo C, Rossi L. Anthropometric profile and sweat rate in young soccer players. Rev Bras Cineantropom Desempenho Hum 2009;11(2):134-11
13. Al-Haazza HM, Al-Refaee SA, Sulaiman MA, Muzaini KS, Abood SA, Al-Jaloud K, et al. Energy demands and fluid loss during youth soccer. Proceeding of the congress on science and football. Tokyo, 1995;310-25.
14. Castagna C, Impellizzeri FM, Chamari K, Carlomagno D, Rampinini E. Aerobic fitness and yo-yo continuous and intermittent tests performances in soccer players: A correlation study. J Strength Cond Res 2006;20:320-5.
15. Perrela M, Noriyuki O, Rossi L. Evaluation of water loss during high intensity rugby training. Rev Brasi Med Esporte 2005;11:229-32.

16. Roberts M, Wenger C, Stolwijk J, Nadel E. Skin blood flow and sweating changes following exercise training and heat acclimatization. J Appl Physiol 1977;43:133-7.
17. Consolazio C, Johnson R, Pecora L. *Physiological measurements of metabolic functions in man*. New York: McGraw-Hill. 1963.
18. Maughan RJ, Watson P, Evans G, Broad N, Shirreffs S. Water Balance and Salt Losses in Competitive Football. International J Sport Nutr Exerc Metabolism 2007; 17:583-94.
19. Antonacci L, Mortimer L, Rodrigues V, Coelho D, Soares D, Silami-Garcia E. Competition, estimated, and test maximum heart rate. J Sports Med Phys Fitness 2007;47:418-21.
20. Helgerud J, Engen L, Wisloff U, Hoff J. Aerobic endurance training improves soccer performance. Med Sci Sports Exerc 2001;33:1925-31.
21. Mortimer L, Condessa L, Rodrigues V, Coelho D, Soares D, Silami-Garcia E.. Comparison between the effort intensity of young soccer players in the first and second halves of the soccer game. Rev Port Ciên Des 2006;6:154-9.
22. Edwards A, Noakes T. Dehydration: cause of fatigue or sign of pacing in elite soccer? Sports Med 2009;39:1-13.
23. Kilding A, Tunstall H, Wraith E, Good M, Gammon C, Smith C. Sweat rate and sweat electrolyte composition in international female soccer players during game specific training. Inter J Sports Med 2009; 30(6):443-7.
24. McGregor S, Nicholas C, Lakomy H, Williams C. The influence of intermittent high-intensity shuttle running and fluid ingestion on the performance of a soccer skill. J Sports Sci 1999;17:895-903.
25. Harvey G, Meir R, Brooks L, Holloway K. The use of body mass changes as a practical measure of dehydration in team sports. J Sci Med Sport 2008;11:600-3.
26. ACSM – American college of sports medicine. Exercise and fluid replacement. Med Sci Sports Exer 2007;39:377-90
27. Armstrong L, Maresh C, Castellani J, Bergeron M, Kenefick R, Lagasse K, Riebe D. Urinary indices of hydration status. Inter J Sport Nutr 1994;4:265-79.
28. Hamouti N, Del Coso J, Avila A, Mora-Rodriguez R. Effects of athletes' muscle mass on urinary markers of hydration status. Eur J Appl Physiol 2010;109:213-19.

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