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DEHYDRATION IN SOCCER PLAYERS AFTER A MATCH IN THE HEAT

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AUTHORS: Guttierres A.P.M.[1], Natali A.J[2], Vianna J.M[3], Reis V.M.[4], Marins J.C.B.[5]

[1] Department of Nutrition and Health, Center of Biological and Health Sciences, Federal University of Viçosa,Viçosa, MG, Brazil
[2] Department of Physical Education, Center of Biological and Health Sciences, Federal University of Viçosa,Viçosa, MG, Brazil
[3] Faculty of Physical Education and Sports, Federal University of Juiz de Fora, Juiz de Fora, MG, Brasil
[4] Research Centre for Sport, Health & Human Development, University of Trás-os-Montes & Alto Douro, Vila Real, Portugal
[5] Department of Physical Education, Center of Biological and Health Sciences, Federal University of Viçosa,Viçosa, MG, Brazil

Reprint request to:
Ana Guttierres
Barão de Cataguases
36085170 juiz de Fora
Brazil
E-mail: paulagutti@gmail.com

ABSTRACT: We investigated the level of dehydration after a match in 20 soccer players (mean ± SD, 17.9 ± 1.3 years old, height 1.75 ± 0.05 m, body mass 70.71± 7.65 kg) from two teams that participate in a Brazilian Championship game performed at a temperature of 29 ± 1.1 C and a relative humidity of 64 ± 4.2%. Body mass, urine specific gravity and urinary protein were measured before and after the match, and self-perception measurements were performed during the match. Body mass loss was 1.00 ± 0.39 kg, corresponding to a dehydration percentage of 1.35 ± 0.87%. The mean sweating rate during the match was 866 ± 319 $ml \cdot h^{-1}$ and total fluid intake was 1265.00 ± 505.45 ml. The sweating rate and the quantity of ingested fluids correlated positively ($r = 0.98$; $P<0.05$). Protein occurred in the urine in 18 soccer players. The players showed no perception of thirst and considered themselves as comfortable during the match. At the end of the match the soccer players replaced 57.7 ± 15% of the water loss and presented a condition of significant to severe dehydration based on the post-match urine specific gravity data (1.027 ± 6 $g \cdot ml^{-1}$). The results of this study demonstrate that most of the soccer players began the match with some degree of dehydration that worsened during the match.

KEY WORDS: hydration, dehydration, fluid intake, sweating rate, soccer, urinary protein

INTRODUCTION

Soccer has been much discussed and studied. There have been studies determining anthropometric and physiological data [11], kinematics, speed, acceleration [19,29] and fatigue, among other aspects [21,23,28], with a view to improving performance.

Hydration is an important issue to consider in sports performance as dehydration can reduce athletes' performance capacity [18,31]. In team sports, such as soccer, dehydration may impair performance due to the duration of the match and the limited amount of breaks that allow athletes to rehydrate.

Sprints are frequently performed during a soccer match and this may decrease the availability of the fluids ingested due to the lower gastric emptying rate [13,17,28]. Furthermore, many soccer players can start the match with fluid deficit, showing a state of hypohydration starting the match with water loss of 1.37% of total body weight [18,25], which suggested that most players ingested insufficient fluid to keep the level of hydration appropriate.

Soccer players are less capable of anticipating sweat losses compared to athletes who take part in moderate intensity, long and continuous events [24]. This is explained by the fact that each match can be considered as a "new game", leading to different physical requirements. Typically, the liquid intake occurs before the match and during the half-time interval as the game rules do not allow formal breaks which could be used to replace fluid loss. Thus, water replacement is occasional during the match (penalty kicks, fouls, substitutions) and is not carefully planned in advance [3].

Some conditions seem to hamper the maintenance of satisfactory hydration status, such as exercising in warm environments [17], more than one training session performed on the same day, lack of available fluids during the sports events, competition circumstances or a combination of these factors [1,2].

The unfavourable conditions associated with a warm climate are constant in soccer matches in tropical and sub-tropical countries and the stress caused by the warm environment reduces the exertion capacity at every dehydration levels [22]. In the literature, data on dehydration during outdoor soccer matches in the heat are scarce [2,12]. Therefore, the aims of the present study were: i) to assess the level of dehydration of soccer players after a match, ii) to assess the presence of urine metabolites after a match.

MATERIALS AND METHODS

Subjects. The sample consisted of 20 soccer players (mean ± SD, 17.9 ± 1.3 years old, height 1.75 ± 0.05 m, body mass 70.71 ± 7.65 kg) from two teams that participate in the Brazilian Junior Championship. These athletes trained on average ten sessions a week (five days x two daily 3-hour sessions) and played one match a week. All the participants were informed about the procedures and possible health risks and signed an informed consent form to participate in the experiment. The protocol of the study was approved by the Ethical Committee of the Federal University of Viçosa, Minas Gerais, Brazil, according to the revised Declaration of Helsinki. From the 20 soccer players, 8 were defenders, 8 were midfielders and 4 were forwarders. Goalkeepers were excluded.

Procedures

In the morning of the data collection day, the subjects visited the laboratory and were submitted to anthropometric measurements carried out by an expert in our laboratory. The body mass was measured by using a digital scale (Soehnle 7820.21, Asimed, Barcelona, Spain). The athletes were wearing trunks, and had their bladder completely empty. Athletes' height was measured by using a stadiometer (Seca 202, Birmingham, UK).

In the afternoon of the same day, the players took part in, the players took part in a soccer match between 4 p.m. and 6 p.m. on a natural grass field with official dimensions and according to the official international rules. Environmental conditions were recorded (THR-130, Instrutherm, São Paulo, Brazil) every five minutes during the total activity period, which consisted of 20 minutes warm-up and the 90 minutes of match with a 15-minute half-time interval. The individual maximum heart rate (MHR) was obtained as the maximum peak value during the games or calculated according to Tanaka et al. [28]. The effort intensity observed during the entire match was 80 ± 3.2%, taking the average heart rate of all players evaluated (Polar Team System®, Polar Electro Oy, Kempele, Finland). That value corroborates other studies for players of the same category [9,15]. The official referee procedures were also followed. The mean temperature during the match was 29 ± 1.1˚C and mean humidity was 64 ± 4.2%. In the last 15 min before the start of the match, the players were weighed. During the match, water intake was self-selected according to the occasional stops that usually occur during a match. The partial and total quantity of liquid intake for each athlete was recorded at the end of each match half. For this purpose, water bottles were assigned to each player and labelled with the respective name. The players were asked to use these bottles for fluid intake only. If the players wanted to pour water over themselves or wash their mouth without ingesting fluid, a separate group of different bottles (larger and with a different colour) were provided to each team.

The players were weighed after the match without emptying the bladder. They were then allowed to empty the bladder completely into a collecting bag and the body mass was measured again. To assess the fluid loss during the match, the total urine volume was weighed and shortly afterwards the urine specific gravity (USG) was determined by an optical refractometer (LF Equipments, model 107/3, São Paulo, Brazil) calibrated with deionised water. Smaller changes in the body mass due to substrate oxidation and other sources of water loss were not considered. Uriquest tapes (Labtest Diagnostica S.A., Lagoa Santa, Brazil) were used to measure the urine protein, leukocyte, haemoglobin, pH and bilirubin. The formula is as follows [14]: Sweating rate = [(initial weight - final weight) + volume of fluid consumed - (faecal volume + urine volume) / exercise time x 60].

Self-perception of the environment was assessed as proposed by Cunningham et al. [8]. Self-perception of the effect of hydration was assessed according to Murray et al. [20]. These measures were collected immediately before the start of the match and at the end of each half.

Statistical analysis

Data are presented as means with standard deviations (SD) and range. The assumption of normality was checked with the Shapiro–Wilk test. Comparisons between measurements were performed with paired Student's t-test or one-way ANOVA, whenever appropriate. Pearson's product–moment correlations were used to examine the relationships between variables. Statistical significance was assumed at $p<0.05$. The Statistical Package for Social Sciences SPSS (v 15, SPSS Inc., Chicago, IL) was used for statistical analyses.

RESULTS

Table 1 presents the body water balance resulting from the soccer match. Body mass loss after the match corrected by water replacement (1.00 ± 0.39 kg; range 0.2-1.7 kg) was not significantly different and corresponded to a dehydration percentage of 1.35 ± 0.87% (range 0-3.27%) ($p>0.05$). The athletes replaced the equivalent of 58 ± 15% (range 31-90%) of the total fluid losses.

Based on the urine collections (5), we found that before the match 9 players presented minimal dehydration (1.010-1.020 $g \cdot ml^{-1}$), 10 players presented significant dehydration (1.021-1.030$g \cdot ml^{-1}$)

TABLE 1. FLUID HOMEOSTASIS OF THE SUBJECTS (n=20)

Dehydration data	Mean (± SD)	Range
Before match body mass (kg)	71.0 ± 7.7	56.7 – 84.8
After match body mass (kg)	70.0 ± 7.6	56.0 – 83.9
Total fluid replacement (ml)	1271 ± 505	680 – 2520
Total after match urine (ml)	82.00 ± 60.17	0 – 200
Sweat loss (kg)	2.36 ± 0.53	1.64-3.82
Relative dehydration (%)	1.0 ± 0.4	0.2 –1.7
Sweating rate ($ml \cdot h^{-1}$).	866 ± 319	388 –1681
Sweating rate ($ml \cdot min^{-1}$)	10.00 ± 3.35	4 – 19

Note: Relative dehydration = before match body mass minus after match body mass; Sweat loss = (before match body mass plus total fluid replacement) minus (after match body mass plus urine produced during the match)

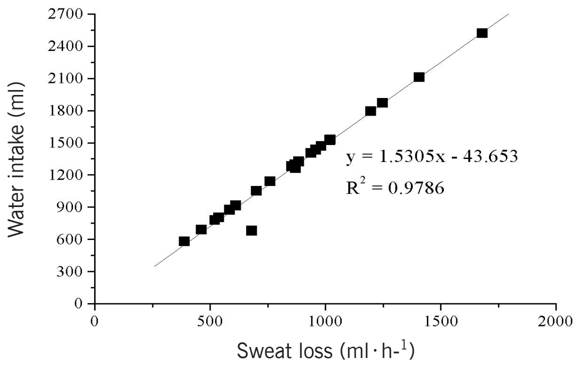

FIG. 1. CORRELATION BETWEEN WATER INTAKE AND SWEATING RATE IN SOCCER PLAYERS (n=20) ($p<0.001$).

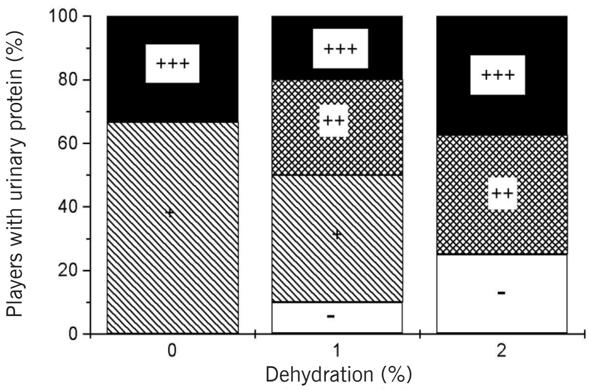

FIG. 2. DEGREE OF DEHYDRATION AND PROTEIN PRESENCE IN THE URINE. Note: (+) appearance of traces; (++) concentration of 30 µg/dl; (+++) concentration of 100 µg/dl. Significant differences were found in urinary protein between all three dehydration levels ($p<0.01$).

TABLE 2. DEGREE OF DEHYDRATION AND PROTEIN PRESENCE IN THE URINE

Players	Dehydration (%)	Urine Protein (µg/dl)
1	1,5	+++
2	1,4	0
3	1,9	++
4	1,4	+
5	2,3	+++
6	1,3	+++
7	1,6	++
8	0,3	+++
9	1,5	0
10	0,4	+
11	0,8	+++
12	0,3	+
13	2,1	++
14	1,2	++
15	1,7	0
16	0,9	+
17	1,2	++
18	1,2	++
19	2,2	+++
20	1,1	+

Note: 0= no appearance, (+) appearance of traces; (++) concentration of 30 µg/dl; (+++) concentration of 100µg/dl.

and a single player was seriously dehydrated (> 1.030 g·ml^{-1}). After the match, the distribution was 3, 11 and 3, respectively for the-above mentioned levels of dehydration. Five players did not urinate after the match.

The sweating rate had a significant correlation ($r=0.98$; $p<0.001$) with the fluid intake. Figure 1 presents this correlation.

The mean pre-match USG was 1.023 ± 6 g·ml^{-1} (range 1.012-1.036 g·ml^{-1}). There was no correlation between pre-match USG and water intake in the first half nor with total water intake ($p>0.05$, $r=0.17$ and $r=0.0$, respectively). The post-exercise mean USG was 1.027 ± 6 g·ml^{-1} (range 1.016-1.040 g·ml^{-1}). Post-match USG did not correlate with the total water intake ($p>0.05$, $r=0.16$). There was no correlation between body mass loss and post-exercise USG ($p>0.04$, $r=0.06$). The metabolite analysis showed that protein was the single metabolite that was present in the urine (in 17 players). The amount of protein presence in the urine was higher with increasing levels of dehydration (Fig. 2). The degree of dehydration and urine protein concentration of each player are shown in Table 2. No player showed the desire to urinate during the match.

Regarding the self-perception of the hydration effect, it did not correlate with water intake during the match in the first half or in the second half ($p>0.05$; $r=0.38$ and $r=0.15$, respectively). Nineteen players did not feel any degree of nausea and 1 felt a slight degree of nausea during the match. The mean degree of thirst was 2 (from 1 to 5) at the beginning of the first and second half, reaching degree 3 by the end of each half. A total of 8 players started the match with a perception of no thirst and 12 ended the match with no thirst or with a slight degree of thirst. The thirst perception index did not correlate ($p>0.05$) with the sweating rate, water intake or heat sensation ($r=0.10$, $r=0.09$ and $r=0.05$, respectively). Regarding the players' heat perception, on average, they started and finished the match perceiving that the environment was slightly warm but comfortable at the start of the match, progressing to a slight discomfort at the end.

DISCUSSION

In the present study we investigated the level of dehydration of soccer players during a match. The players presented a mass loss of 1.00 ± 0.39 kg corresponding to 1.35 ± 0.87% of total body mass, a sweating rate of 866 ± 319 ml·h^{-1} and a total fluid intake of 1265 ± 505 ml. Compared to our data, the values previously reported [24] were higher for body mass loss and sweating rate (1.59 ± 0.61% and 1460 ± 240 ml·h^{-1}, respectively). However, the fluid intake reported [24] was lower (972 ± 335 ml) than in the present study, which could justify a greater body mass loss in that study.

In another study [31] body mass decreased 0.2±0.4%, 2.4±0.4%, and 4.8±0.4% during completion of 3 identical resistance exercise (6 sets of up to 10 repetitions of the back squat) in different hydration states: euhydrated state (HY0), hypohydrated state approximately 2.5% body mass (HY2.5), and hypohydrated state approximately 5.0% body mass (HY5), respectively. Myoglobin concentrations increased significantly (effect size ≥ 1, $p < 0.05$) from euhydrated rest (2.6±1.1, 3.5±2.8, and 3.2±1.6 nmol·L^{-1}) to 1 hour post-exercise (5.3±3.4, 6.8±3.2, and 7.6±2.8 nmol·L^{-1}), and 2 hours post-exercise (5.5±3.8, 6.2±3.0, and 7.2±3.0 nmol·L^{-1}) for HY0, HY2.5, and HY5, respectively, but were not significantly different between trials.

The higher fluid intake in our subjects, as compared to those tested, can be explained by the increased heat stress in our study [24]. On the other hand, differences in the sweating rate between the two studies can be possibly explained by different physical fitness levels of the subjects. Indeed, this work analysed amateur players, whereas the other study [24] tested professional athletes. It is important to understand that exercise fluid losses of 1 to 2% of body mass may not be well tolerated by athletes who started exercise in a hypohydrated state. In the present study, the results indicated that the players started the exercise with some degree of dehydration [26,31]. Additionally, the temperature during the match in the present study was high (29 ± 1.10°C). Therefore the fluid ingestion during the match was high, when compared to another study [26,31], which could help to explain the lower body mass loss during the match. Moreover, the collections were performed 90 minutes after the second training session of the day and not after match play, which could also explain the differences between the results of the two experiments [24].

Despite the insufficient fluid replacement that was observed, there was a positive correlation between fluid intake and sweating rate (Fig. 1). Our results are at odds with the absence of such a correlation described in elite soccer players [18] performing in a cold environment. However, a significant but weaker association ($r=0.315$; $p<0.05$) was described in beach volleyball players during a tournament. In this work we did not perform any control on the liquid ingestion prior to the testing. However, we assessed pre-match level of dehydration and found that most of the players did present a hypohydrated state [32]. Therefore, it is possible that this could have influenced the above-mentioned association. This finding warrants further research to understand whether such a relationship is reproducible or was just an artefact.

The results of the present study showed that ~45% of the players started the match with a minimum dehydration status, ~50% of the players presented a significant level of dehydration and ~5% presented a condition of serious dehydration in the pre-match period. These stages of pre-match hypohydration could be explained by the fact that this was the second training session of the day. This fact is in line with the position of the American College of Sports Medicine (ACSM) [1], which reports that two training sessions in the same day seem to impair the maintenance of a satisfactory hydration state. Although the players' performance was not assessed in the present study, this condition might interfere negatively with it.

In the present study, it was observed that after the match the dehydration status of the players had worsened, as only ~18% of the players presented slight dehydration, ~65% of the players reached significant dehydration levels and ~17% presented a serious dehydration condition. This study is in line with that which reported that after a match in which flavoured water was ingested, the increase in the mean USG (1.024 g·ml^{-1}) was similar to that detected in the present study (1.027 g·ml^{-1}), despite the different fluid replacement protocols that were used in the two studies [10,12]. Indeed, the individuals in the study [12] were submitted to the hydration protocol purposed by the ACSM [1], whereas in the present study water ingestion was self-selected. However, changes in USG during exercise may not necessarily reflect dehydration since the latter may be influenced by other factors such as hormone release (i.e. aldosterone or renin).

We observed that individuals who started the exercise with a greater degree of hypohydration did not seek to compensate the situation with a greater liquid intake. Indeed, the pre-match USG did not correlate with the total quantity of fluids ingested ($p>0.05$). Hypohydration seems to enhance the effects of heat stress and severely damages the capacity of individuals to tolerate exertion [6]. In addition, care should be taken with the hypohydration state because it is considered to be a predisposing factor for the occurrence of heart lesions, especially when prolonged exertion is carried out in high-temperature environments [7]. Furthermore, efficacious hydration strategies are extremely important since dehydration may negatively affect cognitive functions. Team sports, such as soccer, are characterised by a high demand of skill and motor control. Hence, the integrity of the cognitive functions is necessary to meet the tactical changes that occur during the match [4]. Our data suggest that soccer players present inadequate hydration habits, which has probably contributed to the large fraction of individuals (~82%) who attained dehydration considered significant or serious [5] at the end of the match. Such a phenomenon may be confirmed by the fact that in the present study the athletes replaced only 58 ± 15% of their fluid losses.

This study found that ~55% of the players finished the match with no thirst or with a slight degree of thirst, despite the heat perception as a slightly warm environment. Therefore the low thirst sensation may have contributed to the players' insufficient ingestion of fluids. Since thirst in humans is not perceived until the subject reaches a 2% body mass loss deficit [22], our results also suggest that fluid replacement in soccer should not be self-selected as it may contribute to severe dehydration status. Indeed, it was observed that the players suffered a body mass loss less than 2%. It seems therefore reasonable to conclude that thirst should not be used as a sign to start the hydration process during soccer matches. Moreover, since the levels of gastric fullness and nausea were low among the players in the present study, we may consider that such factors did not interfere with the inadequate water replacement. However, we may speculate that the low water palatability contributed to the observed inadequate fluid replacement. Indeed, it has been reported that greater palatability of sport drinks stimulates its ingestion [24].

Further studies are warranted to test the hypothesis that inadequate fluid replacement under a self-selected strategy in soccer players is affected by the choice of the liquid (water vs. flavoured liquids).

It was demonstrated in the present study that the greater the degree of dehydration (2%) the greater the concentration of protein in the urine (see Fig. 2). These results were expected, since protein typically appears in the urine after performing strenuous exercise if the individuals are in a hypohydrated state and the circulating protein is excreted due to the decrease in the plasmatic volume. Urine protein also occurs due to stress caused by exercise and seems to be induced by an increase in blood acidosis that leads to changes in the albumin molecule arrangement [30].

CONCLUSIONS

In summary, the players started the match with some degree of dehydration, which suggests a possible state of chronic dehydration. They did not consume liquids adequately during the match and therefore the initial hypohydration was increased. After the match, the level of dehydration reached 1.35 ± 0.87% and protein was present in most of the urine samples. All together, these results indicate that individual hydration protocols should be elaborated for application before, during and after matches and training sessions, so that the possible effects of dehydration can be minimised or even abolished, thus contributing to optimisation of the individual's performance in soccer.

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