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Pre-game hydration status, sweat loss, and fluid intake in elite Brazilian young male soccer players during competition

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Abstract
In this study, we assessed the pre-game hydration status and fluid balance of elite young soccer players competing in a match played in the heat (temperature 31.0 ± 2.0 °C, relative humidity 48.0 ± 5.0%) for an official Brazilian soccer competition. Fluid intake was measured during the match, as were urine specific gravity and body mass before and after the game to estimate hydration status. Data were obtained from 15 male players (age 17.0 ± 0.6 years, height 1.78 ± 0.06 m, mass 65.3 ± 3.8 kg); however, data are only analysed for 10 players who completed the full game. The mean (±s) sweat loss of players amounted to 2.24 ± 0.63 L, and mean fluid intake was 1.12 ± 0.39 L. Pre-game urine specific gravity was 1.021 ± 0.004, ranging from 1.010 to 1.025. There was no significant correlation between sweat loss and fluid intake (r = 0.504, P = 0.137) or between urine specific gravity and fluid intake (r = 0.276, P = 0.440). We conclude that young, native tropical soccer players started the match hypohydrated and replaced about 50% of the sweat lost. Thus, effective strategies to improve fluid replacement are needed for players competing in the heat.

Keywords: Dehydration, fluid balance, sweating, junior athletes, soccer

Introduction
Soccer is a team sport that requires frequent fluctuation between high and low exercise intensities, where the high work rates and extended nature of the game lead to elevations in body temperature(s) and the initiation of a sweating response (Bangsbo, Mohr, & Krustup, 2006). Several reports in the literature have shown that fluid loss in adult soccer players can be substantial (Kurdak et al., 2010; Maughan, Watson, Evans, Broad, & Shirreffs, 2007; Shirreffs et al., 2005), and even mild dehydration may have adverse effects on a number of physiological and cognitive functions that are important for components of soccer performance (Edwards et al., 2007).

Sweat loss is influenced both by exogenous factors, such as environmental conditions and clothing type, and by endogenous factors, such as metabolic rate (Sawka et al., 2007). While the rate of energy expenditure by soccer players depends on many independent factors, including chronological age, biological maturity, training age, morphology, and anthropometry (Le Gall, Carling, Williams, & Reilly, 2010), sweat loss may be different between soccer players engaged in distinct age categories. Although there are some data on fluid balance in soccer players, most relate to adult players during training in cool environments, with limited data on professional young soccer players competing in warmer environments.

Players would normally be expected to ingest fluids during training or match-play, and both water and carbohydrate-electrolyte drinks are widely used. However, unlike most sports, soccer provides few opportunities to drink because of limited access to fluids and the absence of breaks during a match (Edwards & Clark, 2006). Fluid losses of 1–2% of body mass are typical in adult soccer athletes across most environmental conditions (Shirreffs, Sawka, & Stone, 2006), and the amount of fluid intake during games rarely matches the fluid lost, often resulting in voluntary dehydration (Maughan et al., 2007).
In competitive match-play, the players are under constant emotional and psychological stress, which could influence their motivational behaviour on the field. Such factors may affect elements of self-pacing that determine variables such as distance covered, energy expenditure, and hence fluid balance (Harley et al., 2010). However, limited data are available on professional young soccer players during official competition match-play where habitual hydration regimes were maintained. Furthermore, it has been reported that a great proportion of soccer players start a match in a hypohydrated state (Aragón-Vargas, Moncada-Jiménez, Hernández-Elizondo, Barrenechea, & Monde-Alvarado, 2009; Maughan et al., 2007). However, the extent of this pre-game hypohydration in young soccer players requires further investigation.

The majority of studies have examined thermo-regulatory responses of soccer players in non-tropical natives and limited data are available on fluid balance in young, tropical native soccer players practising in their natural environment. Tropical natives present a more efficient thermo-regulatory system with reduced heat strain and increased tolerance to exercise in hot environments compared with non-tropical natives (Hori, 1995; Magalhães et al., 2010; Nguyen & Tokura, 2003). Recently, Silva et al. (2011) investigated tropical natives and reported a significant relationship between fluid intake and estimated sweat loss of young soccer players during training, while Aragón-Vargas et al. (2009) observed that tropical adult soccer players who report for competition with the highest urine specific gravity are likely to drink more during the match. It remains to be determined, however, whether tropical young soccer players respond similarly during official match-play.

The aim of the present study, therefore, was to assess the fluid losses and fluid intake of elite Brazilian youth soccer players during official match-play for the classification phase of a Brazilian soccer competition. We also assessed pre-game hydration status and its relationship with the volume of sweat loss and the fluid consumed by players.

Methods

Participants

Fifteen adolescent male soccer players agreed to participate in the study. They were the team members and substitutes of a first division Brazilian professional soccer club who took part in a competitive match. All players and parents gave written informed consent and the study was approved by the Institutional Ethics Committee. The players’ physical characteristics were as follow: age 17.0 ± 0.6 years, height 1.78 ± 0.06 m, and body mass 65.3 ± 3.8 kg.

Experimental design

All measurements were made during the last game of the classification phase of an under-17 Brazilian soccer competition. The game, which consisted of two 40-min periods and a 15-min half-time interval, was played in the morning (11:30 h kick-off). The temperature at the time of the match was approximately 31.0 ± 2.0°C with relative humidity (RH) of 48.0 ± 5.0% measured by a wet bulb globe temperature (WBGT) monitor (TGM 100, Homis®, Brazil). Heat stress (WBGT measured every 15 min) was 29.3 ± 2.3°C (range 28.6–32.0°C). Data for the pre-game urine and thirst sensation measurements of all participants are included, but all other data relating to players who did not complete the full match are excluded. Complete data are therefore available for 10 players who completed the full 80 min of play (one player was expelled 5 min into the game) and four substitutes, none of whom played.

Efforts were made to minimally alter the typical behaviour of the athletes, so no change to the athletes' routine was made before they arrived at the stadium for competition. This included instructing athletes to maintain their usual pre-match diet and hydration practices and the measurements made once at the stadium were both fast and efficient so as not to impact on their pre-match routine. Approximately 1 h before the game all players, including substitutes, reported to the dressing room of the stadium after following their normal pre-game routine. Athletes were instructed to empty their bladders as completely as possible and defecate if necessary. Each participant provided a urine sample and was weighed nude on a digital scale accurate to 0.01 kg (Soehnle®, Spain). Pre-game urine specific gravity was assessed within 30 min of collection using a clinical handheld refractometer (model A300; ATAGO Co., Tokyo, Japan) that was calibrated with distilled water before the start of the tests and reviewed periodically between samples. The same individual measured all urine samples, which were discarded immediately after assessment. The participants also responded verbally to a survey enquiring about pre-game thirst sensation using a 9-point scale (Engell et al., 1987) ranging from 1 ("not thirsty") to 9 ("very thirsty").

Thereafter, players and substitutes changed into playing kit (standardized to all athletes: T-shirt, shorts, socks, and shoes), received an individual opaque bottle labelled with the player’s name, and performed the warm-up on the field for about 15 min before returning to the dressing room approximately 5 min before kick-off. The bottles contained water, as this was normally available to the players during
the match. They were allowed to consume water *ad libitum* but drinking only from the bottles provided and not spitting any of the fluid out or using the fluid to rinse their faces. During match-play the players and substitutes had free access to the bottles that were positioned at a specific location off the field of play, reproducing habitual athletes’ behaviour. Individual drink bottles were weighed before being provided to the volunteers and at every refilling using a digital scale (Plenna, MSI Inc., USA; ± 0.01 g). All participants were constantly observed by their own support staff and by the researchers before and during the match to ensure compliance. To reduce potential bias, limited explanations were provided to the participants about fluid intake behaviour. They were informed that measurements of their sensory, subjective, and physiological parameters of fluid replacement would be made, but were unaware that their fluid consumption was measured and were blind to the purpose of the study. Participants were also instructed by the coaching staff to ingest 400 mL of a 6% carbohydrate-electrolyte drink over the course of the game, as well as 200 mL 30 min before the match and an additional 200 mL at half-time; this was in keeping with usual match-day routine/instruction. The athletes were instructed to collect any urine passed during the game in containers provided so that this could be taken into account in the calculation of sweat loss from the measured changes in body mass. None of the players passed urine in the period between baseline measurement of body mass and the start of the match. Two of the 10 players involved in the game and one substitute passed urine at half-time. Substitutes warmed up with players before the game, and then stood on the corner line during the game performing minimal activities directed by coaching staff aimed at keeping them warmed up. None of the participants changed their clothing during the course of the game.

At the end of the match, all bottles were immediately collected and weighed, and the athletes were not allowed to drink anything else until the measurement of their post-game body mass. Any excess of sweat was then towelled off and the players were weighed as before the game. Participants were asked to empty their bladder as fully as possible and to collect the entire volume in a container provided, which was used to assess post-game urine specific gravity and urine volume. Water palatability was reported after the match using a 10-point hedonic-category scale (Peryam & Pilgrim, 1957) ranging from 1 (‘dislike extremely’)) to 10 (‘like extremely’) as well as thirst sensation as before the game. Sweat loss was estimated using the change in body mass, corrected for any urine loss and the volume of fluid consumed. The relatively small changes in body mass due to substrate oxidation and other sources of water loss (primarily evaporative loss from the lungs) were ignored (Maughan & Shirreffs, 2010).

**Statistical analysis**

The data were tested for normality of distribution and are presented as means ± standard deviations (s), minimum and maximum values (range). Pearson correlation coefficients were generated to determine whether there was a relationship between variables such as urine specific gravity, thirst sensation, fluid intake, and sweat loss. A paired *t*-test was performed to evaluate the effects of time (pre or post measurement) on urine specific gravity, body mass, and thirst sensation. Data analyses were conducted with SPSS (version 14.0; SPSS Inc., Chicago, IL). Statistical significance was set at *P* < 0.05.

**Results**

The body mass loss, fluid intake, sweat loss, and urine output data of the players who completed the game (*n* = 10) and substitutes (*n* = 4) are shown in Table I. There was no significant relationship between the total volume of sweat lost during the match and the volume of fluid ingested (*r* = 0.504, *P* = 0.137; *n* = 10) (Figure 1).

The pre-game urine specific gravity of all participants (*n* = 15) was 1.021 ± 0.004 (range 1.010–1.025). The pre-game urine specific gravity (1.020 ± 0.004; range 1.010–1.025) of the players who completed the game (*n* = 10) was significantly different (*P* < 0.05) from the post-game urine specific gravity (1.016 ± 0.004; range 1.007–1.018). There was no statistically significant relationship between pre-game urine specific gravity and the volume of fluid consumed (*r* = −0.276, *P* = 0.440; *n* = 10) (Figure 2).

The pre-game thirst sensation of all participants (*n* = 15) was 4.2 ± 1.6 (range 1–7). There was no significant difference (*P* > 0.05) in thirst sensation of the 10 players who completed the game before (4.0 ± 1.5, range 1–6) and after (4.4 ± 2.5, range 1–8) the match. Pre-game thirst sensation was not correlated to pre-game urine specific gravity (*r* = −0.0868, *P* = 0.768, *n* = 15) or total volume ingested (*r* = 0.0871, *P* = 0.767, *n* = 10). The mean value of drink palatability was 8.3 ± 0.94 (range 7–9).

**Discussion**

This is the first study to report data on fluid balance of Brazilian youth soccer players during an official match where habitual hydration regimes were maintained. We observed that all the players lost weight during the game (*P* < 0.001) and the volume of fluid consumed rarely matched fluid lost (only two players...
and the substitutes ingested sufficient drink to limit body mass loss to less than 1% of the pre-game body mass). The weight loss varied widely between players ranging from minimal (0.40 kg; 0.59%) to substantial (2.10 kg; 3.15%) with mean values of 1.08 ± 0.55 kg (1.62 ± 0.78%). These values are in line with that reported by Edwards and Clark (2006) in recreational adult soccer players (1.6%; temperature 16°C and 47% relative humidity) and by Veale and Pearce (2009) in Australian adolescent soccer players (1.53 kg; range 0–3 kg) during soccer match-play (WBGT 20.1–31.4°C and 42–66% relative humidity). The mean volume of sweat lost by players in the present study was more than 2 L (range 1.48–3.25 L). This is not to say that all sweat losses occurred only during playing time (80 min), as players were sweating at different rates during non-playing time (warm-up, half-time break, and immediately after the game). Although tropical natives have a more efficient thermoregulatory system, requiring less sweat production and evaporation for temperature control (> dry heat exchange) (Hori, 1995; Magalhães et al., 2010), the hot weather in the current study may have been a major influence on the sweating response. It is worth noting that the values of sweat loss in this study are higher than the volume of 1.68 ± 0.40 L reported by Maughan et al. (2007) when non-tropical adults were evaluated during a regular soccer match volume (3.1 L) when adult soccer athletes played in a warm environment (34.3°C).

All players in the present study drank water and a carbohydrate-electrolyte drink. Players consumed between 0.47 L and 1.76 L, and the percentage of replaced sweat loss was *50% (1.12 ± 0.39 L). However, it is noteworthy that the ingestion of 400 mL of carbohydrate-electrolyte drink was recommended by the coaching staff and was not consumed voluntarily. Studies have consistently reported that soccer players do not ingest enough fluid to replace the fluid lost during training or competition (Aragón-Vargas et al., 2009; Shirreffs et al., 2006; Silva et al., 2011). There is further evidence of this when players practise activities in the heat (Kurdak et al., 2010; Silva et al., 2011). Various factors influence fluid replacement by players in team sports like soccer, including provision of individual bottles, proximity to bottles.

### Table I. Changes in body mass (BM), fluid intake, estimated sweat loss, and urine output for the players who completed the game (n = 10) and the substitutes (n = 4).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Players (n = 10)</th>
<th>Range</th>
<th>Substitutes (n = 4)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre BM (kg)</td>
<td>65.79 ± 4.43</td>
<td>61.30–76.20</td>
<td>64.02 ± 1.75</td>
<td>61.90–65.70</td>
</tr>
<tr>
<td>Post BM (kg)</td>
<td>64.71 ± 4.20*</td>
<td>60.60–74.50</td>
<td>63.85 ± 1.71</td>
<td>61.80–65.50</td>
</tr>
<tr>
<td>Mass loss (kg)</td>
<td>1.08 ± 0.55</td>
<td>0.40–2.10</td>
<td>0.17 ± 0.04</td>
<td>0.10–0.20</td>
</tr>
<tr>
<td>Mass loss (%)</td>
<td>1.62 ± 0.78</td>
<td>0.59–3.15</td>
<td>0.27 ± 0.06</td>
<td>0.16–0.31</td>
</tr>
<tr>
<td>Fluid intake (L)</td>
<td>1.12 ± 0.39</td>
<td>0.47–1.76</td>
<td>0.55 ± 0.10</td>
<td>0.40–0.70</td>
</tr>
<tr>
<td>Sweat loss (L)</td>
<td>2.24 ± 0.63</td>
<td>1.48–3.25</td>
<td>0.60 ± 0.12</td>
<td>0.34–0.71</td>
</tr>
<tr>
<td>Urine output (L)</td>
<td>0.12 ± 0.10</td>
<td>0.0–0.29</td>
<td>0.25 ± 0.10</td>
<td>0.11–0.32</td>
</tr>
</tbody>
</table>

*Significantly different from pre BM (P < 0.001).
drink palatability, duration and number of opportunities to drink (Broad, Burke, Cox, Heeley, & Riley, 1996). In the present study, however, the mean value of water palatability was of 8.3 ± 0.94 (range 7–9) and players had unlimited access to fluid and individual bottles provided. Given these factors, a distinct possibility exists that players in our study ingested fluid that corresponded to half of the mean sweat loss due to the nature of the game in which they have few opportunities to drink. We made no record of when the fluid was consumed. There were concerns about influencing the normal drinking behaviour of the players if the bottles were weighed at the times necessary to obtain this information. However, we observed that some water was consumed before kick-off, some at the half-time interval, and very few players consumed water during the game itself. The fluid intake by the substitutes (0.40–0.70 L) was enough to match their sweat loss (0.34–0.71 L). The pre-game warm-up and a constant pattern of soccer-specific activities over the game might have contributed to some sweat loss (0.60 ± 0.12 L) that was easily replaced due to the players’ proximity and constant access to the drinks bottles.

There was no significant relationship between the sweat lost and the fluid ingested by the players, despite a more than trivial association \((r = 0.55)\), perhaps confounded by a relatively small sample size. Studies to date have also not found such a relationship in adult soccer players (Maughan, Shirreffs, Merson, & Horswill, 2005). Silva et al. (2011) investigated young Brazilian soccer players during training and observed a significant relationship between fluid intake and estimated sweat loss. In that study, however, the coaching staff scheduled regular breaks in activities to allow the players to consume the fluid \textit{ad libitum} and players had much more opportunity to drink than the athletes in the present study. Replication of the current design with a greater number of participants might provide increased power and further enhance our ability to achieve statistical significance.

Studies that have measured the hydration status of athletes in a free-living situation before exercise have observed that they typically start the exercise dehydrated (Bergeron, Waller, & Marinik, 2006; Osterberg, Horswill, & Baker, 2009; Silva et al., 2010). Data regarding pre-game hydration status of adult soccer players are similar (Aragón-Vargas et al., 2009; Decher et al., 2008; Maughan et al., 2005). In the present study, we classified as dehydrated the individuals with urine specific gravity above 1.020, as suggested by the National Athletic Trainers’ Association for trained athletes (Casa et al., 2000). Mean values of pre-game urine specific gravity \((1.021 ± 0.004)\) suggest that the young players were at the lower limit for significant dehydration.

Individual analyses make it clear that not all players were well hydrated before the match (10 of 15 athletes had pre-game urine specific gravity greater than 1.020) in spite of the game being played late in the morning, thereby affording ample opportunity for fluid intake in the hours beforehand. Decher et al. (2008) also observed that urine specific gravity remained consistently high in active youths participating in a 4-day sports camp (soccer and American football). However, in the current study, none of the players presented with urine specific gravity greater than 1.020 after the match. Nevertheless, this may not necessarily be interpreted as displaying better hydration during the game, as players still developed mild dehydration \((1.62 ± 0.78\%\text{ of body mass})\) by the end of the match.

When total fluid intake during the game was correlated with the pre-game urine specific gravity and thirst sensation, no significant relationship was observed. This is in contrast to a previous report in which the volume of fluid ingested by adult tropical players in a match (WBGT 31.9°C) was significantly related to the pre-game urine specific gravity (Aragón-Vargas et al., 2009). This association, however, was influenced by an outlier, and other studies have also not found any relationship (Bergeron et al., 2006; Osterberg et al., 2009). The reason we failed to find an association among pre-game urine specific gravity, thirst sensation, and fluid intake is not clear, although factors regarding the thirst mechanism may be responsible. The sensation of thirst typically lags behind the fluid deficit, and dehydration may reach 2–3% of body mass before an increase in plasma osmolality stimulates the thirst mechanism (Greenleaf, 1992).

**Conclusion**

Sweat loss and fluid deficits can be high (up to 3% of body mass) in tropical young soccer players taking part in a match played in the heat. The mean fluid intake was about half of the mean sweat loss, indicating that under official match-play conditions, fluid replacement remains a challenge for certain athletes, and a more effective strategy of fluid replacement is required for players competing in the heat. We conclude that it is worthwhile to educate young soccer players about the importance of pre-game hydration since several athletes were hypohydrated before kick-off.

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References


