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Fluid balance of elite Brazilian youth soccer players during consecutive days of training

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Abstract

In this study we investigated pre-training hydration status, fluid intake, and sweat loss in 20 elite male Brazilian adolescent soccer players (mean \pm s: age 17.2 ± 0.5 years; height 1.76 ± 0.05 m; body mass 69.9 ± 6.0 kg) on three consecutive days of typical training during the qualifying phase of the national soccer league. Urine specific gravity (USG) and body mass changes were evaluated before and after training sessions to estimate hydration status. Players began the days of training mildly hypohydrated (USG > 1.020) and fluid intake did not match fluid losses. It was warmer on Day 1 ($33.1 \pm 2.4^\circ\text{C}$ and $43.4 \pm 3.2\%$ relative humidity; $P < 0.05$) and total estimated sweat losses (2822 ± 530 mL) and fluid intake (1607 ± 460 mL) were significantly higher ($P < 0.001$) compared with Days 2 and 3. Data also indicate a significant correlation between the extent of sweat loss and the volume of fluid consumed (Day 1: $r = 0.560$, $P = 0.010$; Day 2: $r = 0.445$, $P = 0.049$; Day 3: $r = 0.743$, $P = 0.0001$). We conclude that young, native tropical soccer players arrive hypohydrated to training and that they exhibit voluntary dehydration; therefore, enhancing athletes' self-knowledge of sweat loss during training might help them to consume sufficient fluid to match the sweat losses.

Keywords: Soccer, hydration status, tropics, fluid replacement, dehydration

Introduction

Soccer is a physically demanding, self-paced endurance sport characterized by repeated short sprints that can lead to large increases in metabolic heat production, subsequent elevations in body temperature and the initiation of a sweating response to promote heat loss (Bangsbo, Mohr, & Krstrup, 2006). Continued sweating will result in a body water deficit unless replaced and the greater the body water deficit the greater the increase in physiological strain during exercise, such as elevations in core temperature, heart rate, glycogen utilization, and perceived exertion (Sawka & Coyle, 1999).

Researchers have demonstrated the negative consequences of dehydration on soccer skills (McGregor, Nicholas, Lakomy, & Williams, 1999) and physical performance (Edwards et al., 2007), and emphasized the need to ensure fluid balance during

soccer training and competition. Several laboratory-based studies involving soccer players have reported data on fluid balance (Drust, Reilly, & Cable, 2000; McGregor et al., 1999; Nicholas, Williams, Lakomy, Phillips, & Nowitz, 1995). However, outdoor activities expose athletes to oscillations in environmental conditions that could, for example, both impose radiative heat gain/stress and increase the efficiency of evaporative heat loss so as to minimize elevations in thermal stress. There are reports in the literature where habitual training and hydration regimes are maintained, which reflect what happens in the field. For example, Mustafa and Mahmoud (1979) have reported mean sweat rates of $0.6 \text{ L} \cdot \text{h}^{-1}$ and $2.9 \text{ L} \cdot \text{h}^{-1}$ for soccer players in cool and hot environments, respectively. More recently, Shirreffs and colleagues (Shirreffs, Sawka, & Stone, 2006) found a wide inter-individual variability in the sweat loss (1–3 L) between soccer players. Maughan and

colleagues (Maughan, Shirreffs, Merson, & Horswill, 2005) reported that not all soccer players were well hydrated at the beginning of training and those players who started practice with the highest urine osmolality voluntarily drank more fluid during practice, possibly to compensate for their pre-practice fluid deficit.

In the aforementioned studies, however, measurements were made on a single day in adult athletes. Very few data are available on fluid balance during consecutive days or in youth players (Godek, Godek, & Bartolozzi, 2005b; Stover, Zachwieja, Stofan, Murray, & Horswill, 2006). Many independent factors, including chronological age, biological maturity, training age, morphology, and anthropometry are important in determining the player's aerobic energy system and vary across different age categories of soccer players (Silva, Bloomfield, & Marins, 2008). Therefore, it is also important to take into account the variation in fluid balance of youth players. Furthermore, several studies have reported thermoregulatory differences between tropical and non-tropical natives (Fox, Budd, Woodward, Hackett, & Hendrie, 1974; Nguyen & Tokura, 2003). Tropical natives present physiological adaptations (reduced resting and exercise heart rate, core temperature, sweating onset threshold, and tend to sweat less for a given stimulus), which reduce heat strain and increase tolerance to exercise in hot environments, contributing to a more efficient thermoregulatory system (Fox et al., 1974; Hori, 1995) compared with non-tropical natives (Buono, Heaney, & Canine, 1998; Nguyen & Tokura, 2003). However, limited data are available on fluid balance in young, native tropical soccer players practising in their natural conditions.

Like adults, adolescent Brazilian soccer players are engaged in professional tournaments throughout the year and participate daily in high-workload training sessions during differing weekly environmental conditions that may affect fluid balance. Recently, a study reported that young Brazilian soccer players have inappropriate fluid replacement habits (Ferreira et al., 2009). In that study, the players responded to surveys about their level of knowledge regarding hydration management; however, specific measures of daily hydration status were not included. Therefore, the aim of the present study was to assess the fluid balance of Brazilian youth soccer players on three consecutive days of typical training.

Methods

Participants

Twenty adolescent soccer players, all members of the same first division Brazilian professional soccer team,

volunteered for the study. The experimental protocol received approval from the Institutional Ethics Committee, and all players and parents gave written informed consent before testing began. The physical characteristics of the participants (mean \pm s) were as follows: age 17.2 ± 0.5 years; height 1.76 ± 0.05 m; body mass 69.9 ± 6.0 kg; body fat $6.5 \pm 3.0\%$.

Experimental design

All measurements were made on three consecutive days before the last game of the qualifying phase of a national competition, with the first day of data collection being the first training day of the week. Training sessions were directed by the coach, began at approximately 09:00 h and lasted approximately 2.5 h. The training was that normally carried out by all players at this time of the season, and consisted of a warm-up, intermittent running, ball drills, and a short game. All players wore standard training clothing: T-shirt, soccer vest, shorts, socks, and shoes. None of the players changed their clothing during the course of training. Efforts were made to minimally alter the typical behaviour of the participants so that they maintained their habitual nutrition and hydration. Environmental conditions were measured every 15 min during the training session using a wet bulb globe temperature (WBGT) monitor (TGM 100, Homis[®], Brazil). Skinfold thickness measurements were taken at three sites – biceps, triceps, and subscapular and assessed in triplicate using skinfold callipers (Cescorf[®], Brazil). Sum of skinfolds was calculated using the mean of three values and percent body fat was estimated as described by Jackson and Pollack (1985).

On arrival at the training ground, participants were instructed to empty their bladders as completely as possible and defecate if necessary. A sample of urine was collected and the pre-training urine specific gravity was assessed within 30 min of collection, which was used as an index of hydration status. Urine was analysed with a clinical handheld refractometer (model A300; ATAGO Co., Tokyo, Japan) that was calibrated with distilled water before the start of each test and reviewed periodically between samples, with the same individual measuring all urine samples. Nude body mass was then measured using a digital electronic scale (Soehnle[®], Spain) accurate to 0.01 kg. The delay between the weigh-in and the start of training was approximately 30 min. The players were instructed to collect any urine passed during training in containers provided so that this could be taken into account for the calculation of sweat loss from the measured changes in body mass. However, no player produced urine during training.

In an effort to investigate the players' normal behaviour only water was provided, as this was what

was normally available to the players during training. The players were allowed to consume water *ad libitum* until their body mass was measured. Thereafter, players were instructed to continue with their normal drinking routines but drinking only from the bottles provided. Each player's bottle was opaque and clearly labelled with his name and was refilled when necessary. Individual drink bottles were weighed before being provided to the players and at every refilling using a digital scale (Plenna, MSI Inc., USA) accurate to 0.01 g. During the training session, all players had free access to water and the coaching staff scheduled regular breaks to allow the players to drink, according to the normal practice of these players. Players were instructed to drink as much or as little as they wanted but to drink only from the bottles provided and not to spit out any of the fluid or use the fluid to rinse their faces. Separate unmarked bottles were available for those players who chose to rinse their faces. At the end of the training sessions, all bottles were immediately collected and weighed, and the athletes were not allowed to drink anything else until the measurement of their post-training body mass. All players were under constant observation before and during the training to ensure compliance. The players 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.

At the end of the training sessions, athletes towelled dry and were again weighed nude. Players were asked to empty their bladder as fully as possible and to collect the entire volume in a container provided and the post-training urine specific gravity and urine volume were assessed. Before and after training sessions, players were requested to verbally report their thirst sensation using a 9-point scale (Engell et al., 1987) ranging from 1 ("not thirsty") to 9 ("very thirsty"). In addition, water palatability was reported after training sessions using a 10-point hedonic-category scale (Peryam & Pilgrim, 1957) with anchors ranging from 1 ("dislike extremely") to 10 ("like extremely").

Determination of body mass loss, sweat loss, and sweat rate

Percent body mass (BM) loss during the practice was estimated as the net body mass loss (kg) during the practice divided by the pre-practice body mass (equation 1):

$$\text{Percent BM loss (\%)} = \frac{(\text{pre BM} - \text{post BM})}{\text{pre BM}} \times 100 \quad (1)$$

Sweat loss (mL) was calculated from the change in body mass (kg) after correction for fluid intake (mL) and for any urine passed (mL) (equation 2):

$$\text{Sweat loss} = [(\text{pre BM} - \text{post BM}) - (\text{urine output}) + (\text{fluid intake})] \quad (2)$$

Sweat rate ($\text{mL} \cdot \text{h}^{-1}$) was estimated as the sweat loss divided by the exercise time (2.5 h training) (equation 3):

$$\text{Sweat rate} = \text{sweat loss} \div \text{exercise time} \quad (3)$$

The relatively small changes in mass due to substrate oxidation and other sources of water loss (primarily evaporative loss from the lungs) were ignored because this would have been a small component of the total mass lost.

Statistical analysis

The data were tested for normality of distribution and are presented as means \pm 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 ($\text{mL} \cdot \text{kg}^{-1}$), and sweat loss ($\text{mL} \cdot \text{kg}^{-1}$), for each of the 3 days of training. A 2×3 analysis of variance (ANOVA) was performed to evaluate the effects of time (pre or post measurement) and day (Day 1, Day 2, and Day 3) on urine specific gravity, body mass, and thirst sensation. The Scheffé test was used for *post hoc* analysis in the event that ANOVA showed a significant main effect. ANOVA was used to determine differences over time (Day 1, Day 2, and Day 3) on the following dependent measures: body mass changes (kg), percent dehydration, fluid intake, sweat loss, sweat rate, urine output, urine specific gravity, and drink palatability. Tukey honestly significant difference *post hoc* tests were employed to determine where the differences lay. Data analyses were conducted with SPSS (version 14.0; SPSS Inc., Chicago, IL). Statistical significance was set at $P < 0.05$.

Results

Body mass loss, fluid intake, sweat loss, and urine output for each day are shown in Table I. Sweat rate is presented in Figure 1.

Mean ambient temperatures measured during Day 1 ($33.1 \pm 2.4^\circ\text{C}$; range $29.5\text{--}34.4^\circ\text{C}$) were significantly different ($P < 0.05$) from those on Day 2 ($29.7 \pm 2.2^\circ\text{C}$; range $27.3\text{--}31.0^\circ\text{C}$) and Day 3 ($27.6 \pm 0.9^\circ\text{C}$; range $26.3\text{--}28.7^\circ\text{C}$). Relative humidity was lower ($P < 0.05$) on Day 1 ($43.4 \pm 3.2\%$;

Table I. Changes in body mass (BM), fluid intake, sweat loss, and urine passed ($n=20$).

	Day 1				Day 2				Day 3			
	mean	s	min	max	mean	s	min	max	mean	s	min	max
Pre BM (kg)	68.70	6.34	56.20	81.10	68.58	6.54	56.00	81.00	68.87	6.51	55.8	80.7
Post BM (kg)	67.48*	6.26	55.30	79.60	68.28*	6.37	55.90	80.20	68.29*	6.42	55.2	79.9
BM change (kg)	-1.21	0.46	-0.40	-2.50	-0.30 [#]	0.40	0.40	-1.00	-0.58 [#]	0.56	0	-2.60
BM change (%)	1.77	0.70	0.64	3.90	0.42 [#]	0.32	-0.64	1.50	0.84 [#]	0.80	0	3.71
Fluid intake (mL)	1607	460	255	2458	1141 [#]	322	660	1977	650 ^{#^}	257	107	1135
Sweat loss (mL)	2822	530	1683	3958	1446 [#]	422	794	2407	1235 [#]	730	507	3551
Urine passed (mL)	136	68	11	298	148	44	91	242	134	50	70	257

Values are mean, standard deviation (s), minimum (min), and maximum (max).

*Significantly different from pre BM ($P < 0.001$). [#]Significantly different from Day 1 ($P < 0.001$). [^]Significantly different from Day 2 ($P < 0.001$).

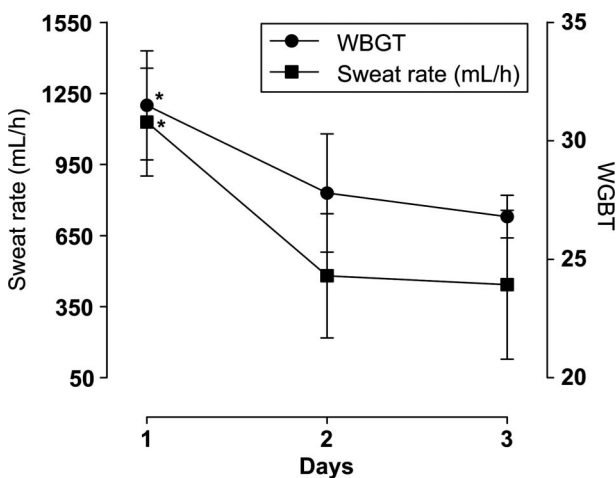


Figure 1. Sweat rate ($\text{mL} \cdot \text{h}^{-1}$) and WBGT ($^{\circ}\text{C}$) during training. *Significantly different to Days 2 and 3 ($P < 0.05$).

range 40.2–45.6%) than on Day 2 ($60.3 \pm 5.6\%$; range 58–65%) and Day 3 ($75 \pm 10\%$; range 60–85%). Values of heat stress (WBGT) were as follows: Day 1, $31.5 \pm 2.3^{\circ}\text{C}$ (range 28.1 – 32.2°C); Day 2, $27.8 \pm 2.5^{\circ}\text{C}$ (range 25.3 – 30.3°C); Day 3, $26.8 \pm 0.9^{\circ}\text{C}$ (range 25.3 – 27.2°C).

There was a significant correlation between the extent of sweat loss and the volume of fluid consumed on all days of training (Day 1: $r = 0.560$, $P = 0.010$; Day 2: $r = 0.445$, $P = 0.049$; Day 3: $r = 0.743$, $P = 0.0001$) (Figure 2).

Several players provided urine samples in which the urine specific gravity was greater than 1.020 (Figure 3). Pre- and post-training urine specific gravity ranged from 1.012 to 1.038 and from 1.013 to 1.037 on Day 1, from 1.011 to 1.035 and from 1.012 to 1.036 on Day 2, and from 1.010 to 1.036 and from 1.010 to 1.034 on Day 3, respectively.

The mean urine specific gravity values of the urine samples provided by players before and after training are shown in Figure 4. There was no statistically significant relationship between pre-training urine

specific gravity and the volume of fluid consumed (Day 1: $r = -0.239$, $P = 0.310$; Day 2: $r = 0.242$, $P = 0.304$; Day 3: $r = 0.015$, $P = 0.950$).

There was no significant difference ($P > 0.05$) in thirst sensation before (Day 1: 4.7 ± 1.9 ; Day 2: 3.3 ± 1.7 ; Day 3: 3.4 ± 1.2) and after (Day 1: 3.9 ± 2.0 ; Day 2: 2.8 ± 1.3 ; Day 3: 3.5 ± 1.5) training or among days. Pre-training thirst sensation was not correlated to pre-training urine specific gravity on Day 1 ($r = 0.049$, $P = 0.251$), Day 2 ($r = 0.019$, $P = 0.934$) or Day 3 ($r = -0.143$, $P = 0.548$). There was no correlation between thirst sensation and the total volume ingested (Day 1: $r = -0.032$, $P = 0.893$; Day 2: $r = 0.052$, $P = 0.954$; Day 3: $r = -0.136$, $P = 0.569$). Palatability of the drink (Day 1: 8.2 ± 1.4 ; Day 2: 8.5 ± 1.6 ; Day 3: 8.4 ± 1.6) was not significantly different among the days ($P > 0.05$).

Discussion

This study is the first to report data on fluid balance of Brazilian youth soccer players during consecutive days when habitual training and hydration regimes were maintained. As currently limited data are available regarding fluid balance in youth soccer players, possible comparisons are equally limited.

We found that the players did not consume sufficient fluid during training to match sweat losses, particularly on the warmer day (Day 1) and so they exhibited a significant reduction in post-training body mass. We observed that body mass loss (-1.21 ± 0.46 kg, equivalent to dehydration of $1.77 \pm 0.70\%$ of pre-training body mass), total sweat loss (2822 ± 530 mL), and fluid intake (1607 ± 460 mL) were significantly higher on Day 1 than on the other days. Sweat rate was also significantly higher on Day 1 (1.12 ± 0.22 $\text{L} \cdot \text{h}^{-1}$) than on Day 2 (0.48 ± 0.26 $\text{L} \cdot \text{h}^{-1}$) and Day 3 (0.44 ± 0.31 $\text{L} \cdot \text{h}^{-1}$). Our data for Day 1 are in line with slightly lower values of body mass change

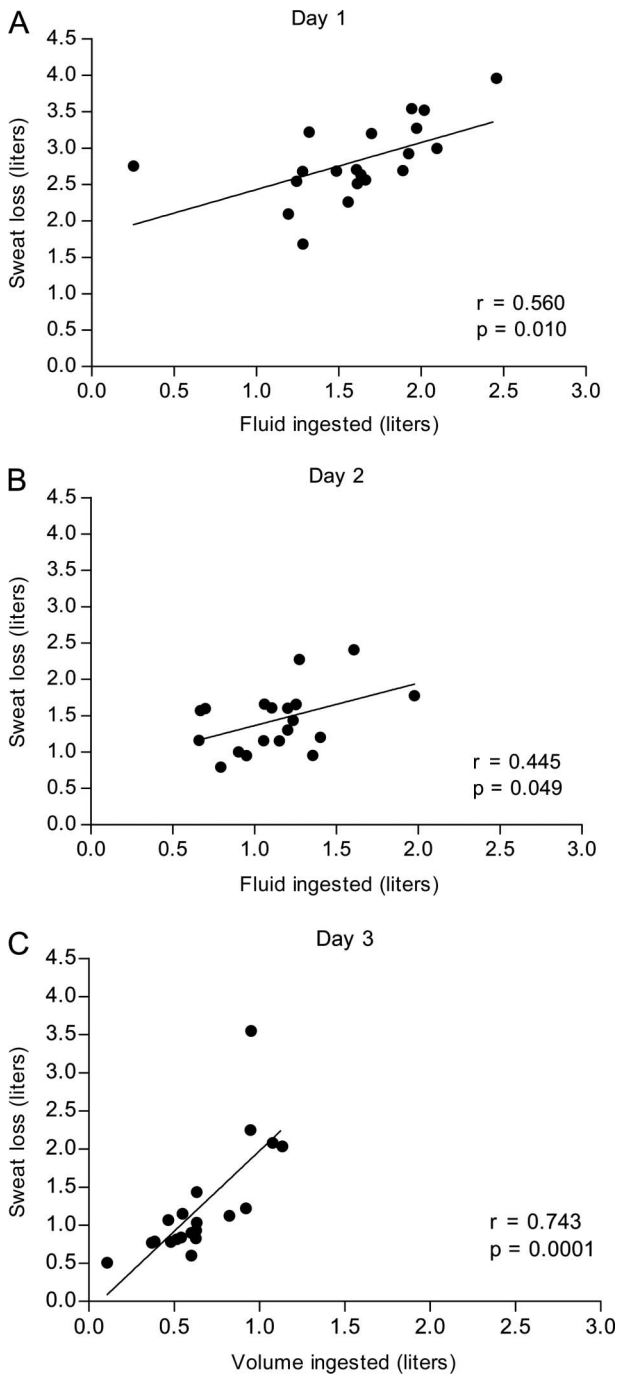


Figure 2. Total volume of sweat lost versus total volume of fluid consumed by the players ($n = 20$) during Days 1 (A), 2 (B), and 3 (C) of training.

($1.12 \pm 0.74\%$) and sweat rate ($0.91 \pm 0.27 \text{ L} \cdot \text{h}^{-1}$) reported by Stover et al. (2006) during adolescent American football players' training sessions (WBGT: $23.9\text{--}25.6^\circ\text{C}$; relative humidity: 38–45%), and higher than those reported for collegiate football players ($0.99 \pm 0.41 \text{ L} \cdot \text{h}^{-1}$; non-crampers during morning practice) during twice daily training (WBGT: $22.7\text{--}26.0^\circ\text{C}$; relative humidity: 72–93%) (Stofan et al., 2005). During match-play, where

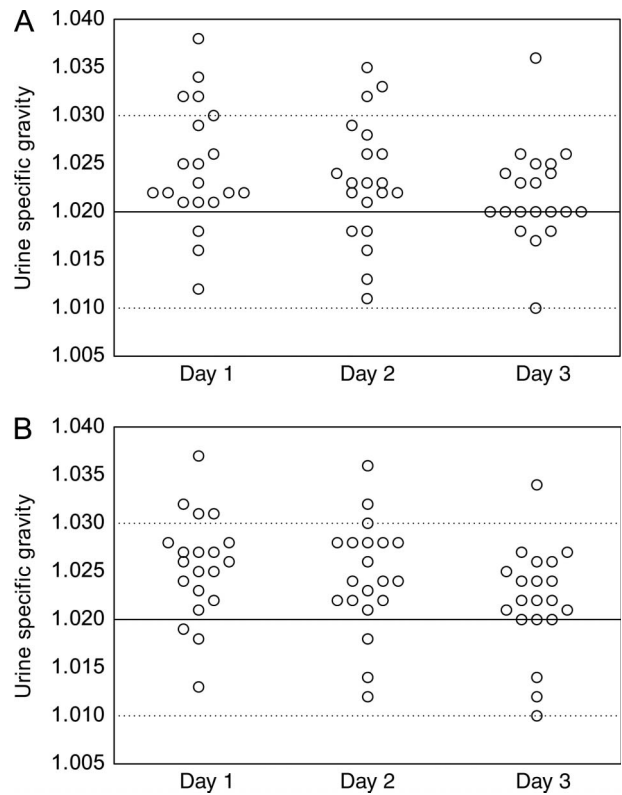


Figure 3. Individual variability of urine specific gravity before (A) and after (B) training. Dashed lines are limits for well-hydrated (< 1.010) and serious dehydration (> 1.030). Solid line is the limit for minimal (1.010–1.020) and significant dehydration (1.021–1.030) according to Casa et al. (2000).

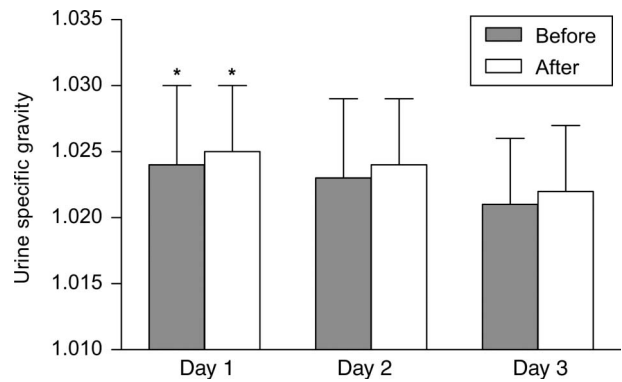


Figure 4. Urine specific gravity in Brazilian youth soccer players before and after training. Values are mean (s). *Significantly different to Day 3 ($P < 0.001$).

soccer players typically have fewer opportunities for fluid intake, it is not uncommon to observe body mass losses of more than 1–3%, with fluid intake seldom matching fluid lost (Aragón-Vargas, Moncada-Jiménez, Hernández-Elionzo, Barrenechea, & Monge-Alvarado, 2009; Maughan, Watson, Evans, Broad, & Shirreffs, 2007). However, during training this voluntary dehydration might be avoided. Several factors contribute to fluid balance, including

differences in body composition, physical fitness, clothing, drink palatability, intensity and duration of exercise (Sawka et al., 2007; Silva, Altoé, & Marins, 2009) and might explain the discrepancies between studies. Moreover, environmental factors, including ambient temperature, relative humidity, and wind speed have a major influence on the sweating response (Shirreffs et al., 2005), whereby the warmer conditions during training on Day 1 in the current study (WBGT 31.5°C; relative humidity 43.4%) may have contributed to higher sweat and body mass losses. However, we did not account for wind speed and direction, running speed, distance covered, or other factors that might have contributed to the evaporation of sweat on the different days.

We observed a wide inter-individual variability in sweat loss. We verified that six of 20 players lost more than 3 L and one player lost 3.9 L on Day 1 (range 1683–3959 mL). On Day 2 (range 794–2407 mL), very few players had sweat loss more than 2 L and on Day 3 (range 507–3551 mL) only one player presented sweat loss of more than 3 L. This variability has previously been reported in professional adult soccer players during match-play and training (Maughan et al., 2005, 2007; Shirreffs et al., 2005). Even though some players incur an acute fluid deficit during the course of training on consecutive days, recommendations for an increase in fluid intake to all players would not be appropriate for those who incur only a small fluid deficit, whereas the amount and rate of fluid replacement should be according to the individual sweating rate (Sawka et al., 2007). In addition, efforts aimed at educating players to weigh themselves before and after exercise might be of value for controlling this sweat rate variability.

A significant relationship was observed between fluid intake and estimated sweat loss on all days of training (Figure 2). Studies to date have not reported such a relationship (Godek, Bartolozzi, Burkholder, Sugarman, & Peduzzi, 2008; Maughan et al., 2005, 2007). We are not aware of studies that have evaluated adolescent soccer players where similar measurements have been made. In the current study, even with removal of the highest and lowest (outliers) fluid intake or sweat loss data points, a statistically significant association persists for all days except Day 2 ($r=0.019$, $P=0.934$). Several factors that vary between studies can influence drinking behaviour, including provision of individual bottles, proximity to bottles, drink palatability, duration and number of opportunities to drink (Broad, Burke, Cox, Heeley, & Riley, 1996). Besides, the majority of studies have examined thermoregulatory responses of soccer players in non-tropical natives and data from tropical natives are lacking. Aragón-Vargas et al. (2009) assessed fluid balance in professional

tropical native soccer players and also observed a significant correlation between individual sweat loss and fluid intake during a match played in a tropical climate (WBGT 31.9°C). In the present study, several players ($n=8$) were able to match fluid lost on the two cooler days of measurement. We suspect that the sweat loss-based perception of the need to replace fluid may be more reliable in players that live in tropical regions such as the volunteers in the study of Aragón-Vargas et al. (2009) and the participants in the current study. Tropical natives are typically heat-acclimated, presenting with reduced resting and exercise heart rate, core temperature, sweating onset threshold, and tend also to sweat less for a given stimulus compared with non-tropical natives (Buono, Heaney, & Canine, 1998; Nguyen & Tokura, 2003). These physiological adaptations reduce heat strain and increase tolerance to exercise in hot environments and tropical natives would have, therefore, a more efficient thermoregulatory system (Fox et al., 1974; Hori, 1995). Passe and colleagues (Passe, Horn, Stofan, Horswill, & Murray, 2007) also propose enhancing athletes' self-perception of sweat loss via training to avoid voluntary dehydration. Future research could determine whether the relationship between sweat loss and drinking persists under different (warmer and colder) environmental conditions and exercise modalities, as well as if tropical athletes accurately perceive fluid loss and are able to use it as a guide for rehydration.

The pre-training body mass of the participants in the present study was not different throughout the 3-day period. However, this does not necessarily indicate that the athletes consumed enough fluid to re-establish their total body water, and therefore it cannot be assumed the players were well hydrated before the training sessions. If a value of 1.020 for urine specific gravity is accepted as a cut-off point for indication of adequate hydration status (Casa et al., 2000), several players in the present study were not well hydrated when they arrived at the training grounds, because their pre-training urine samples provided values higher than 1.020 (Figure 3). Mean pre-training values were greater than 1.020 on all days. However, mean pre and post urine specific gravity values were significantly higher on Day 1 than on Day 3. This may be due, in part, to lower sweat loss and body mass change on Day 2, thus being easier for the players to replace the fluid lost during the resting period before training on Day 3. Studies that have evaluated adult soccer players and other team-sport athletes prior to exercise have reported that athletes often began the exercise inadequately hydrated (Godek, Bartolozzi, & Godek, 2005a; Osterberg, Horswill, & Baker, 2009; Silva et al., 2010; Volpe, Poule, & Bland, 2009). Decher et al. (2008) assessed the hydration status and level of

hydration knowledge of active youths participating in a 4-day sports camp (soccer and football) that consisted of two or three practice sessions per day. Although they observed no significant difference in pre-practice body mass throughout the days, the pre-practice urine specific gravity values remained consistently high each day, ranging from 1.019 to 1.027. This is of some concern because pre-training hypohydration combined with a high sweat loss and an incomplete fluid replacement during training lead to a loss of body water that, if it is of sufficient magnitude, might impair both physical and mental performance (Kirkendall, 1993).

Maughan et al. (2005) have previously shown that adult soccer players who report for training with the highest urine osmolality are likely to drink more during training. Using urine specific gravity as the parameter of hydration status, Aragón-Vargas et al. (2009) also observed a significant correlation between soccer players' initial hydration status and fluid intake during the game; however, this was not supported by the results of the current study. Even though our players were not well hydrated prior to training, pre-training urine specific gravity did not correlate with the volume of fluid intake during training. Other studies have also failed to observe this association (Bergeron, Waller, & Marinik, 2006; Osterberg, Horswill, & Baker, 2009). The sensation of thirst typically lags behind the fluid deficit, and dehydration may reach 2–3% of body mass before the thirst mechanism is stimulated (Greenleaf, 1992). In the present study, thirst sensation was also not correlated to fluid ingestion and players rated the water as palatable. It is possible, therefore, that either the pre-training water deficit was not enough to stimulate the thirst mechanism(s) or the players were not able to accurately interpret the thirst scale and replace the fluid based on thirst, as opposed to fluid ingestion based on fluid loss, which correlated significantly. Other studies have observed that thirst did not ensure adequate fluid intake, nor was it predictive of drinking behavior (Passe et al., 2007). In addition, providing flavoured drinks such as sports drink that contain sodium might help to stimulate fluid intake and maximize the volume ingested rather than providing water only.

Conclusion

Our findings indicate that a substantial proportion of the players were likely hypohydrated before all days of training. Sweat losses can be substantial (> 3.5 L in approximately 2.5 h of training time) in tropical young soccer players and fluid intake does not match fluid loss mainly on warmer days. However, enhancing athletes' self-knowledge of sweat loss for fluid replacement may prove useful rather than relying on

sensations of thirst alone. Regardless of the environmental conditions, there is a large variation in sweating response among individual players taking part in the same training session, reinforcing the fact that players must be treated individually with regard to their fluid needs, especially when daily environmental conditions vary.

References

- Aragón-Vargas, L. F., Moncada-Jiménez, J., Hernández-Elionzo, J., Barrenechea, A., & Monge-Alvarado, M. (2009). Evaluation of pre-game hydration status, heat stress, and fluid balance during professional soccer competition in the heat. *European Journal of Sport Science*, 9, 269–276.
- Bangsbo, J., Mohr, M., & Krstrup, P. (2006). Physical and metabolic demands of training and match-play in the elite football player. *Journal of Sports Sciences*, 24, 665–674.
- Bergeron, M. F., Waller, J. L., & Marinik, E. L. (2006). Voluntary fluid intake and core temperature responses in adolescent tennis players: Sports beverage versus water. *British Journal of Sports Medicine*, 40, 406–410.
- Broad, E. M., Burke, L. M., Cox, G. R., Heeley, P., & Riley, M. (1996). Body weight changes and voluntary fluid intakes during training and competition sessions in team sports. *International Journal of Sport Nutrition*, 6, 307–320.
- Buono, M. J., Heaney, J. H., & Canine, K. M. (1998). Acclimation to humid heat lowers resting core temperature. *American Journal of Physiology: Regulatory, Integrative and Comparative Physiology*, 274 (5 Pt. 2), R1295–R1299.
- Casa, D. J., Armstrong, L. E., Hillman, S. K., Montain, S. J., Reiff, R. V., Rich, B. S. et al. (2000). National Athletic Trainers' Association Position Statement: Fluid replacement for athletes. *Journal of Athletic Training*, 35, 212–224.
- Decher, N. R., Casa, D. J., Yeargin, S. W., Ganio, M. S., Leveault, M. L., Dann, D.L. et al. (2008). Hydration status, knowledge, and behavior in youth at summer sports camps. *International Journal of Sports Physiology and Performance*, 3, 262–278.
- Drust, B., Reilly, T., & Cable, N. T. (2000). Physiological responses to laboratory-based soccer-specific intermittent and continuous exercise. *Journal of Sports Sciences*, 18, 885–892.
- Edwards, A. M., Mann, M. E., Marfell-Jones, M. J., Rankin, D. M., Noakes, T. D., & Shillington, D. P. (2007). Influence of moderate dehydration on soccer performance: Physiological responses to 45 min of outdoor match-play and the immediate subsequent performance of sport-specific and mental concentration tests. *British Journal of Sports Medicine*, 41, 385–391.
- Engell, D. B., Maller, O., Sawka, M. N., Francesconi, R. N., Drolet, L., & Young, A. J. (1987). Thirst and fluid intake following graded hypohydration levels in humans. *Physiology and Behavior*, 40, 229–236.
- Ferreira, F. G., Altoé, J. L., Silva, R. P., Tsai, L. P., Fernandes, A., Brito, C. J. et al. (2009). Level of knowledge and hydration strategies of young soccer players. *Brazilian Journal of Kinanthropometry and Human Performance*, 11, 204–211.
- Fox, R. H., Budd, G. M., Woodward, P. M., Hackett, A. J., & Hendrie, A. L. (1974). A study of temperature regulation in New Guinea people. *Philosophical Transactions of the Royal Society of London Series B: Biological Sciences*, 268, 375–391.
- Godek, S. F., Bartolozzi, A. R., Burkholder, R., Sugarman, E., & Peduzzi, C. (2008). Sweat rates and fluid turnover in professional football players: A comparison of National Football League linemen and backs. *Journal of Athletic Training*, 43, 184–189.

- Godek, S. F., Bartolozzi, A. R., & Godek, J. J. (2005a). Sweat rate and fluid turnover in American football players compared with runners in a hot and humid environment. *British Journal of Sports Medicine*, *39*, 205–211.
- Godek, S. F., Godek, J. J., & Bartolozzi, A. R. (2005b). Hydration status in college football players during consecutive days of twice-a-day preseason practices. *American Journal of Sports Medicine*, *33*, 843–851.
- Greenleaf, J. E. (1992). Problem: Thirst, drinking behavior, and involuntary dehydration. *Medicine and Science in Sports and Exercise*, *24*, 645–656.
- Hori, S. (1995). Adaptation to heat. *Japanese Journal of Physiology*, *45*, 921–946.
- Jackson, A., & Pollack, M. (1985). Assessment of body composition. *Physician and Sportsmedicine*, *13*, 76–90.
- Kirkendall, D. T. (1993). Effects of nutrition on performance in soccer. *Medicine and Science in Sports and Exercise*, *25*, 1370–1374.
- Maughan, R. J., Shirreffs, S. M., Merson, S. J., & Horswill, C. A. (2005). Fluid and electrolyte balance in elite male football (soccer) players training in a cool environment. *Journal of Sports Sciences*, *23*, 73–79.
- Maughan, R. J., Watson, P., Evans, G. H., Broad, N., & Shirreffs, S. M. (2007). Water balance and salt losses in competitive football. *International Journal of Sport Nutrition and Exercise Metabolism*, *17*, 583–594.
- McGregor, S. J., Nicholas, C. W., Lakomy, H. K., & Williams, C. (1999). The influence of intermittent high-intensity shuttle running and fluid ingestion on the performance of a soccer skill. *Journal of Sports Sciences*, *17*, 895–903.
- Mustafa, K. Y., & Mahmoud, N. E. (1979). Evaporative water loss in African soccer players. *Journal of Sports Medicine and Physical Fitness*, *19*, 181–183.
- Nguyen, M. H., & Tokura, H. (2003). Sweating and tympanic temperature during warm water immersion compared between Vietnamese and Japanese living in Hanoi. *Journal of Human Ergology*, *32*, 9–16.
- Nicholas, C. W., Williams, C., Lakomy, H. K., Phillips, G., & Nowitz, A. (1995). Influence of ingesting a carbohydrate-electrolyte solution on endurance capacity during intermittent, high-intensity shuttle running. *Journal of Sports Sciences*, *13*, 283–290.
- Osterberg, K. L., Horswill, C. A., & Baker, L. B. (2009). Pregame urine specific gravity and fluid intake by National Basketball Association players during competition. *Journal of Athletic Training*, *44*, 53–57.
- Passe, D., Horn, M., Stofan, J., Horswill, C., & Murray, R. (2007). Voluntary dehydration in runners despite favorable conditions for fluid intake. *International Journal of Sport Nutrition and Exercise Metabolism*, *17*, 284–295.
- Peryam, D. R., & Pilgrim, F. J. (1957). Hedonic scale method of measuring food preferences. *Food Technology*, *11*, 9–14.
- Sawka, M. N., Burke, L. M., Eichner, E. R., Maughan, R. J., Montain, S. J., & Stachenfeld, N. S. (2007). American College of Sports Medicine Position Stand: Exercise and fluid replacement. *Medicine and Science in Sports and Exercise*, *39*, 377–390.
- Sawka, M. N., & Coyle, E. F. (1999). Influence of body water and blood volume on thermoregulation and exercise performance in the heat. *Exercise and Sport Sciences Reviews*, *27*, 167–218.
- Shirreffs, S. M., Aragon-Vargas, L. F., Chamorro, M., Maughan, R. J., Serratos, L., & Zachwieja, J. J. (2005). The sweating response of elite professional soccer players to training in the heat. *International Journal of Sports Medicine*, *26*, 90–95.
- Shirreffs, S. M., Sawka, M. N., & Stone, M. (2006). Water and electrolyte needs for football training and match-play. *Journal of Sports Sciences*, *24*, 699–707.
- Silva, C. D., Bloomfield, J., & Marins, J. C. B. (2008). A review of stature, body mass and maximal oxygen uptake profiles of U17, U20 and first division players in Brazilian soccer. *Journal of Sports Science and Medicine*, *7*, 309–319.
- Silva, R. P., Altoé, J. L., & Marins, J. C. B. (2009). Relevance of temperature and gastric emptying of liquids consumed by individuals who practice physical activities. *Brazilian Journal of Nutrition*, *22*, 755–765.
- Silva, R. P., Mündel, T., Altoé, J. L., Saldanha, M. R., Ferreira, F. G., & Marins, J. C. B. (2010). Preexercise urine specific gravity and fluid intake during one-hour running in a thermoneutral environment – a randomized cross-over study. *Journal of Sports Science and Medicine*, *9*, 464–471.
- Stofan, J. R., Zachwieja, J. J., Horswill, C. A., Murray, R., Anderson, S. A., & Eichner, E. R. (2005). Sweat and sodium losses in NCAA football players: A precursor to heat cramps? *International Journal of Sport Nutrition and Exercise Metabolism*, *15*, 641–652.
- Stover, E. A., Zachwieja, J., Stofan, J., Murray, R., & Horswill, C. A. (2006). Consistently high urine specific gravity in adolescent American football players and the impact of an acute drinking strategy. *International Journal of Sports Medicine*, *27*, 330–335.
- Volpe, S. L., Poule, K. A., & Bland, E. G. (2009). Estimation of prepractice hydration status of National Collegiate Athletic Association Division I athletes. *Journal of Athletic Training*, *44*, 624–629.