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ORIGINAL RESEARCH

Ad Libitum Fluid Intake Does Not Prevent Dehydration in Suboptimally Hydrated Young Soccer Players During a Training Session of a Summer Camp

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There is a lack of studies concerning hydration status of young athletes exercising in the heat. ***Purpose:*** To assess preexercise hydration status in young soccer players during a summer sports camp and to evaluate body-water balance after soccer training sessions. ***Methods:*** Initial hydration status was assessed in 107 young male soccer players (age 11–16 yr) during the 2nd day of the camp. Seventy-two athletes agreed to be monitored during 2 more training sessions (3rd and 5th days of the camp) to calculate dehydration via changes in body weight, while water drinking was allowed ad libitum. Hydration status was assessed via urine specific gravity (USG), urine color, and changes in total body weight. Mean environmental temperature and humidity were 27.2 ± 2 °C and 57% ± 9%, respectively. ***Results:*** According to USG values, 95 of 107 of the players were hypohydrated (USG ≥ 1.020) before practice. The prevalence of dehydration observed was maintained on both days, with 95.8% and 97.2% of the players being dehydrated after the training sessions on the 3rd and 5th days, respectively. Despite fluid availability, 54 of the 66 (81.8%) dehydrated players reduced their body weight (–0.35 ± 0.04 kg) as a response to training, while 74.6% (47 out of the 63) further reduced their body weight (–0.22 ± 0.03 kg) after training on the 5th day. ***Conclusion:*** Approximately 90% of the young soccer players who began exercising under warm weather conditions were hypohydrated, while drinking ad libitum during practice did not prevent further dehydration in already dehydrated players.

Keywords: hydration status, thirst, children, exercise, fluid balance

It is well documented that dehydration increases physiological strain and perceived effort to perform the same exercise task, and this is accentuated in warm weather (Sawka et al., 2007; Sawka & Coyle, 1999). In addition, water losses >2% of total body weight significantly impair endurance exercise, both in laboratories (Cheuvront, Carter, & Sawka, 2003; Gonzalez-Alonso, Mora-Rodriguez, Below, & Coyle, 1997) and in field studies (Carvalho et al., 2011; Casa et al., 2010; Dougherty, Baker, Chow, & Kenney, 2006; Stearns et al., 2009), as well as mental performance in hot environments (Casa, Clarkson, & Roberts, 2005; Ganio et al., 2011; Shirreffs, 2009).

The majority of the published research has been performed with well-trained adults exercising in the heat, while on the other hand, little information is available concerning children exercising under similar environmental conditions. Most of those studies were performed in active but nonathletic, nonacclimatized children under controlled environments (Bar-Or, Dotan, Inbar, Rotshtein, & Zonder, 1980; Iuliano, Naughton, Collier, & Carlson, 1998; Meyer, Bar-Or, & Wilk, 1995; Wilk & Bar-Or, 1996). Moreover, there are limited studies investigating children's hydration status in free-living conditions (Rivera-Brown, Ramirez-Marrero, Wilk, & Bar-Or, 2008; Wilk, Rivera-Brown, & Bar-Or, 2007). To our knowledge, the hydration status in free-living athletic children has not been investigated systematically. A recent work by McDermott et al. (2009) showed that children arrived and remained hypohydrated throughout their stay in a football camp. Similarly, Decher et al. (2008) observed that more than 50% of their participants remained hypohydrated during their stay at a summer sports camp despite their improvement on hydration awareness. In the later study, improvement in hydration knowledge did not result in enhanced hydration levels. Finally, a recent study by Kavouras et al. (2012) in a summer sports camp found that a simple intervention program enhanced hydration status of exercising children in just over a 2-day period. Furthermore, this improvement in hydration status, through ad libitum water intake, also led to a significant increase in children's endurance performance. Nevertheless, it must be highlighted that, despite the 25% reduction in the prevalence of dehydration, almost 60% of the subjects remained hypohydrated, thus suggesting that thirst did not lead to successful fluid replenishment.

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Soccer is the world's most popular sport, especially in youth. It consists of moderate activity levels combined with intermittent high-intensity bursts, leading to high rates of metabolic heat production. It is well documented that substantial fluid losses can occur in soccer players during training and matches, with a graded sweat response observed with increased environmental temperature (Maughan, Merson, Broad, & Shirreffs, 2004; Maughan, Shirreffs, Merson, & Horswill, 2005; Ozgunen et al., 2010; Shirreffs, 2010; Shirreffs et al., 2005). Recently, Da Silva et al. (2012) reported mean sweat losses of approximately 2.5 L in young soccer players during a match played in the heat (31.0 ± 2.0 °C). Those researchers also observed that the players replaced less than 50% of their sweat loss. Likewise, recent data showed significant water deficit in soccer players, even when water or sports drinks were freely available, thus indicating involuntary dehydration (Kurdak et al., 2010).

Therefore, the aim of the current study was twofold: to examine the preexercise hydration status of young soccer players and to evaluate body-water balance during training in which ad libitum water intake was allowed.

Methods

Subjects

One hundred seven young male soccer players (age 13.2 ± 2.6 years, range 11–16 years; weight 52.2 ± 8.5 kg; height 1.58 ± 0.08 m) volunteered to participate in the study. Each participant was informed of the experimental procedures, and their parents provided written informed consent. The university ethics committee approved the study, and it was carried out in accordance with the Declaration of Helsinki (1983) of the World Medical Association. Eligibility criteria for participation in this study included absence of any metabolic, cardiovascular, and renal disease and any history of heat illnesses. All participants were skilled young soccer players who were not taking any medications and had condition that could affect fluid or electrolyte balance.

Protocol

To determine the prevalence of dehydration, the participants' pretraining hydration status was assessed based on their first urine sample on the second day of the camp. Seventy-two of the 107 young athletes agreed to undergo additional testing on 2 more separate training days (third and fifth days of the camp). Each soccer player was tested twice, in the morning (preexercise urine sample) and immediately after the training session.

The schedule of the camp was as follows. At 8 a.m., immediately after participants woke up, urine samples were collected and body mass (in underwear) was recorded to the nearest 100 g (Seca model 7701321004, Vogel & Hamburg, Germany). Then, a standardized breakfast consisting of 1 cup of milk with 50 g cereal and one slice of white-bread toast with butter and honey was provided. Training started at 10 a.m. and lasted 90 min. The training program included a 15-min standardized warm-up (10 min jogging and 5 min stretching), followed by three small-sided games (eight against eight, four against four, and two against two). Each training session included three 5-min breaks for hydration, during which children had access to bottled water next to the field. Volunteers had free access to water, but the research team did not encourage participants to hydrate. Immediately after training, body mass with the players wearing only their underwear was recorded and another urine sample was collected for immediate analysis of urine specific gravity (USG) and urine color. During the training hours of the third and fifth days of the measurements, environmental temperatures were 27.0 °C and 29.0 °C, respectively, while humidity levels were 54% and 61,% respectively. Statistical comparisons between environmental temperature values for the 2 days did not reveal any significant differences.

Urine Analysis

Urine samples were collected, and urine color was determined by comparing each specimen container with an original urine color scale (Armstrong et al., 1994; Armstrong et al., 1998). Evaluation was carried out by the same person at all times, standing in a well-lighted room (temperature 20–22 °C) with samples placed in a clear glass tube against a white background. Urine samples were taken before breakfast to standardize the procedure and allow day-to-day comparisons. USG was assessed by a desktop refractometer (clinical refractometer, Euromex Rf 460, Euromex Microscopes Ltd., Utrechtseweng 250, Aruhem, Holland) in duplicate. The young athletes were classified as euhydrated or dehydrated based on the USG criteria (³1.020) for hydration status in adults proposed by the American College of Sports Medicine (Sawka et al., 2007).

Statistical Analysis

Results are presented as *M* ± *SD* for continuous variables, as well as absolute and relative frequencies. Correlation between preexercise USG values and changes in body weight was assessed using a scatter plot, and a linear-regression line was fitted in the graph. Participants' distribution of USG values is presented using a histogram. Statistical analysis was carried out with SPSS 19.0, with statistical significance set at .05.

Results

Hydration assessment showed that 88.7% (95 of 107) of the young players were hypohydrated based on first morning urine sample. Likewise, according to the urine color chart, 93.7% (100 of 107) were classified as hypohydrated.

Pretraining morning urine measurements for the third day of the camp showed that only 8.4% of the soccer players were euhydrated, and on the fifth day 12.5% were classified as euhydrated. Conversely, posttraining values for these 2 training days indicated that a state of dehydration was observed in 95.8% and 97.2% of the players, respectively. Despite fluid availability, mean weight losses of –0.35 ± 0.04 kg (0.77% ± 0.5%) after practice on the third day and –0.22 ± 0.03 kg (0.61 ± 0.4%) after training on the fifth day were observed among the subjects (Table 1). Remarkably, 54 of the 66 young players (81.8%) with preexercise USG ≥1.020 reduced their body weight after training (third day), and 47 of the 63 dehydrated soccer players (74.6%) further reduced their body weight after the end of the training session (fifth day).

Correlation between preexercise USG values and changes in body weight failed to reveal any relationship ($p > .05$; Figure 1). The high percentages of dehydration in the young soccer athletes, according to USG range, are illustrated in Figure 2.

Discussion

The aims of the current study were, first, to evaluate the pretraining hydration status of young soccer players participating in a summer sports camp and, second, to evaluate body-water balance after two training sessions in which ad libitum water intake was allowed during practice. Our main finding was that the majority of the young players in the camp were not only hypohydrated but also remained in a hypohydrated state during their stay. Furthermore, we observed that the preexercise hypohydrated athletes dehydrated even more during practice, despite fluid availability on the field.

The high incidence of dehydration observed in this study is in agreement with other studies (Decher et al., 2008; McDermott et al., 2009; Stover, Zachwieja, Stofan, Murray, & Horswill, 2006). In 2006, Stover et al. (2006) found consistently high baseline USG values for young football players, the result being that athletes reported

Table 1 Mean Changes of Hydration Indices Among the Young Soccer Players, Pre- and Posttraining, for the Third and Fifth Days of the Camp (N = 72), $M \pm SD$

	3rd Day		5th Day	
	Before	After	Before	After
Urine specific gravity	1.033 ± 0.007	1.033 ± 0.005	1.031 ± 0.008	1.030 ± 0.006
Urine color	5.40 ± 0.11	5.70 ± 0.90	5.40 ± 0.12	5.50 ± 0.90
Dehydration prevalence (%)	91.6	95.8	87.5	97.2
Change in body weight (kg)	–0.35 ± 0.04		–0.22 ± 0.03	
Change in body weight (%)	–0.77 ± 0.50		–0.61 ± 0.40	

Note. Dehydration was defined as USG ≥1.020.

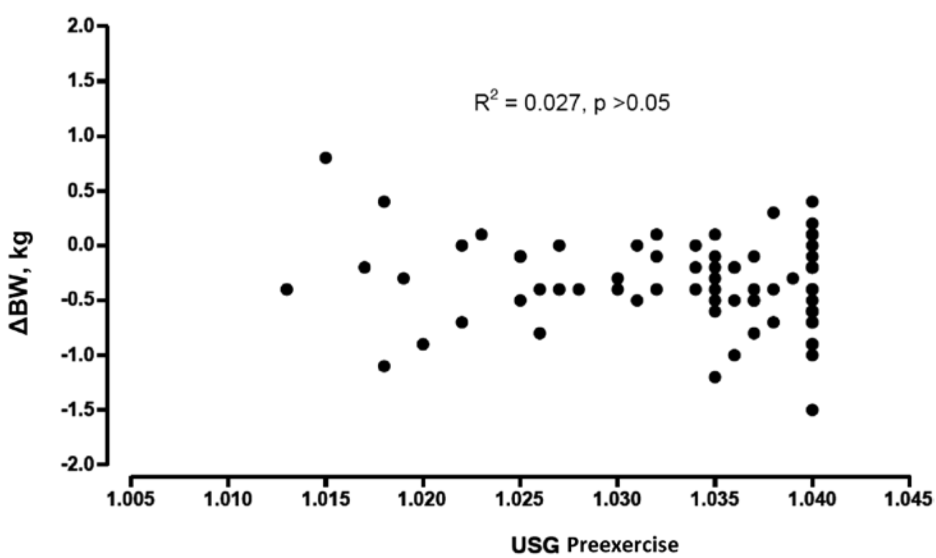

Figure 1 — Scatter plot for the correlation of preexercise urine specific gravity (USG) and changes in body weight (ΔBW).

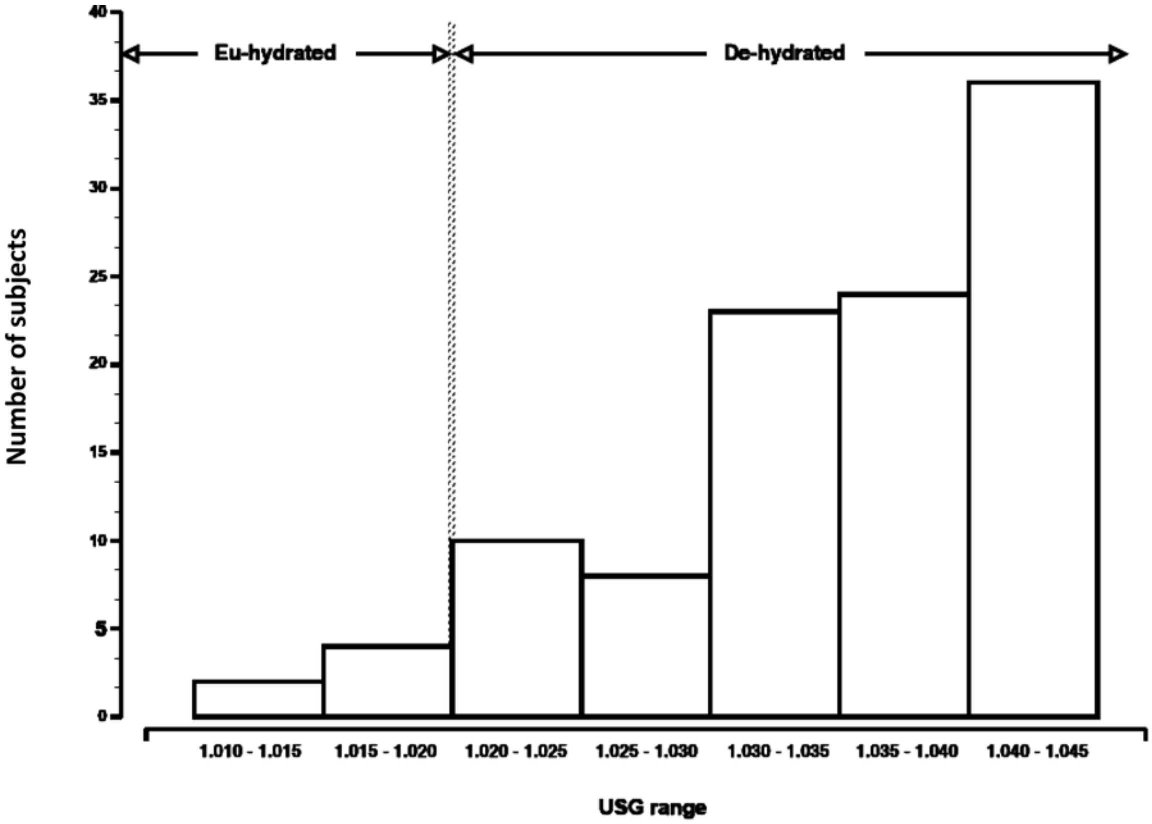

Figure 2 — Participants' distribution regarding urine specific gravity (USG).

to practice in a hypohydrated state. In a recent study, McDermott et al. concluded that children at a football camp arrived and remained hypohydrated throughout their stay. Decher et al. reported that the 67 active youths who participated in a summer sports camp, although they recognized whether they were doing a good or bad job hydrating via the use of a hydration-awareness questionnaire, remained in a hypohydrated state. Similarly, in a recent published study by Kavouras et al. (2012) ~60% of the subjects remained dehydrated even after participation in an educational intervention program for hydration and while scoring 9.0 ± 1.9 out of 10 on the hydration-awareness questionnaire for stating that they were well hydrated. Obviously, in both of the aforementioned studies, it seems that young athletes demonstrate a failure to translate hydration knowledge into useful hydration strategies. These data indicate that hydration knowledge alone is not effective enough to change health behavior; thus, constant efforts must be made by athletic trainers, coaches, and athletes to enhance hydration.

The high rate of dehydration observed in the current study among young athletes (13.2 ± 2.6 years), despite their free access to fluids, highlights the phenomenon of involuntary dehydration. Even in indoor sports like basketball, where more opportunities are provided to drink because of closer proximity to fluids and a greater number of breaks, involuntary dehydration is observed (Osterberg, Horswill, & Baker, 2009). In a soccer field study, Kurdak et al. (2010) examined the hydration status and drinking behavior of 22 male players during a football match in the heat (34.3 ± 0.6 °C). The results indicated that the majority of the players experienced substantial sweat water and electrolyte losses during the match, even though water or sports drinks were freely available. Moreover, data from young soccer players indicate that even elite young players do not drink sufficient volumes to replace their sweat losses (Da Silva et al., 2012). This observation is common despite weather conditions (Maughan et al., 2005; Shirreffs, 2010), and it is present during preseason training (Maughan et al., 2004) and competitive matches in the regular season (Maughan, Watson, Evans, Broad, & Shirreffs, 2007).

The extremely high percentages of young soccer players classified as significantly dehydrated (Figure 2) question the validity of the proposed cutoff points for dehydration (i.e., USG ≥1.020) by several associations (Casa et al., 2000; Sawka et al., 2007). Only recently, Armstrong et al. (2010) published a study providing euhydration reference values for commonly used hydration indices (i.e., USG, urine osmolality, urine color) in free-living, active men, which, in turn, differ significantly from the proposed values. By considering the data of the current study, it may be suggested that these hydration cutoff points do not adequately reflect the real hydration status of young soccer players exercising in the heat, and the commonly used reference values are not fully representative for all age groups.

Finally, in an attempt to ideally prepare English field hockey players to compete under challenging environmental conditions (i.e., 32 °C, 80% humidity), Dabinett, Reid, and James (2001) developed a practical hydration strategy. They instructed players to consume 1 L of a 3% carbohydrate-electrolyte solution immediately before training and to drink this regularly (~250 ml every 15 min) throughout their training session. This hydration strategy proved successful in maintaining athletes' hydration status during exercise under warm conditions. Moreover, Stover et al. (2006) concluded that the ingestion of two 591-ml bottles of water or sport drink (one between dinner and sleep and the other before morning training) is a simple and effective method to significantly improve the hydration status of high school football players, as indicated by their USG values. Therefore, hydration education, improvement of hydration accessibility, and simple and realistic hydration strategies can benefit youth exercising in warm conditions.

Thirst is stimulated by both osmotic and pressure receptors (Fitzsimons, 1976). We expected that the dehydrated subjects would experience hyperosmotic hypovolemia, which in turn would stimulate thirst. Therefore, we hypothesized that the dehydrated players would be thirstier during exercise in the heat, resulting in greater fluid intake. We were expecting that ad libitum drinking during training would lead to a lesser involuntary dehydration as assessed by changes in body weight, especially in the dehydrated athletes. To examine that, we correlated the USG, as an index of hydration, with changes in body weight during exercise. To our surprise, we found that the degree of exercise-induced dehydration was not influenced by preexercise hydration status, thus indicating that thirst could not be an effective signal to prevent further dehydration in already dehydrated young athletes.

On the other hand, it has been suggested that the only advice needed during exercise in the heat is to drink according to thirst (Goulet, 2011; Noakes, 2007, 2010). The data from the current study do not support this notion. The fact that most of the dehydrated players (81.8% and 74.6% after the two training sessions) further reduced their total body weight, despite fluid availability in the soccer field, indicates that drinking according to thirst is not an effective means of fluid replacement during exercise, not even for the dehydrated young athletes. Thus, it would be interesting to investigate the effectiveness of an individualized hydration protocol, as suggested by the American College of Sports Medicine, versus ad libitum fluid intake on exercise performance and thermoregulation.

Finally, a possible limitation of our study is the use of USG from the first morning sample as the baseline sample for the assessment of athletes' hydration status. It is documented that USG use may be susceptible to errors (Hamouti, Del Coso, Avila, & Mora-Rodriguez, 2010; Oppliger, Magnes, Popowski, & Gisolfi, 2005), which in turn can lead to a slightly higher estimation of the degree of dehydration, most likely due to increased overnight urine concentration. Nevertheless, it is a practical, noninvasive, and reliable technique frequently used in the setting of dynamic dehydration assessment and in many field studies (Armstrong, 2007; Cheuvront, Ely, Kenefick, & Sawka, 2010).

In conclusion, the current study showed the highest reported prevalence of dehydration among young athletes participating in a summer soccer camp. Furthermore, it is noteworthy that approximately 90% of the dehydrated soccer players dehydrated more during soccer practice, regardless of fluid availability. These findings indicate that drinking according to thirst during practice does not prevent further dehydration in suboptimally hydrated young soccer players.

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