Published in final edited form as:
J Strength Cond Res. 2015 December ; 29(12): 3447–3452. doi:10.1519/JSC.0000000000000400.

FLUID BALANCE DURING TRAINING IN ELITE YOUNG ATHLETES OF DIFFERENT SPORTS

Giannis Arnaoutis[1], **Stavros A. Kavouras**[1,2], **Athanasia Angelopoulou**[1], **Chara Skoulariki**[1], **Stefani Bismpikou**[1], **Stamatis Mourtakos**[1], and **Labros S. Sidossis**[1,3]

[1] Laboratory of Nutrition & Clinical Dietetics, Department of Nutrition and Dietetics, Harokopio University, Athens, Greece

[2] Human Performance Laboratory, Department of Health, Human Performance and Recreation, University of Arkansas, Fayetteville, Arkansas

[3] Department of Internal Medicine-Geriatrics, Sealy Center on Aging, Institute for Translational Sciences and Shriners Burns Institute, University of Texas Medical Branch, Galveston, Texas

Abstract

Although there are many studies demonstrating a high percentage of adult athletes which start exercise in sub-optimal hydration state, limited data concerning hydration levels in athletic youth exists. The purpose of this study was to identify the hydration status of elite young athletes of different sports, during a typical day of training. Fifty-nine young elite men athletes from different sports (basketball, gymnastics, swimming, running, canoeing) participated in the study (age: 15.2±1.3 y, years of training: 7.7±2.0). Hydration status was assessed in the morning, before and immediately after practice. Data collection took place at the same time of the day, with mean environmental temperature and humidity at the time of the measurements at 27.6±0.9 °C and 58±8%, respectively. All athletes trained for approximately 90 min and they were consuming fluids ad libitum throughout their practice. Over 89% of the athletes were hypohydrated (USG≥1.020 mg/dl) based on their first morning urine sample. Pre-training urine samples revealed that 76.3% of the athletes were hypohydrated, while a significant high percent remained hypohydrated even after training according to USG values ≥ 1.020 mg/dl (74.5%) and urine color scale: 5-6 (76.3%). Mean body weight loss during training was −1.1±0.07%. We concluded that the prevalence of hypohydration among elite young athletes is very high, as indicated by the USG and urine color values. The majority of the athletes was hypohydrated throughout the day and dehydrated even more during practice despite fluid availability.

Keywords

hydration status; thirst; voluntary dehydration; hypohydration; exercise

Conflicts of interest
There are no conflicts of interest to report.

INTRODUCTION

Maintenance of fluid homeostasis is vital for athletic performance and thermoregulation in youths and adults. It is well documented that even moderate levels of dehydration increase physiological strain, most likely via disproportionately elevation in heart rate and a concomitant reduction in cardiac output, resulting in body's inability to dissipate heat (12, 13). Furthermore, water losses ≥ 2% of total body weight impair significantly exercise and skill performance (1, 5) both in laboratories and field studies as well as mental performance in hot environments (7, 27, 28). Moreover, recent studies indicated that even lower levels of dehydration (~ −1%) provoke unfavorable changes in the athletic performance (6, 18).

To our knowledge there are limited studies investigating the hydration status of young athletes in free-living situations. In a study conducted by Kavouras and his colleagues, it was indicated that a simple but comprehensive intervention program enhanced hydration status over just a two-day period in children exercising in a summer sports-camp. Moreover, the improvement of hydration status, through ad-libitum water intake, led also to a significant increase in children's endurance performance. Nevertheless, it must be emphasized that despite the significant reduction in the percentage of the dehydrated children after intervention (−25%), almost 60% of the participants remained hypohydrated (17).

Furthermore, studies examining the hydration status in youths exercising under warm environmental conditions indicated that the majority of the exercisers were hypohydrated from the beginning of data collection and maintained this condition throughout the measurement days, demonstrating inadequate hydration habits (4, 22, 29). It should also be highlighted, that in many sports the majority of the young athletes exhibit voluntary dehydration. A phenomenon characterized by insufficient fluid intake and prolonged fluid deficit despite ample fluid availability in the training field. Recent data demonstrate that adolescent athletes arrive hypohydrated to practice, do not drink enough during training, thus exhibiting voluntary dehydration, a common observation in indoor (24) as well as in outdoor sports (10, 11). Although there are many studies examining hydration status and related variables in professional athletes, there are limited data concerning different age groups within adolescence and also comparing the hydration status of young elite athletes from different sports. Therefore, we aimed to examine the prevalence of dehydration in a group of elite young athletes, participating in different sports throughout a typical training day within a week.

METHODS

Experimental Approach to the Problem

The detrimental effects of hypohydration on the athletic performance are well documented by numerous studies. The vast majority however involve professional adult athletes, in contrast to young athletes, where there has been no systematic documentation of the phenomenon of dehydration. Moreover, in this work we wanted to measure the changes of hydration status in elite athletes of different type of sports, throughout a typical training day. Consequently, this descriptive study was designed to document the prevalence of hypohydration among elite young athletes and simultaneously identify their hydration habits during a training day.

Subjects

Fifty-nine young elite male athletes from different sports (basketball n=12, gymnastics n=10, swimming n=12, running n=12, canoeing n=10, age range: 14-16.5 y), participated in the study; their physiological characteristics are presented in Table 1. All participants were highly trained athletes which competed in national and international championships. The study was approved by institution ethics committee and it was carried out in accordance with the Declaration of Helsinki (1983) of the World Medical Association. For each participant an informed consent was singed by a legal guardian. Eligibility criteria for participation in the study included a normal physical examination and absence of any metabolic, cardiovascular or renal disease. All subjects trained in daily base and had a normal BMI for age, according to Cole criteria (9).

Procedures

The day before the measurements, urine containers were provided to the athletes after their last evening training, for the collection of their first morning urine sample of the following day, with no further information about the nature of the experiment. The athletes were also instructed to avoid consuming any alcohol, or any caffeine-containing drinks throughout the rest of the day and until the time of the measurements. In the day of the experiment, the participants reported in their training facility at 1700 with their first urine sample of the day. Before and after practice, a urine sample was collected and body weight was recorded, while athletes trained with no further interaction. All athletes had free access to their fluid bottles throughout their practice and the research team did not encourage participants to hydrate. Immediately after training, body mass was recorded and the final urine sample was collected for immediate analysis of urine specific gravity and urine color. Mean environmental temperature and humidity at the time of the measurements were 27.6±0.9 ° C and 58±8%, respectively (swimming: 26.4, basketball: 28.8, running: 27.7, canoe: 27.0, and gymnastics: 28.4 ° C). All athletes trained for 90±11 min (swimming: 110, basketball: 86, running: 87, canoe: 81, gymnastics: 90 min).

Hydration status was assessed via the first morning, pre- and post-training urine sample, based on urine specific gravity (USG), and urine color. The young athletes were classified as euhydrated or dehydrated based on the criteria for hydration status in adults (USG≥1.020), proposed by the American College of Sports Medicine position statement (26). USG was measured with a handheld refractometer (ATAGO SUR-NE, Tokyo, Japan) in duplicate. Urine color was determined by comparing each specimen container next to an original urine color scale (3). Evaluation was carried out by the same person at all times, standing in a well-lighted room (temperature 20-22°C) with samples placed on a clear glass tube 100 × 16 mm, against a white background. Body weight changes were recorded to the closest 100 g (Seca, model: 7701321004, Vogel & Hamburg, Germany). With the exception of swimmers which they were measured with a new, dry, swimming suit after training, all athletes were towel dried and their post-training body weight was recorded wearing only their underwear.

Statistical Analyses

The results are presented as means ± 1 standard deviation (SD) for continuous variables, as well as, absolute and relative frequencies. Data were analyzed using analysis of variance with repeated measures. Correlations between USG values and changes in body weight were assessed using a scatter-plot; and a linear regression line was fitted in the graph. Statistical analysis was carried out by SPSS 19.0, with statistical significance set at .05.

RESULTS

Hydration assessment showed that, based on the first morning USG, 89.8% (53 out of 59) of the young athletes were hypohydrated. Likewise, according to the urine color chart, 96.6% (57 out of 59) were also classified as hypohydrated.

Pre-practice urine measurements showed that only 23.7% of all children began their training session in a euhydrated state (swimmers: 16.6, runners: 26.7, basketball players: 16.7, gymnasts: 29 and canoers: 30%). Despite fluid availability in all training facilities during practice, the vast majority of the athletes from all sports experienced additional body weight loss (mean weight loss of −1.1±0.07 %) with gymnasts exhibiting the higher losses (−1.7±0.07 %) (Table 2).

Correlations between pre-exercise USG values and % of changes in body weight along with the changes in urine specific gravity values (ΔUSG post-pre) and in body weight (ΔBW) failed to reveal any relationship ($p>0.05$) (figures 2 and 3).

DISCUSSION

We examined the prevalence of hypohydration in elite young athletes from different sports throughout a typical training session, under warm environmental conditions. Our data indicate high prevalence of hypohydration in across different sports. The majority of the young athletes started practice in a hypohydrated state, and maintained or even aggravated their pre-exercise hypohydration state, despite ad libitum fluid consumption, throughout the day.

More specifically, elevated first morning USG values indicated that the majority of these athletes do not return to their euhydrated state following a practice. Taken into consideration the fact, that data collection was conducted in the middle of a typical training week, it is indicative that the athletes adopted inadequate rehydration habits outside practice and as a result they appeared for practice, hypohydrated. Similarly, Yeargin and her colleagues demonstrated that heat-acclimatized, high-school football players exhibit inadequate hydration habits when they were not at practice (29). The later, was a combination of participant’s misapprehension concerning their fluid losses and lack of successful rehydration strategies. Thus, constant efforts along with realistic and practical rehydration strategies should be made by coaches, athletes and parents towards the education of the exercisers, for the harmful effects of dehydration in health and performance.

It is also important to observe that from all athletes, swimmers were the only ones which reduced their USG values during their training session. It would be expected that due to the nature of the sport, water immersion and body posture would increase central blood volume and central venous pressure, which in turn would load cardiopulmonary baroreceptors (25). These changes would reduce both thirst and arginine vasopressin (AVP) secretion leading to greater diuresis. Even though we did not measure AVP, the decrease in USG could be a result in lower AVP level as a response of the water immersion.

Remarkably, we also observed that basketball and gymnastic athletes experienced the higher degree of dehydration during their practice (figure 1). Moreover, male gymnasts, a rarely studied athletic population which follow a non-continuous type of exercise, showed significant dehydration as a response to training. This observation is noteworthy, given the fact that in indoor sports like the aforementioned, athletes have much more opportunities to drink, due to closer proximity to fluids and greater number of breaks. However, there are published studies in indoor sports like basketball, judo (22, 24) and ice-hockey (23), where also a significant percentage of young athletes experiences moderate to severe water losses; a notion that highlights the prevalence of voluntary dehydration in young athletes.

It has also been a common suggestion for athletes that the only advice needed during exercise in the heat, is to drink according to thirst (14, 19, 20). The data from the present study do not support this notion. We expected that the dehydrated athletes from all sports (according to their high pre-training USG values) would experience hyperosmotic hypovolemia and as a result, they would be thirstier during practice, which in turn would lead to greater fluid intake. On the contrary, most of the athletes dehydrated even more, despite fluid availability in the field, as demonstrated by the reductions of their total body weight after training. Thus, it might be useful to apply an individualized hydration protocol, as suggested by the American College of Sports Medicine, versus the ad libitum fluid intake on exercise performance and thermoregulation.

Moreover, it is considered that changes in body weight during exercise, is a valid way to describe changes in hydration status. Since drinking itself affects AVP hormone secretion and in turn urine concentration ability and urine markers, we wanted to examine if changes in urine hydration markers will be indicative of changes in hydration state. We observed that changes in urine marker as indicated by USG were not related in hydration state as indicated by changes in body weight. We therefore conclude that changes in USG during exercise with mild dehydration while drinking might not be utterly indicative of changes in hydration state (figure 3).

Finally, a limitation of our study is the use of the first morning sample for the assessment of athletes' hydration status. It is documented that USG use may be susceptible to errors (15, 21) which in turn, can lead to a slightly higher estimation of the degree of dehydration, most likely due to increased overnight urine concentration. Nevertheless, USG measurement it's a practical, non-invasive and reliable technique frequently used in many field studies (2, 8, 16).

ACKNOWLEDGMENTS

The authors would like to thank all the athletes who volunteered to participate in the study. The results of the present work do not constitute any endorsement from the NCSA.

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PRACTICAL IMPLICATIONS

The data from the present study indicate high prevalence of hypohydration for the majority of the athletes from different kind of sports. Young, elite athletes experience severe dehydration during practice, despite fluid availability in their training facilities, along with inadequate hydration habits outside practice, throughout a typical day of training, thus compromising the quality of their training. Consequently, maintenance of fluid balance for the athletes should be an important point of attention for the strength and conditioning professionals, who should also carefully monitor the hydration status of their athletes. It is also noteworthy that even athletes in indoor sports which have much more opportunities to drink, due to closer proximity to fluids and greater number of breaks exhibit high levels of dehydration. Therefore, coaches should educate young athletes concerning the importance of hydration for performance and well-being; while at the same time try to improve fluid accessibility in the field of play. Our findings also indicate that drinking according to thirst during practice did not prevent further dehydration in sub-optimally hydrated young athletes; thus, an individual hydration protocol should be applied from the coaches for every athlete while taken into consideration the unique characteristics of each sport. Finally, it is suggested that changes in body weight during practice, may be more indicative and practical method of observing changes in hydration status. Hence, continuous efforts along with realistic and practical rehydration strategies should be made by practitioners, athletes and parents towards the education of the young athletes, concerning the detrimental effects of dehydration on performance.

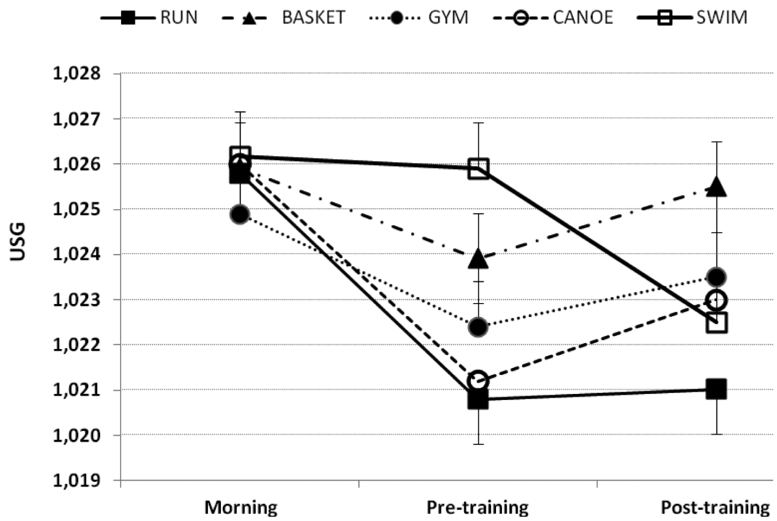

Figure 1.

Mean USG values of the athletes during the experimental procedure

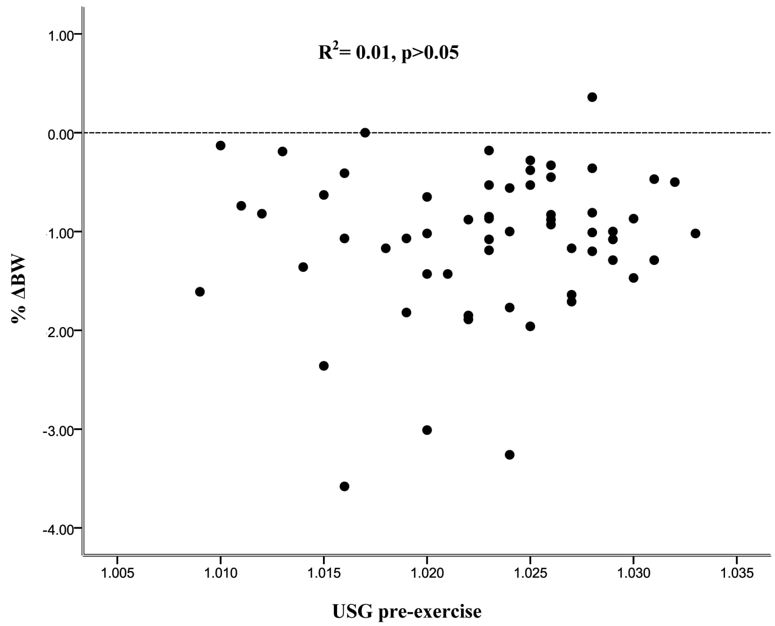

Figure 2.

Scatter plot for the correlation of pre-exercise urine specific gravity values (USG pre-exercise) and % changes in body weight (% ΔBW)

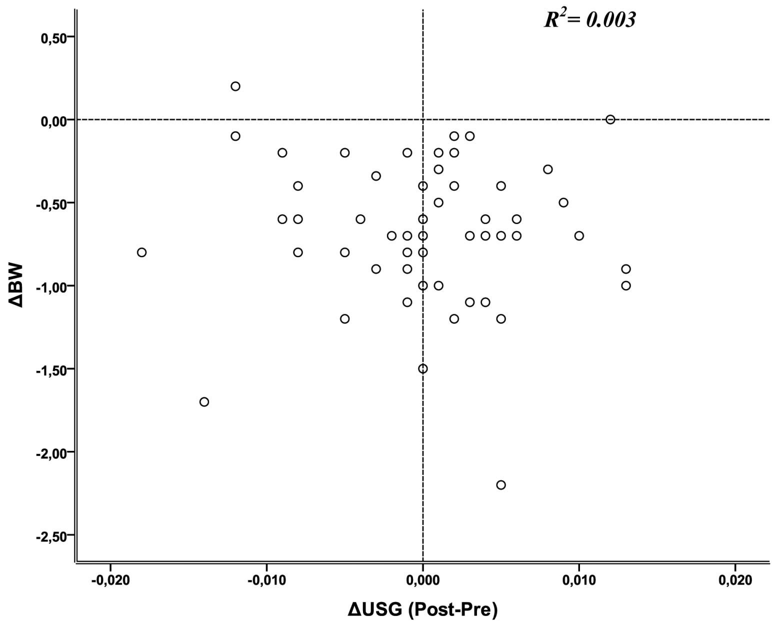

Figure 3.

Scatter plot for the correlation of changes in urine specific gravity values (ΔUSG post-pre) and changes in body weight (ΔBW)

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Table 1

Physiological characteristics of the study participants

Sport	Swimming	Basketball	Canoeing	Running	Gymnastics	Overall
Subjects (#)	n=12	n=12	n=10	n=15	n=10	n=59
Age (y)	15.4±1.3	15.5±0.5	14.6±0.8	15.9±1.2	14.4±1.5	15.2±1.3
Weight (kg)	67.3±13.5	78.8±8.9	70.9±6.5	57.4±7.9	46.8±9.8	64.7±14.6
Height (m)	1.75±0.1	1.89±0.11	1.74±0.07	1.72±0.07	1.53±0.1	1.73±0.14
BMI($kg{\text -}m^{-2}$)	21.7±2.2	22.0±1.1	23.4±1.8	19.3±1.7	19.6±1.9	21.2±2.2
Training (y)	8.0±2.3	7.8±3.1	6.5±1.4	8.4±2.2	8.1±1.3	7.7±2.0

Values are means ± 1 SD

Table 2

Changes in hydration indices throughout the training day

	Urine Specific Gravity			Urine Color			Change in Body Weight	
	Morning	**Pre-training**	**Post-training**	**Morning**	**Pre-training**	**Post-training**	**(kg)**	**(%)**
Swimming	1.026±0.003	1.026±0.006	1.023±0.008	5±1	5±1	4±1	−0.53±0.23	−0.8±0.16
Running	1.026±0.006	1.021±0.006	1.021±0.007	4±1	3±1	3±1	−0.58±0.12	−1.0±0.09
Canoeing	1.026±0.004	1.021±0.008	1.023±0.005	5±1	4±1	5±1	−0.67±0.01	−1.0±0.01
Basketball	1.026±0.005	1.024±0.005	1.026±0.005	5±1	4±1	5±1	−0.79±0.01	−1.0±0.01
Gymnastics	1.025±0.007	1.022±0.004	1.024±0.008	5±1	4±1	4±1	−0.80±0.02	−1.7±0.01
Overall	1.026±0.005	1.023±0.006	1.023±0.007	5±1	4±1	4±1	−0.68±0.07	−1.1±0.07

Values are means ± 1 SD