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Research article

Pre-Practice Hydration Status and the Effects of Hydration Regimen on Collegiate Division III Male Athletes

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Abstract
Pre-practice euhydration is key in the prevention of heat related injuries. The pre-practice hydration status of male National Collegiate Athletic Association (NCAA)-Division III athletes and the effects of a direct hydration regimen have yet to be investigated therefore; the aim of the study was 1) to analyze the pre-practice hydration status of current NCAA-DIII male athletes and 2) assess the impact of a directed intervention on pre-practice hydration status. The study was divided into baseline, pre and post intervention phases. For baseline, hydration status through urine specific gravity (USG) and anthropometric indices were measured prior to morning practice. Following baseline, pre-intervention commenced and participants were assigned to either control (CON) or experimental (EXP) groups. The CON and EXP group participants were instructed to maintain normal hydration and diet schedules and record fluid intake for seven days leading to post-intervention. The EXP group participants were asked to consume an additional 23.9 fl oz (~ 750 ml) per day for one week (7 days) leading to post-intervention. After 7 days the same measures were taken. At baseline, the majority of the participants were hypohydrated. Following the intervention, the EXP group participants consumed significantly more fluids than the participants in the CON group (3277.91 ± 1360. 23 ml vs 1931.54 ± 881.81 ml; $p < 0.05$). A-two-way repeated measure ANOVA revealed a non-significant time or treatment effect for USG or body mass but did demonstrate a significant USG interaction. In addition, an independent t-test examining absolute changes in USG demonstrated a significant difference between groups in which the EXP group improved hydration status and the CON group did not (-0.02 ± 0.006 vs 0.001 ± 0.005 ml; $p < 0.05$). In addition, there was no significant ($p > 0.05$) difference in the regression slopes or intercepts between the CON and EXP groups when expressed as daily fluid intake per kg body ($ml \cdot kg^{-1}$) and change in USG from pre-intervention to post-intervention. Most of the participants were hypohydrated at baseline/pre-intervention and the direct hydration intervention improved post-intervention hydration status but only to a small extent.

Key words: Hypohydration, refractometer, hydration intervention, urine specific gravity.

Introduction

It is well documented that hypohydration can adversely affect thermoregulation, cardiovascular function, metabolism and cognitive function (Armstrong et al., 2012; Montain and Coyle, 1992; Sawka, 1992; Sawka and Coyle, 1999). These detriments are due, at least in part, to the increase in body temperature, a decrease in stroke volume and a reciprocal increase in heart rate, and serum electrolytes imbalance (Hargreaves et al., 1996; Montain and Coyle, 1992). In addition to the damaging effects on physiological function, hypohydration may also increase the risk of mild to severe heat related injuries (Armstrong et al., 2007). During team sports, where many times the activity varies between near maximal intensity bouts and low intensity periods, dehydration due to sweat loss could be substantial and therefore, proper hydration prior to and during exercise is crucial (Burke and Hawley, 1997). Furthermore, heat related injuries are entirely preventable with proper hydration regimens, and appropriate preparation and education (Howe and Boden, 2007).

While proper hydration is key for optimal function and health, Nichols et al. (2005) has demonstrated that collegiate athletes lack the educational knowledge that is required to make wise decisions regarding pre-activity hydration. This finding was further supported by Volpe and colleagues (2009) who studied the pre-practice hydration status in 263 male and female National Collegiate Athletic Association (NCAA)-Division I (DI) athletes and demonstrated that close to 70% were hypohydrated prior to practice. These findings are pivotal and serve as a discussion point when introducing the topic of proper hydration to collegiate athletes. Nevertheless, the data represents only one segment of NCAA athletics and may not provide accurate data concerning NCAA-Division III (DIII) athletes. In addition, these studies (Nichols et al., 2005; Volpe et al., 2009) have neither suggested nor examined any practical intervention to improve pre-activity hydration.

In academic institutions in the United States, the major collegiate sports (American football, basketball, baseball etc.) are sanctioned by sport governing organizations such as the NCAA (Rosandich, 2002). Within the NCAA there is a further partitioning to divisions (D1, DII and DIII) based on the size of the academic institution and the number of sponsored sports (National Collegiate Athletic Association., 2010). Unlike coaches at the NCAA-DI level, NCAA-DIII coaches are not allowed to award financial aid on the basis of athleticism and therefore have limited financial leverage to regulate nutritional behaviors. In NCAA-DIII, any financial aid that is awarded to a student-athlete must be, procedurally, the same and scrutinized similar to those awards given to non-athletes (National Collegiate Athletic Association., 2010) therefore, the ability to deliver nutritional input and enforce reciprocal behaviors of the student-athletes may be challenging. Further compounding this problem, in many cases, NCAA-DIII athletic programs have less resources and lower athletic department budgets resulting in lower numbers of coaches and support staff (athletic trainers, managers, etc.). This in turn may lead to reduced ability

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to closely monitor and provide proper hydration education to the student-athletes. As a result of these differences, NCAA-DIII athletes may be at even greater risk as the athletes are likely to have a lower level of athletic prowess (Magal et al., 2009), less than optimal preparation for practice and competition, hence predisposing them to a higher risk for the development of heat related injuries.

Therefore, the purpose of the study was twofold: 1) to analyze the pre-practice hydration status of current NCAA-DIII male athletes from various sports and 2) to assess the effects of directed intervention on pre-practice hydration status. We hypothesized that the majority of the participants in our study will be hypohydrated during pre-practice prior to treatment and that direct hydration intervention would improve hydration status during pre-practice.

Methods

Participants

Fifty-six currently active NCAA-DIII male athletes from a small liberal arts college were recruited by word of mouth from the mens' soccer, basketball and baseball teams to participate in the study. Testing occurred during pre-season, two to four weeks prior to the beginning of their respective competition seasons. All participants received a detailed explanation of both the benefits and the risks that were involved with the study, completed a medical history form and gave their written consent. All experimental procedures were approved by the North Carolina Wesleyan College's Institutional Review Board for the Protection of Human Participants.

Procedures

Experimental approach

The study was divided into two phases: baseline, and intervention. The intervention consisted of pre intervention and post intervention. During the baseline phase, hydration status and anthropometric measures were assessed on all participants as one group. Following the baseline phase, participants were matched for hydration status, based on USG values, and divided in a counterbalanced manner into control (CON) and experimental (EXP) groups and pre-intervention phase commenced. Baseline measures for the group as a whole were also used as the baseline measure for the CON and EXP groups in pre-intervention. Seven days later and in a manner similar to pre-intervention, post-intervention measures commenced (Figure 1).

Pre-intervention and post-intervention were conducted at the same time of the day (6:00 am), and one week apart and included the collection and analysis of the first morning voided urine sample and completion of a daily fluid chart between groups. On pre-intervention and upon arriving to the NCWC human performance laboratory (HPL), participants were asked to empty their bladder into a specimen cup and provide a urine sample for the analysis of urine specific gravity (USG). Body mass and height were measured using a scale (Ohaus Champ II Model CH 150 R11, Ohaus Corporation, Florhan Park, NJ) and standardized wall mounted stadiometer (Seca 202 Wall Mounted Stadiometer, 40 Barn Street, B5 5QB Birmingham, United Kingdom), and Body Mass Index (BMI) was calculated (Pescatello et al., 2014) and recorded. Following the urine collection and anthropometric measurements, participants were given an 8 fl oz (240 ml) cup to be used as a measuring tool and were assigned to either the CON or EXP group. The division of the participants in the two groups was based on matching hydration status. Participants of the CON group were asked to maintain normal diet and hydration habits and complete the daily fluid chart in the week leading up to post-intervention. Participants assigned to the EXP group were asked to consume an additional 16.9 fl oz (500 ml) of water during daytime hours and 8 fl oz (240 ml) of water in the evening on a daily basis in addition to maintaining normal diet and hydration habits, and completing the daily fluid chart in the week leading to post-intervention (Figure1). For post-intervention, participants submitted their daily fluid charts and performed the same measurements as in pre-intervention.

Urine Specific Gravity (USG)

In contrast to other authors (Stover et al., 2006; Volpe et al., 2009) who used spot urine samples, we collected first morning void samples which could be reliably referenced against hydration standards. The samples were analyzed

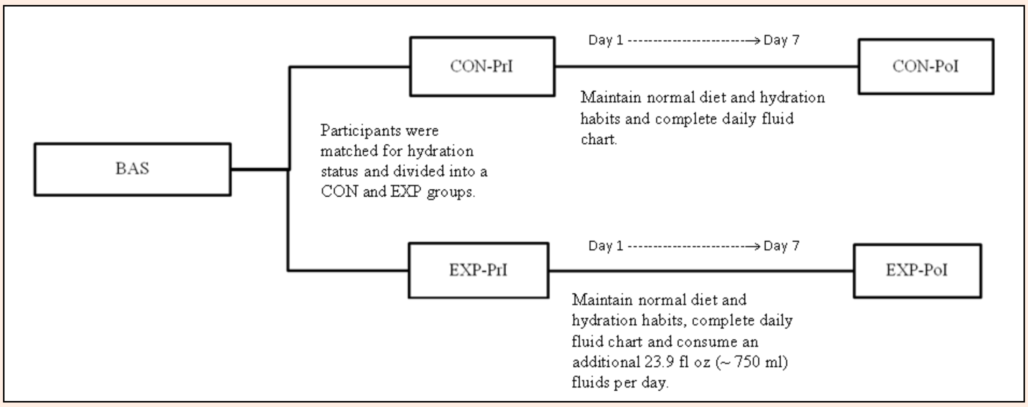

Figure 1. Graphical representation of the experimental protocol. BAS, baseline; CON-PrI, control trial pre intervention; EXP-PrI, experimental trial pre intervention; CON-PoI, control trial post intervention; EXP-PoI, experimental trial post intervention.

Table 1. **Baseline, control (CON) and experimental (EXP) groups anthropometric measures. Data are means (±SD).**

	Overall (n = 56)	CON (n= 28)	EXP (n= 28)
Age, y	20.2 (1.7)	20.1 (2.0)	20.4 (1.6)
Height, m	1.81 (.10)	1.80 (.12)	1.81 (.9)
Body mass, kg	78.5 (8.9)	78.4 (8.0)	78.5 (9.8)
Body mass index, kg·m^{-2}	24.2 (3.6)	24.5 (3.7)	24.0 (3.4)

for USG using a refractometer (Hand-held refractometer, Atago, Japan), in duplicates and using the average within 30 minutes of specimen collection. Between sample readings, the refractometer was recalibrated using distilled water. In order to reduce the risk of inter-rater error, the same researcher conducted all analyses by applying a drop of urine, from the specimen cup onto the refractometer measuring surface, using a mineral-free pipette, and recording the USG. For clarification, while some authors have claimed that total body water in combination with plasma osmolality provides the "gold standard" for the assessment of hydration (Ritz and Source, 2001; Sawka et al., 2005). In the present study where a large number of athletes have been tested prior to practice, USG provided an economical, practical and sensitive tool in the assessment of acute hydration status and therefore, is appropriate (Oppliger et al., 2005).

The hydration status was determined by USG and was based on a scale that was published by both by the American College of Sports Medicine (ACSM) and the National Athletic Training Association (NATA) (Sawka et al., 2007; Casa et al., 2000), and has been used previously (Volpe et al., 2009). Hydration status was divided to three escalating categories in which euhydration was defined as USG between 1.000 and 1.020; hypohydration was defined as USG between 1.021and 1.029; and significant hypohydration, was defined as USG of 1.030 or greater.

Daily fluid chart and diet

Participants from both groups (CON and EXP) recorded total fluid intake on a daily basis, using the supplied daily fluid chart, in the week leading up to post-intervention. In order to reduce the chance of errors in calculating fluid intake and similar to Volpe et al. (2009), we supplied the participants with an 8 fl oz (240 ml) cup and asked that the report will be truthful and as accurate as possible. To reduce the risk of inter-rater error, only one researcher was responsible for distributing, explaining, collecting and interpreting the findings of the fluid chart. Although the participants were not asked to keep a written diet record, they were asked to maintain normal eating habits, be truthful and report any food consumption that exceeded "normal eating habits".

Statistical analysis

Analysis of variance (ANOVA), Bonferroni correction and t-test were performed using a statistical software package (IBM SPSS Statistics, Version 20.0, SPSS, Inc., Chicago, IL). A two-way repeated-measure ANOVA, time by treatment, was used to analyze differences in body mass and urine specific gravity. A Bonferroni correction was applied to eliminate the possibility of type I errors in the consequent pairwise comparison. Independent t-tests were computed to compare absolute changes in USG from pre-intervention to post-intervention and fluid consumption between the groups. Regression slopes and intercepts for individual daily fluid intake per kg body (ml·kg^{-1}) and change in USG from pre-intervention to post-intervention were also computed. For this study, statistical significance was set at $p < 0.05$.

Results

Baseline mean values for anthropometric measures are presented in Table 1. Table 2 presents the hydration status of the participants in absolute values and percentages, across time and treatment. At baseline, 25, 59 and 16% of the participants were euhydrated, hypohydrated and significantly hypohydrated, respectively. In respect to USG and body mass, the two-way repeated measure ANOVA revealed no significant time or treatment effects ($p > 0.05$) but a significant interaction ($p < 0.05$) across time and treatment was apparent for USG (Table 3). Examining the absolute changes in USG, an independent t-test demonstrated a significant difference between groups in which the EXP group improved hydration status and the CON group did not (EXP:-0.02 ± 0.006 versus CON: 0.001 ± 0.005 ml; $p < 0.05$). In regards to fluid consumption, an independent t-test demonstrated that in the EXP group, daily fluid consumption volume was significantly higher than the CON group (EXP:3277.91 ± 1360. 23 ml

Table 2. **Hydration status in absolute number and percentages, across treatment and time.**

Hydration status	Baseline (n = 56)	Pre-intervention		Post-intervention	
		CON (n = 28)	**EXP** (n = 28)	**CON** (n = 28)	**EXP** (n = 28)
Euhydration	14 (25%)	7 (25%)	7 (25%)	7 (25%)	9 (32%)
Hypohydration	33 (59%)	17 (61%)	16 (57%)	16 (57%)	17 (61%)
Significant hypohydration	9 (16%)	4 (14%)	5 (18%)	5 (18%)	2 (7%)

CON, control group; EXP, experimental group.

Table 3. **Baseline, pre-intervention and post-intervention body mass and USG, all the data is presented as means (±SD).**

	Baseline (n = 56)	Pre-intervention		Post-intervention	
		CON (n = 28)	**EXP** (n = 28)	**CON** (n = 28)	**EXP** (n = 28)
BM (kg)	78.5 (8.9)	78.4 (8.0)	78.5 (9.8)	78.5 (8.0)	78.8 (9.6)
USG	1.024 (.005)	1.023 (.005)	1.025 (.005)	1.024 (.005)	1.022 (.006) *

BM, body mass; USG, urine specific gravity; CON, control group; EXP, experimental group. * Indicates significant interaction between time and treatment in post-intervention. Significance was set at $p < 0.05$

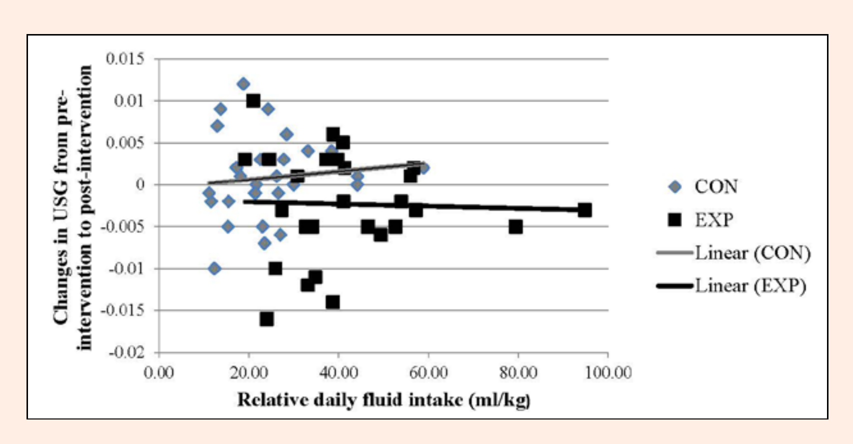

Figure 2. The relationship between the change in USG from pre-intervention to post-intervention in CON and EXP, and relative daily fluid intake.

versus CON: 1931.54 ± 881.81 ml; $p < 0.05$). There was no significant difference in the regression slopes or intercepts between the CON and EXP groups, ($y = 0.00005\,x - 0.00037$) and ($y = -0.00001\,x - 0.0018$), respectively (Figure 2).

Discussion

Baseline

The purpose of baseline was to measure and analyze the pre-practice hydration status of current NCAA-DIII male athletes. Similar to Volpe and colleagues (Volpe et al., 2009) who used, at baseline, the majority of athletes were hypohydrated, some were significantly hypohydrated and only a small minority were euhydrated (Table 2). Similar findings, in which the majority of the athletes were hypohydrated during pre-practice, were also demonstrated in adolescent American football players following a few days of two-a-day practices (Stover et al., 2006). These findings may be related to either the level of knowledge, the application of the knowledge of the athletes in respect to the importance of hydration prior to practice or the timing of the testing. Nichols and colleagues (2005) have suggested that even if athletes have the knowledge, the proper behavior may not follow. In line with Nichols et al. (2005), Volpe and associates (2009) have proposed that in some cases (early morning practice, for example), individual hydration habits may supersede known knowledge which may be the case in our study.

Alternatively, our findings may be related to the professional level of play of the athletes and/or more dedicated coaching and supporting staff. Osterberg and colleagues (2009) have demonstrated that in professional National Basketball Association (NBA) players, during a summer season, only half of the athletes were hypohydrated prior to the beginning of the game. In another study, hydration status was assessed in professional soccer players and was demonstrated that well over 50% of the players were hydrated upon arriving to the event (Aragón-Vargas et al., 2009). Similar results were also shown in a recent study that examined the hydration status of elite female basketball players prior to the commencement of international competition. (Peacock et al., 2011) Clearly, these findings are in contrast to the finding of the present investigation in which 84% of the athletes were rated as hypohydrated. This hypothesis may have merit in our situation since coaches have less financial leverage and programs have less resources and lower athletic department budgets leading to a lower number of coaching and support staff (National Collegiate Athletic Association., 2007). Additionally, coaches at the NCAA-DIII level typically have many other responsibilities placed upon them other than coaching therefore, hydration related education may be "pushed" further down in the list of priorities.

Intervention

In phase two of the study and in an effort to study the effects of direct hydration intervention on pre-practice hydration status, the pool of participants were divided into two groups, CON and EXP (Tables 1 and 2). As expected, the EXP group participants consumed a significantly greater volume of fluids in the week leading to post-intervention when compared to the CON group participants (~3278 versus 1932 $ml \cdot day^{-1}$). However, this greater fluid consumption translated to only a minor and non-significant improvement in pre-practice hydration status. Yet, there was a significant interaction in respect to time and treatment (Table 3) and a trend was visible in which the EXP group improved hydration status from pre-intervention to post-intervention in terms of the number of participants and the magnitude of change (Tables 2 and Figure 2). Although small but yet significant, the difference was also apparent when we compared absolute changes in USG between the two groups demonstrating an improved hydration status in the EXP group but not in the CON group (EXP: -0.02 versus CON: 0.001). Nevertheless while USG improved in the EXP group post-intervention, participants were still classified as hypohydrated (Table 3).

One possible explanation for the lack of significant main effects and only a minute decrease in USG in the EXP group may be related to the prescribed intervention volume. Since the scope of this study was not to equate the intervention volume with daily fluid replacement volume but rather to introduce a novel hydration intervention regimen, sweat and urine volumes were not accounted for. The intervention volume that was chosen meant to be in line with the published pre-exercise hydration recommendations set by ACSM and NATA (Casa et al., 2000; Sawka et al., 2007). We instructed the EXP group participants to consume an additional 24.9 fl oz (~750ml) per day during the week leading to post-intervention. This was evident from the results in which the EXP group consumed 70% more fluid during that time period. However, based on our findings, it is possible that a larger intervention volume would have led to a more favorable hydration status in this population.

Conversely, due to the significant and substantial differences in average daily fluid consumption between the groups with only minute changes in the USG, it is possible that the reports from participants in the EXP group were inaccurate. Cook and Campbell (1979) have demonstrated that in some cases the subjective reporting of participants may be biased. Participants may report what they think the researcher is trying to prove or report findings that may display their effort in a positive light. These findings have been reported in other studies that examined self-reporting energy intake (Schoeller et al., 1990; Weber et al., 2001) and exercise related energy expenditure. (Neilson et al., 2008; Shephard, 2003). In addition, the accuracy of the data may also be questionable if the participants did not fill out the daily fluid chart every day by using the measuring cup, as requested, but rather filled the chart by estimating fluid intake and using memory. It has been suggested that such practices may lead to inherent inaccuracies (Schacter, 1999). It is important to point out, that while the researchers have stressed to the participants the importance of following the assigned hydration protocol (i.e. using the measuring cup, recording on time and accurately etc.); it is possible that participants did not fully follow the directions as requested.

Limitation

It is important to point out that the current study has one limitation. Since daily diet was neither controlled nor recorded, it is possible that the elevated USG was a result of insufficient water intake to dilute the renal solute load (diet) and not just a reduction in renal water output (dehydration) (Cheuvront and Kenefick, 2014). To minimize the likelihood of such occurrence, and as previously mentioned, we asked the participants to maintain normal eating habits, be truthful, and report any food consumption that exceeded “normal eating habits”.

Practical application

Proper hydration prior to practice and competition is critical for health. Collegiate athletes need to be educated about the importance of hydration and the negative consequences that are associated with improper hydration. Since personal behavior may supersede hydration knowledge, for a hydration intervention to succeed, coaching and supporting staff should practice positive reinforcement (Nichols et al., 2005). Further, the use of subjective tools to report average fluid consumption may prove to be unreliable. Therefore, it may be more practical for coaches and athletes alike to follow published fluid replacement guidelines (Casa et al., 2000). Future research should examine the effects of applying larger intervention volumes while controlling solute intake and the applicability of implementing proper education and awareness program on pre-practice hydration status.

Conclusion

Our findings indicate that the majority of NCAA-DIII male athletes whom we assessed prior to practice through the use of USG appeared to be hypohydrated. It is challenging to determine if the participants in our study were hypohydrated due to lack of prior knowledge and/or personal habits, or more systemic causes such as the level of play and/or the lack of athletic support staff and coaches. Ultimately, the hydration intervention of adding 24.9 fl oz (~750ml) per day to an athlete’s daily fluid intake led to a significant increase in fluid consumption but resulted in only small improvements in USG. This finding may be a result of an intervention volume that is too small or an under-reporting of fluid consumption. Regardless of the cause in this population, it is critical to implement a program that addresses proper education and awareness of suitable hydration and its effects on health. This issue is pivotal in the case of hydration since heat related morbidity and mortality are completely preventable with proper education and support.

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Key points

- The majority of NCAA-DIII male athletes whom we assessed prior to practice through the use of USG appeared to be hypohydrated.
- The hydration intervention of adding 24.9 fl oz (~750ml) per day to an athlete's daily fluid intake led to a significant increase in fluid consumption but resulted in only small improvements in USG.
- The only small improvement in hydration status following the intervention may be a result of an intervention volume that is too small or an under-reporting of fluid consumption.

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