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Efficacy of an Educational Intervention for Improving the Hydration Status of Female Collegiate Indoor-Sport Athletes

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Context: Research focusing on improving hydration status and knowledge in female indoor-sport athletes is limited. Investigators have demonstrated that hydration education is an optimal tool for improving the hydration status of athletes.

Objective: To assess the hydration status and fluid intake of collegiate female indoor-sport athletes before and after a 1-time educational intervention.

Design: Controlled laboratory study.

Setting: Collegiate women's volleyball and basketball practices.

Patients or Other Participants: A total of 25 female collegiate volleyball and basketball athletes (age = 21 ± 1 years, height = 173.5 ± 8.7 cm, weight = 72.1 ± 10.0 kg) were assessed during 6 days of practices.

Intervention(s): Participants' hydration status and habits were monitored for 3 practice days before they underwent a hydration educational intervention. Postintervention, participants were observed for 3 more practice days.

Main Outcome Measure(s): Change in body mass, fluid consumed, urine specific gravity (Usg), urine color (Ucol), and sweat rate were recorded for 6 practice days. Participants completed a hydration-knowledge questionnaire before and after the intervention.

Results: Three-day mean Usg and Ucol were considered euhydrated prepractice (Usg = 1.015 ± 0.006, Ucol = 4 ± 1) and remained euhydrated postpractice (Usg = 1.019 ± 0.005, Ucol = 5 ± 2) during the preintervention period. Decreased prepractice Ucol ($P < .01$) and increased hydration knowledge ($P < .01$) were present postintervention. Basketball athletes had greater body mass losses from prepractice to postpractice than did volleyball athletes ($P < .001$). Overall increases were evident when we compared prepractice and postpractice measures of Usg and Ucol in the preintervention ($P < .001$ and $P = .001$, respectively) and postintervention ($P = .001$ and $P < .001$) period, respectively. No correlation was found between hydration knowledge and physiological indices of hydration and fluid intake.

Conclusions: Overall, female collegiate indoor-sport athletes were hydrated and knowledgeable on hydration. However, our variable findings indicated that further research on these athletes is needed; clinically, attention should be given to the individual needs of each athlete. More examination will demonstrate whether a 1-time educational intervention may be an effective tool for improving hydration status in this population.

Key Words: dehydration, hydration assessment, hydration knowledge, urine specific gravity, urine color

Key Points

- The collegiate female indoor-sport athletes began the study with good knowledge of hydration, which improved after a 1-time educational intervention.
- Simple monitoring of both body mass changes and urinary measures of hydration can assist a clinician in identifying those athletes who may need additional hydration interventions.
- Clinicians should use individualized hydration measures and responses to educate athletes about the importance of hydration before, during, and after exercise.

Proper hydration allows the body to function at an optimal level.[1] Although the effects of body fluid loss may vary on an individual basis, body mass (BM) losses of sweat >2% led to performance deficits, ranging from decreases in cognitive function to decreases in sport-specific skills.[1–5] Although recommendations for proper hydration practices have been created for athletes,[1,6,7] these guidelines may not have been followed appropriately, based on the incidence of dehydration. Prepractice dehydration is very common in athletes at all competition levels.[8–15] Exercise-induced dehydration is also frequent in athletes due to increased sweat losses and improper fluid intake during or after those sweat losses.[8,16–19] To date, much of the research[15–18] has focused on the hydration practices of outdoor-sport athletes, which has shown that these athletes exhibit prepractice dehydration. The few investigators[11,20,21] who assessed indoor-sport athletes demonstrated that sweat rates were high and dehydration was still prevalent. This was especially true in basketball players due to the intermittent nature of play.[21,22] Regarding volleyball players, only 1 group[9] examined the hydration status of adolescent athletes in a

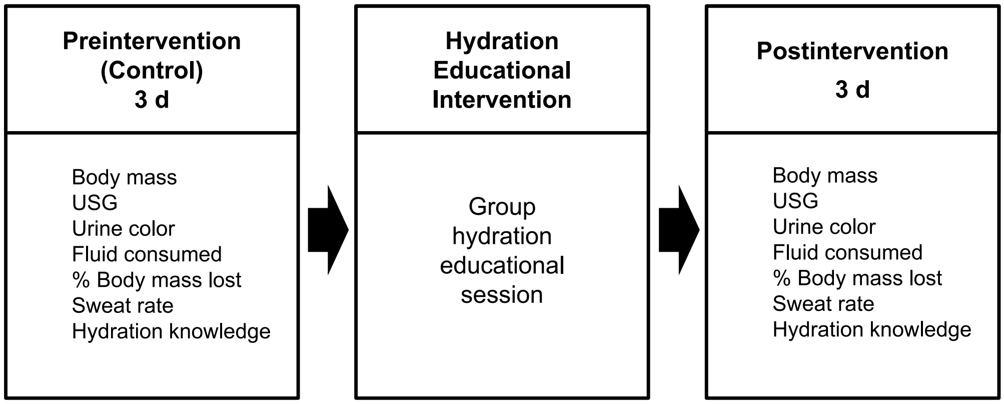

Figure 1. Protocol for educational intervention on hydration. Abbreviation: USG, urine specific gravity.

non–air-conditioned facility. Therefore, the hydration knowledge and practices of female collegiate indoor-sport players are unknown, as is the effectiveness of an educational intervention in improving hydration knowledge and habits.

Studies focused on improving hydration status and knowledge in female indoor athletes, especially collegiate volleyball and basketball athletes, remain limited. Previous authors[23,24] claimed that hydration education was an optimal tool for improving the hydration status of athletes, and a recent position statement[1] recommended educating physically active individuals to reduce the incidence of severe hypohydration and exercise-associated hyponatremia (EAH). Therefore, educational interventions could have positive implications for the hydration status of indoor-sport athletes. However, no researchers have examined the efficacy of an educational intervention for collegiate female indoor-sport athletes. Therefore, the purpose of our study was to determine whether 1 educational session on hydration would improve the hydration status and fluid intake of collegiate female indoor-sport athletes. We hypothesized that these athletes would arrive at practice hypohydrated and that a 1-time educational intervention would lead to improvements in hydration status. The findings from this study may help establish evidence-based fluid-replacement recommendations for this population.

METHODS

Participants

A total of 25 female collegiate indoor-sport athletes from a National Collegiate Athletic Association Division II institution were recruited (age = 21 ± 1 years, height = 173.5 ± 8.7 cm, weight = 72.1 ± 10.0 kg, mean body mass index = 24 ± 3). The participants were recruited from the women's volleyball and basketball teams. Their typical training consisted of 2 hours of indoor sport-specific practice 3 to 4 times a week, 1 hour of strength and conditioning 2 times a week, and 2 games per week. Practice plans were similar across days and only included structured team practices. We collected data at midseason to limit the effect of physiological changes or adaptations that might occur at the beginning of the season. Criteria for exclusion were individuals younger than 18 years, a current injury or illness that limited sport participation, and an inability to perform any portion of the testing protocols. Approval for this study was granted by the university's institutional review board.

Design and Procedures

Demographic data were obtained at the start of data collection. All data were collected over 6 days of team sport-specific practices; each day consisted of prepractice and postpractice collection for the preintervention period, an educational intervention, and the postintervention period (Figure 1). Practices were similar in structure and intensity during both periods. All practices took place in an indoor, controlled, and air-conditioned facility. Pregame practices and strength and conditioning sessions were excluded from the study.

Preintervention Period

The preintervention period (control period) was used to establish the participants' hydration knowledge, hydration status, and fluid-intake practices before the educational intervention. At the beginning of this period, all participants filled out informed consent forms and questionnaires. A hydration awareness questionnaire (HAQ) was designed using a multidisciplinary approach to determine hydration knowledge and habits.[16] The HAQ is a Likert-type scale ranging from 0 (*strongly disagree*) to 10 (*strongly agree*). The questionnaire was shown to be understandable and reliable (70% reliability).[16]

Prepractice and postpractice measures consisted of urine samples and BM measurements. Urine samples were used to measure the urine specific gravity (Usg) and urine color (Ucol). The Usg was measured using a clinical refractometer (model REF312ATC; General Tools & Instruments LLC). Before testing, the refractometer was calibrated using distilled water. Values ≥1.020 indicated hypohydration.[1] The Ucol was determined by comparing the sample's Ucol with the chart created by Armstrong.[25] All urine samples were measured by the same researcher (I.S.A.). Upon arrival, participants were instructed to fully empty their bladders and provide a midstream urine sample. Once the participant provided her sample, the researcher measured BM to the nearest 0.1 kg using a digital scale (model BWB-800S; Tanita Corp of America). A BM decrease of 2% to 5% indicated mild to moderate hypohydration, whereas a decrease of >5% reflected severe

SUMMARY OF HYDRATION STATUS

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	Before Practice	After Practice
Urine Color		
Urine Specific Gravity		

Average Weight Change During Practice (lbs and %):

Average Amount of Water Drank During Practice:

Average Sweat Losses During Practice:

Figure 2. Sample of hydration-status summary.

hypohydration. Hyperhydration was indicated by an increase in BM during exercise.[1] Each individual was weighed before practice in athletic shorts and a sports bra while barefoot.

Data collection during practice consisted of fluid-intake measurements. Each athlete was given a designated water bottle filled with chilled water from a cooler, and the investigator kept track of the volume of fluid consumed using a digital scale (model KD-320; Tanita Corp of America). The investigator weighed each participant's filled water bottles and subtracted the weight of the bottle itself. At the end of practice, the volume of fluid remaining was recorded and subtracted from the initial amount in the bottle. Participants drank fluids ad libitum during all practices, were encouraged to continue their normal hydration habits, and were instructed not to share their water bottles with teammates during data collection. They were told to inform the investigator if they needed to urinate during practices, so that the urine could be collected and the volume recorded.

At the end of each practice, the athletes were instructed to complete their BM measurement and then give a postpractice urine sample. Except for the order of the measurements, all procedures after practice were the same as for the prepractice measurements.

Educational Intervention

After the preintervention period, a 1-time educational intervention was provided. This occurred in a group setting after practice on day 3 and lasted approximately 20 minutes. The women's volleyball and basketball teams were both given the same educational information; however, the sessions were conducted separately because their practice times differed. The educational intervention consisted of a presentation to the entire team containing information regarding the importance of hydration, negative effects of dehydration, and how to prevent dehydration. The information was based on the recommendations of the National Athletic Trainers' Association,[1] American College of Sports Medicine,[6] and American Dietetic Association,[7] which were the most current guidelines at the time of the study. Each participant was also given an summary of her own hydration status (Figure 2) from the control period, a copy of the urine color chart, and a National Collegiate Athletic Association flyer on performance hydration. The presentation included general recommendations for increasing or decreasing fluid intake based on their hydration summaries but no individualized feedback. Each person received an individual summary of hydration status with her prepractice and postpractice Usg and Ucol, as well as her average weight change during practice (pounds) and as a percentage of BM loss, average amount of fluid consumed (ounces), and average sweat losses during the preintervention practices.

Postintervention Period

The postintervention period was designed to determine the effect of the educational intervention on the participants' hydration knowledge, hydration status, and fluid intake. At the beginning of this period, the participants filled out the same questionnaire as from the preintervention period. All data-collection procedures were conducted exactly the same as during the preintervention period.

Statistical Analysis

We calculated a 1-way within-subject analysis of variance (ANOVA) with repeated measures to determine differences between the control and postintervention

Table 1. **Hydration Status, Fluid Intake, and Hydration Knowledge Before and After the Educational Intervention (Mean ± SD)**

	Urine Specific Gravity		Urine Color						
Time	Prepractice	Postpractice	Pre-practice	Post-practice	Δ Body Mass, %	Fluid Intake, mL	Sweat Rate, L/h	Fluid Replacement, %	Hydration Awareness Questionnaire Score
Preintervention	1.015 ± 0.006	1.019 ± 0.005	4 ± 1[a]	5 ± 2	−0.3 ± 0.4	575.1 ± 146.1	0.5 ± 0.2	82.8 ± 47.9	117 ± 11[a]
Postintervention	1.015 ± 0.007	1.019 ± 0.006	3 ± 1[a]	4 ± 1	−0.5 ± 0.5	591.5 ± 239.3	0.5 ± 0.2	72.9 ± 33.8	125 ± 7[a]

[a] Indicates difference between preintervention and postintervention ($P < .05$).

periods for indicators of hydration status (3-day mean of %BM lost, Usg, Ucol), fluid-intake practices (3-day mean of fluid-intake volume), and hydration knowledge (HAQ score). A 1-way ANOVA with repeated measures was computed to identify differences between prepractice and postpractice Usg and Ucol. A 1-way mixed-model ANOVA with repeated measures was performed to characterize differences in indicators of hydration status (3-day mean of %BM lost, Usg, Ucol), fluid-intake practices (3-day mean of fluid-intake volume), and hydration knowledge (HAQ score) between sports. Pearson correlations were used to determine the relationship between hydration knowledge (HAQ) and actual hydration status (Usg, Ucol, %BM loss). The data were analyzed using SPSS (version 21.0; IBM Corp), and the results were reported as mean ± SD. Given that our research question was specific to collegiate female volleyball and basketball athletes, we chose a sample of convenience. Therefore, no power analysis was performed.

RESULTS

The following analyses involved all 25 participants. Means and SDs for all dependent variables during the preintervention and post intervention periods are provided in Table 1. A decrease in prepractice Ucol ($P = .027$) and an increase in HAQ score ($P = .001$) were present after a 1-time educational intervention. No differences were found for prepractice Usg ($P = .979$), postpractice Usg ($P = .980$), postpractice Ucol ($P = .095$), BM change ($P = .068$), fluid intake ($P = .665$), sweat rate ($P = .894$), or fluid-replacement percentage ($P = .180$) after the intervention.

Prepractice to postpractice measures of Usg ($P < .001$, $P = .001$) and Ucol ($P = .001$, $P < .001$) increased in the preintervention and postintervention periods, respectively.

Means and SDs for all dependent variables by sport are shown in Table 2. No interaction was found between time period (preintervention and postintervention) and sport. Differences were demonstrated between sports for BM change ($P < .001$): basketball players experienced greater BM losses than volleyball players. Basketball players also displayed higher sweat rates ($P = .001$) and lower fluid-replacement percentages ($P = .008$) than volleyball players. No differences were present between sports for prepractice Usg ($P = .353$), postpractice Usg ($P = .063$), prepractice Ucol ($P = .871$), postpractice Ucol ($P = .761$), fluid intake ($P = .719$), or HAQ score ($P = .134$).

No significant correlations occurred between HAQ scores and indices of hydration status (Usg, Ucol, %BM change) or fluid intake (P values $> .05$). Strong positive correlations were noted between prepractice Usg and prepractice Ucol during the preintervention ($r = 0.844$, $P < .001$) and postintervention ($r = 0.930$, $P < .001$) periods. Strong positive correlations were also evident between postpractice Usg and postpractice Ucol during the preintervention ($r = 0.719$, $P < .001$) and postintervention ($r = 0.791$, $P < .001$) periods. A weak positive correlation ($r = 0.410$, $P = .042$) was present between %BM change and fluid intake during the control period.

DISCUSSION

Our purpose was to determine whether a 1-time educational intervention improved the hydration status and fluid-intake practices of collegiate female indoor volleyball and basketball players. Based on our results, these collegiate female indoor athletes appeared to have proper hydration knowledge and hydration habits to keep themselves euhydrated before, during, and after practices. Many previous researchers have focused on prepractice and pregame hydration levels because prepractice euhydration is a vital component of any athlete's hydration status. Beginning exercise in a hypohydrated state can predispose athletes to further dehydration,[26] which can negatively affect both their performance and physiological function.[15] Magal et al[12] and Thigpen et al[27] found that at least half of collegiate basketball athletes began sport participation in a

Table 2. **Assessing Hydration Status, Fluid Intake, and Hydration Knowledge By Sport Before and After the Educational Intervention (Mean ± SD)**

	Urine Specific Gravity		Urine Color						
Sport Time	Prepractice	Postpractice	Pre-practice	Post-practice	Δ Body Mass, %	Fluid Intake, mL	Sweat Rate, L/h	Fluid Replacement, %	Hydration Awareness Questionnaire Score
Volleyball (n = 15)									
Preintervention	1.013 ± 0.006	1.018 ± 0.005	4 ± 1	5 ± 1	−0.2 ± 0.4	589.66 ± 162.28	0.4 ± 0.1	98.5 ± 55.8	114 ± 11
Postintervention	1.015 ± 0.008	1.017 ± 0.006	3 ± 1	4 ± 1	−0.2 ± 0.4	555.79 ± 267.09	0.4 ± 0.1	88.4 ± 35.6	123 ± 8
Total	1.014 ± 0.007	1.017 ± 0.006	4 ± 1	5 ± 1	−0.2 ± 0.4[a]	572.73 ± 217.83	0.4 ± 0.1[a]	94.0 ± 68.7[a]	119 ± 11
Basketball (n = 10)									
Preintervention	1.017 ± 0.006	1.021 ± 0.005	4 ± 1	5 ± 2	−0.6 ± 0.3	553.35 ± 122.91	0.6 ± 0.1	59.4 ± 27.3	121 ± 8
Postintervention	1.015 ± 0.006	1.022 ± 0.004	3 ± 1	5 ± 1	−0.9 ± 0.3	645.08 ± 190.96	0.6 ± 0.1	52.3 ± 24.7	126 ± 7
Total	1.016 ± 0.006	1.021 ± 0.005	4 ± 1	5 ± 1	−0.7 ± 0.3[a]	599.22 ± 163.22	0.6 ± 0.1[a]	55.8 ± 26.0[a]	124 ± 8

[a] Indicates difference between sports ($P < .05$).

less than euhydrated state. Other investigators[8–14] observed this was also true among athletes at different levels and in different sports. During our preintervention period, 28% of participants arrived at practice in a hypohydrated state (Usg $\geq$ 1.020 and Ucol $\geq$ 4), and 44% ended practice in a hypohydrated state. This trend was stronger among the basketball athletes: 40% were hypohydrated before practice, compared with only 20% of volleyball participants. After practices, 60% of basketball athletes were hypohydrated versus only 33% of volleyball athletes. Thus, mild hypohydration may be more prevalent among certain female athletes, specifically basketball players.

Despite these percentages, on average, our female volleyball and basketball athletes began practices in a euhydrated state (Usg $<$ 1.020 and Ucol $\leq$ 3) and ended practice in a euhydrated state. However, variability among participants was evident in prepractice Usg, Ucol, and %BM change, indicating that variability among female athletes can be quite common in a field setting and should be considered. It is important to acknowledge that in the field setting, outside factors can and will affect an individual's hydration status and to use various methods of hydration assessment.[1] Although no criterion standard exists for hydration assessment, using urinary hydration markers along with BM changes can give the clinician a better indication of the athlete's hydration status.[1,28,29] Therefore, clinicians should use individualized hydration measures and responses to educate athletes about the importance of hydration before, during, and after exercise.

Our hypothesis that a 1-time educational intervention would improve overall hydration status and fluid-intake practices was partially supported because a decrease occurred in prepractice Ucol during the postintervention period. Previous researchers[9,17,23] demonstrated that a Ucol chart may be an effective educational tool because athletes are able to judge their hydration level by comparing their Ucol with the chart, allowing them to adjust their behaviors to improve their Ucol. Although Ucol may be affected by certain vitamins or supplements, it is a valuable tool that can be used effectively by many, particularly in combination with BM loss. Urine color is a clinically applicable measure that can be assessed in a matter of seconds in the field, which makes these findings noteworthy. In addition, HAQ scores were higher after the educational intervention, which indicates an increase in the participants' hydration knowledge. Despite this, postpractice Ucol, prepractice Usg, postpractice Usg, %BM change, and fluid intake did not improve. Thus, even though their hydration knowledge increased, the participants did not drastically change their hydration habits, probably because they had good initial knowledge of hydration, as indicated by a 90% HAQ score during the preintervention period. These results contrast with those of earlier investigators who observed that collegiate athletes lacked proper hydration knowledge. Sobana and Many[24] and Torres-McGehee et al[30] reported knowledge scores of $<$55% and Nichols et al[31] noted an average of 81.7%. The former also demonstrated a significant positive correlation among knowledge, attitude, and behavior, which could suggest that the more knowledge athletes have, the better their hydration practices and status will be. To examine this possibility further, Decher et al[16] incorporated hydration-status assessment when studying the relationship between hydration knowledge and behaviors in youth athletes. Their participants were mildly to severely dehydrated, even though they demonstrated a good knowledge of hydration. Similarly, we identified no significant correlation between hydration knowledge and indices of hydration (Usg, Ucol, %BM loss) and fluid intake. No previous researchers have assessed hydration knowledge in combination with specific measures of hydration status in collegiate female indoor-sport athletes, especially in volleyball and basketball. However, past results from collegiate outdoor-sport athletes displayed inconsistencies between hydration knowledge and hydration behaviors.[30,31]

A notable unexpected finding in our study was that multiple individuals were drinking more fluids than necessary and gaining weight during practices. Hyperhydration can lead to *EAH*, which is defined as an abnormally low serum or plasma sodium concentration (typically $<$135 mmol/L).[32] This is often caused by excessive fluid intake compared with sweat losses and can lead to serious symptoms and even death.[32] Athletes who drink excessively during exercise could be at risk for EAH. In addition, female athletes have a higher likelihood of developing EAH.[6] This could indicate a risk of hyponatremia in this population, specifically volleyball athletes, because multiple participants gained weight during practices.

During the educational intervention, participants were given a written summary of their hydration measures (ie, Ucol and Usg) along with average BM changes and sweat rates. During the control period, no single athlete had a 3-day mean BM loss of $>$2%. The intervention included general recommendations about how participants should increase or decrease their fluid intake based on the measures in their hydration summaries. Three basketball athletes and 2 volleyball athletes who began the study displaying less than optimal hydration markers during the control period showed overall improvement in prepractice and postpractice hydration measures after the intervention. Six individuals gained weight during the control period; although the educational session included information about avoiding hyperhydration, their behaviors did not change, and weight gain continued in the ensuing practices. It is important to recognize, though, that we did not assess the participants' blood sodium levels. Therefore, whether they were hyponatremic at any point during the study is unknown. Furthermore, although certain athletes appeared to be hyperhydrating, some arrived at practice in a hypohydrated state; hence, consuming excessive fluids may have been necessary simply to regain the euhydrated state. Thus, using various hydration methods in combination is preferred over any single hydration measure.[1] These trends were not as prevalent in basketball players, given that most lost weight during practices.

Consistent with previous authors,[11,20] we showed that our athletes were able to replace enough fluids to prevent significant dehydration, although mild dehydration was still seen occasionally. The lack of improvement in BM changes after the intervention was likely due to the fact that many participants achieved adequate hydration before the intervention. Individuals still experiencing $\geq$2% BM loss were perhaps not being given enough opportunities to drink water during practices or choosing not to drink enough when given these opportunities. Although it is not unusual for an athlete to experience a BM loss during practice, it is important to acknowledge that losses >2% caused performance decrements in high-performance athletes, such as collegiate players.[1]

Differences in BM changes were present between sports throughout the study (Table 2). These likely reflected increased sweat rates and decreased fluid replacement in basketball versus volleyball athletes. The inherent differences between these sports (which we did not measure) might have also affected the sweat losses. On average, basketball athletes lost 0.7% of their BM during all practices (preintervention and postintervention), whereas volleyball athletes lost only 0.2%. This loss is not concerning for basketball players: our findings are consistent with the BM losses of ≤2% observed in collegiate and professional basketball athletes during practices and games.[22,27] The single investigation[9] of volleyball athletes was conducted on youth, who demonstrated a BM loss of 0.4% during control and 0.5% after an educational intervention, which was slightly higher than our result (0.2% loss preintervention and postintervention).

Overall, it was clear that not all of our participants needed to improve their hydration status. Those who experienced prepractice hypohydration seemed to benefit the most from the educational intervention because they decreased their Usg and Ucol during the postintervention period. This indicates that a 1-time educational intervention may be useful for individuals who need to improve their hydration status. Earlier investigations of hydration education produced conflicting outcomes. Kavouras et al[23] determined that youth athletes displayed changes in their hydration behaviors after receiving a 1-time lecture on hydration. In addition, Sobana and Many[24] assessed the effects of education in collegiate athletes (though not outdoor-sport athletes) and identified improvements in fluid-intake behaviors, as well as knowledge and attitudes on hydration. Our conclusions agree with those of Cleary et al[9] in that education alone was not enough to significantly improve indices of hydration status and fluid intake. Instead, prescribing adequate amounts of fluid specific to their sweat losses was successful in athletes.[9] Contrary to our findings, the participants in various similar studies[9,23,24] were hypohydrated before the intervention, indicating a significant need for improvement.

Practical Applications

Our female collegiate indoor-sport athletes had a very high level of knowledge of hydration and exhibited hydration behaviors that kept them euhydrated before and after practices. Accordingly, further education may have been unnecessary for the majority. However, variability was evident, as some individuals were hypohydrated before, during, and after practices. Certain athletes displayed improper hydration habits by hyperhydrating during practices. Reducing improper hydration behaviors is of the utmost importance for collegiate athletes, coaches, and athletic trainers (ATs). Hypohydration has negative effects on overall health and athletic performance, and hyperhydration and hyponatremia can be dangerous. Athletes and coaches consistently aim for high performance levels, whereas ATs are trained to emphasize the health and safety of the athlete throughout participation. Improper hydration can not only impede peak performance but also affect health and safety; thus, strategies are needed to reduce these practices by athletic populations. Coaches and ATs can use the information from this study to identify individuals who exhibit improper hydration practices and then implement educational interventions. As we noted, individuals who needed the intervention benefited and improved their hydration status. Simply monitoring BM changes and urinary measures of hydration can assist clinicians in screening athletes to identify those who may require an educational intervention.

Future researchers should consider similar variables among other indoor-sport athletes, including males. Additional educational interventions (ie, multiple sessions) or prescribed hydration protocols should also be evaluated to determine their effectiveness in combating improper hydration behaviors in collegiate indoor-sport athletes. Barriers to changes in hydration behaviors (ie, practice design, coaches' hydration knowledge) should be assessed as well. Furthermore, focusing on preventing hyperhydration and hyponatremia may be warranted.

CONCLUSIONS

These female collegiate indoor-sport athletes were generally well hydrated before, during, and after volleyball and basketball practices. Overall, they began the study with good hydration knowledge, which improved after a 1-time educational intervention. However, not all measures of hydration status improved because many participants were euhydrated before the intervention, as indicated by their urinary markers. Some individuals did experience hypohydration and benefited from hydration education by improving their hydration status. Others needed hydration education to ensure that they were not overhydrating and putting themselves at risk for hyponatremia. Overall, ATs and coaches should pay particular attention to individualizing the needs of their athletes to improve hydration in those who are hypohydrated and decrease hyperhydration in those whose fluid intake during activity is too high. Athletes who are unable to judge their fluid needs should be identified and educated on strategies for improvement.

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REFERENCES

1. McDermott BP, Anderson SA, Armstrong LE, et al. National Athletic Trainers' Association position statement: fluid replacement for the physically active. *J Athl Train*. 2017;52(9):877–895. doi:10.4085/1062-6050-52.9.02
2. D'Anci KE, Vibhakar A, Kanter JH, Mahoney CR, Taylor HA. Voluntary dehydration and cognitive performance in trained college athletes. *Percept Mot Skills*. 2009;109(1):251–269. doi:10.2466/PMS.109.1.251-269
3. Dougherty KA, Baker LB, Chow M, Kenney WL. Two percent dehydration impairs and six percent carbohydrate drink improves boys basketball skills. *Med Sci Sports Exerc*. 2006;38(9):1650–1658. doi:10.1249/01.mss.0000227640.60736.8e

4. Hayes LD, Morse CI. The effects of progressive dehydration on strength and power: is there a dose response? *Eur J Appl Physiol*. 2010;108(4):701–707. doi:10.1007/s00421-009-1288-y
5. Patel AV, Mihalik JP, Notebaert AJ, Guskiewicz KM, Prentice WE. Neuropsychological performance, postural stability, and symptoms after dehydration. *J Athl Train*. 2007;42(1):66–75.
6. Casa DJ, Clarkson PM, Roberts WO. American College of Sports Medicine roundtable on hydration and physical activity: consensus statements. *Curr Sports Med Rep*. 2005;4(3):115–127. doi:10.1097/01.csmr.0000306194.67241.76
7. Rodriguez NR, DiMarco NM, Langley S, et al. Position of the American Dietetic Association, Dietitians of Canada, and the American College of Sports Medicine: nutrition and athletic performance. *J Am Diet Assoc*. 2009;109(3):509–527. doi:10.1016/j.jada.2009.01.005
8. Arnaoutis G, Kavouras SA, Angelopoulou A, et al. Fluid balance during training in elite young athletes of different sports. *J Strength Cond Res*. 2015;29(12):3447–3452. doi:10.1519/JSC.0000000000000400
9. Cleary MA, Hetzler RK, Wasson D, Wages JJ, Stickley C, Kimura IF. Hydration behaviors before and after an educational and prescribed hydration intervention in adolescent athletes. *J Athl Train*. 2012;47(3):273–281. doi:10.4085/1062-6050-47.3.05
10. Finn JP, Wood RJ. Incidence of pre-game dehydration in athletes competing at an international event in dry tropical conditions. *Nutr Diet*. 2004;61(4):221–225.
11. Hamouti N, Del Coso J, Estevez E, Mora-Rodriquez R. Dehydration and sodium deficit during indoor practice in elite European male team players. *Eur J Sport Sci*. 2010;10(5):329–336. doi:10.1080/17461391003632022
12. Magal M, Cain RJ, Long JC, Thomas KS. Pre-practice hydration status and the effects of hydration regimen on collegiate Division III male athletes. *J Sports Sci Med*. 2015;14(1):23–28.
13. Rivera-Brown AM, De Felix-Davila RA. Hydration status in adolescent judo athletes before and after training in the heat. *Int J Sports Physiol Perform*. 2012;7(1):39–46. doi:10.1123/ijspp.7.1.39
14. Silva RP, Mundel T, Altoe JL, Saldanha MR, Ferreira FG, Marins JC. Preexercise urine specific gravity and fluid intake during one-hour running in a thermoneutral environment—a randomized cross-over study. *J Sports Sci Med*. 2010;9(3):464–471.
15. Volpe SL, Poule KA, Bland EG. Estimation of prepractice hydration status of National Collegiate Athletic Association Division I athletes. *J Athl Train*. 2009;44(6):624–629. doi:10.4085/1062-6050-44.6.624
16. Decher NR, Casa DJ, Yeargin SW, et al. Hydration status, knowledge, and behavior in youths at summer sports camps. *Int J Sports Physiol Perform*. 2008;3(3):262–278. doi:10.1123/ijspp.3.3.262
17. McDermott BP, Casa DJ, Yeargin SW, Ganio MS, Lopez RM, Mooradian EA. Hydration status, sweat rates, and rehydration education of youth football campers. *J Sport Rehabil*. 2009;18(4):535–552. doi:10.1123/jsr.18.4.535
18. Yeargin SW, Casa DJ, Judelson DA, et al. Thermoregulatory responses and hydration practices in heat-acclimatized adolescents during preseason high school football. *J Athl Train*. 2010;45(2):136–146. doi:10.4085/1062-6050-45.2.136
19. Yeargin SW, Eberman LE, Falconer S, Vaal T. Examination of baseline body mass validity across various collegiate athletic teams. *Med Sci Sports Exerc*. 2010;42(5):641.
20. Garcia-Jimenez JV, Yuste JL, Garcia-Pellicer JJ. Hydration habits of elite field futsal players during official matches: defenders and forwards. *Am J Sports Sci Med*. 2014;2(3):88–92. doi:10.12691/ajssm-2-3-4
21. Vukasinovic-Vesic M, Andjelkovic M, Stojmenovic T, Dikic N, Kostic M, Curcic D. Sweat rate and fluid intake in young elite basketball players on the Fiba Europe U20 championship. *Vojnosanit Pregl*. 2015;72(12):1063–1068. doi:10.2298/vsp140408073v
22. Osterberg KL, Horswill CA, Baker LB. Pregame urine specific gravity and fluid intake by National Basketball Association players during competition. *J Athl Train*. 2009;44(1):53–57. doi:10.4085/1062-6050-44.1.53
23. Kavouras SA, Arnaoutis G, Makrillos M, et al. Educational intervention on water intake improves hydration status and enhances exercise performance in athletic youth. *Scand J Med Sci Sports*. 2012;22(5):684–689. doi:10.1111/j.1600-0838.2011.01296.x
24. Sobana RM, Many JN. Effect of hydration education on college athletes' hydration status and KAP. *Int J Sci Res*. 2014;3(7):1654–1658.
25. Armstrong LE. *Performing in Extreme Environments*. Human Kinetics; 2000.
26. Stearns RL, Casa DJ, Lopez RM, et al. Influence of hydration status on pacing during trail running in the heat. *J Strength Cond Res*. 2009;23(9):2533–2541. doi:10.1519/JSC.0b013e3181b73c3f
27. Thigpen LK, Green JM, O'Neal EK. Hydration profile and sweat loss perception of male and female Division II basketball players during practice. *J Strength Cond Res*. 2014;28(12):3425–3431. doi:10.1519/JSC.0000000000000549
28. Armstrong LE, Maresh CM, Castellani JW, et al. Urinary indices of hydration status. *Int J Sport Nutr*. 1994;4(3):265–279. doi:10.1123/ijsn.4.3.265
29. Armstrong LE, Soto JA, Hacker FT, Casa DJ, Kavouras SA, Maresh CM. Urinary indices during dehydration, exercise, and rehydration. *Int J Sport Nutr*. 1998;8(4):345–355. doi:10.1123/ijsn.8.4.345
30. Torres-McGehee TM, Pritchett KL, Zippel D, Minton DM, Cellamare A, Sibilia M. Sports nutrition knowledge among collegiate athletes, coaches, athletic trainers, and strength and conditioning specialists. *J Athl Train*. 2012;47(2):205–211. doi:10.4085/1062-6050-47.2.205
31. Nichols PE, Jonnalagadda SS, Rosenbloom CA, Trinkaus M. Knowledge, attitudes, and behaviors regarding hydration and fluid replacement of collegiate athletes. *Int J Sport Nutr Exerc Metab*. 2005;15(5):515–527. doi:10.1123/ijsnem.15.5.515
32. Hew-Butler T, Ayus JC, Kipps C, et al. Statement of the Second International Exercise-Associated Hyponatremia Consensus Development Conference, New Zealand, 2007. *Clin J Sport Med*. 2008;18(2):111–121. doi:10.1097/JSM.0b013e318168ff31

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