Hydration Status, Sweat Rates, and Rehydration Education of Youth Football Campers

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Context: Previous field research has not identified sweat rates (SR), fluid consumption (FC), or the efficacy of an educational intervention (EI) for youth during football camp. Objective: To measure hydration status and rehydration performance and examine EI using these data. Design: Observational with EI randomized comparison. Participants: Thirty-three boys (mean ± SD: 12 ± 2 y, 52.9 ± 13.6 kg, 156 ± 12 cm) volunteered during a 5-d camp with 3 (~2-h) sessions per day (WBGT: 25.6 ± 0.5°C). Main Outcome Measures: Hydration status, SR, and FC. Results: Urine osmolality averaged 796 ± 293 mOsm/L for days 2–5. Game SR (1.30 ± 0.57 L/h) was significantly greater than practice SR (0.65 ± 0.35 L/h; P = .002). Subjects dehydrated during free time but matched fluid losses with FC (0.76 ± 0.29 L/h) during football activities. Conclusions: Subjects arrived at camp hypohydrated and maintained this condition. They matched FC and SR during, but dehydrated when not playing, football. This may impair recovery and subsequent performance. Hydration EI seemed to have a positive influence on hydration practices.

Keywords: hypohydration, fluid intake, electrolytes, sweat rate, youth sports

The hydration status of youth sports participants is an important medical component for health care professionals, coaches, parents, and athletes themselves. Fluid replacement and maintenance of a healthy hydration status provide a positive environment for youth to perform optimally and prevent illness.¹,² Hydration recommendations for athletes of all ages have been published by experts of the National Athletic Trainers’ Association³ and the American College of Sports Medicine.⁴ These represent the most conclusive and specific recommendations to date based on available research. Rehydration is an important factor in maintain-
ing hydration status, facilitating recovery, and optimizing body regulatory factors.\textsuperscript{1–4} A common focus of published recommendations is the importance of consuming fluids before, during, and after activities for all ages and exercise intensities. Another prevalent recommendation is to ensure that sodium and energy levels are balanced.

A large majority of hydration research has focused on adult athletes or those with a specific illness. However, some work has been completed with youth in a laboratory setting.\textsuperscript{1,5–11} Research with subjects age 10 to 12 years in a climatic chamber resulted in voluntary hypohydration when participants were provided fluids ad libitum, as opposed to forced fluids.\textsuperscript{5} Another study found similar results with high school football players during preseason practices.\textsuperscript{12} Other researchers using simulated or laboratory conditions have reported that adolescents and youth prefer sports drinks and attenuate sweat losses when these are provided but dehydrate when they are not.\textsuperscript{9,11,13,14} Limited research regarding youth, adolescent, and college athletes at sports camps has reported maintained hypohydration throughout camp.\textsuperscript{12,15–17}

Sweat rates and voluntary fluid consumption have been reported with various age groups, including youth.\textsuperscript{2,5,7,9–13,15–19} Falk et al\textsuperscript{6} reported developmental changes wherein there was an increased sweat rate per gland overall. Evaporative heat losses improve with maturation. Research has not been reported on youth football sweat rates and fluids consumed at summer camps. Previous studies are limited in their results because they have not identified when during development heat dissipation improves to its maximum.

Regarding hydration knowledge and practices, only adolescents and adults have been a focus in preceding studies. Nichols et al\textsuperscript{19} and Jonnalagadda et al\textsuperscript{18} conducted surveys of college athletes assessing knowledge, attitudes, and behaviors regarding hydration. The first of these reports showed a gap between knowledge, attitudes, and behaviors, meaning that athletes may have been aware that dehydration decreases performance, but their behavior did not always reflect that knowledge.\textsuperscript{19} Jonnalagadda et al\textsuperscript{18} reported that 29\% of respondents incorrectly indicated that thirst was an accurate hydration measure during and after activity. These authors concluded that specific areas of misinformation continue to be perpetuated and recommended nutrition education for athletes. The sources and timing of acquisition of hydration misinformation have yet to be identified. Youth athletes remain a target of advertising for a variety of companies. Researchers suggested that a rehydration strategy attenuated decreases in body weight and urine specific gravity (U\textsubscript{SG}) with adolescents.\textsuperscript{12} This highlights the importance of potentially targeting a younger audience with an educational intervention (EI) to avert misguided practices in the future. We do not know if educating youth on hydration indices, perceptions of thirst, and sweat rate helps separate fact from preconceived ideas regarding hydration. There is a void in the existing literature regarding youth hydration knowledge and habits, as well as an evaluation of an EI targeting this age group.

Previous studies have not reported youth sweat electrolyte concentrations of participants in a field setting. Sweat electrolyte concentrations may play a role in dietary and fluid recommendations for youth sport participants in the future and should be known.
To address the current gaps in the literature regarding youth football athletes, the purposes of this study were to (1) observe hydration status, sweat rates, fluid consumption, rehydration strategies, forearm sweat Na\(^+\) and K\(^+\), youth thirst perceptions, heat-associated symptoms, ratings of perceived exertion (RPE), and hydration knowledge and habits of football campers over the course of a privately run full-contact camp during the summer months and (2) preliminarily examine the effectiveness of an EI using individual hydration status and fluid loss measures.

**Methods**

All subjects were approached during camp registration to determine their interest in participating in the study. Subjects and guardians were made aware of the procedures involved, informational questions were answered, and a University of Connecticut IRB–approved informed-consent form was signed. Subjects then filled out a demographic information form to document recent exercise, heat illness and medical history, and years of football experience. A total of 40 subjects were initially recruited for participation in the study. Seven provided incomplete data or decided not to participate, bringing our final subject number to 33. Subject demographics for the 33 completed subjects were 12 ± 2 years, 52.9 ± 13.6 kg, and 156 ± 12 cm. It was not feasible to assess more subjects, given the design and variables collected for this study. Subjects completed a morning, afternoon, and evening session daily, which all lasted ~2 hours in length. They wore a football helmet, shoulder pads, mesh jersey, football pants, full pads, and cleats for all practices and games. Games occurred during selected afternoon and evening sessions only.

A small urine sample was obtained from subjects at camp registration to determine baseline hydration status.\(^{20,21}\) Thereafter, each day before breakfast (AM) and dinner (PM), subjects provided a urine sample. Hydration status was assessed after urine collection by measuring urine color\(^{20}\) (U\(_{\text{Col}}\)), U\(_{\text{SG}}\) (Model A300CL, Spartan Refractometers, Japan), and urine osmolality (U\(_{\text{Osm}}\); Model 3DII, Advanced Instruments, Inc, Needham Heights, MA). Urine analysis took place at a local, temporary laboratory, to which urine samples were immediately transported in labeled urine cups. Total transport time was estimated at ~10 min. An overall hydration status was determined via changes in body mass (Model BWB-800A, Tanita Corp, Tokyo, Japan). Body mass was measured at AM and PM time points daily to assess overall changes in hydration status. All AM and PM body-mass measures were taken while subjects wore only lightweight shorts and underwear.

Sweat rates were measured at select practice sessions by subtracting postactivity from preactivity body mass and accounting for fluid consumed and urine volume. Body-mass measures both before and after practice were obtained with subjects wearing only football pants and undergarments (no shirts, shoes, socks, or footwear). After activities, subjects wiped visible sweat off with their own shirts or towels before body-mass assessment. Fluid consumption was measured during activity by first ensuring that subjects began exercise sessions with a container full of a fluid of their choice. Each subject was given a numbered water...
bottle at the beginning of each session, with which fluid consumed was measured. Subjects were instructed to drink ad libitum until the entire container was empty and to fill it completely before drinking from it again. They were instructed not to pour any fluid from the container on their head, ground, body, or friends. When possible, a researcher was present at water stations to ensure that only study subjects consumed fluids from labeled containers and that no fluid was poured out of the containers unless consumed by subjects. Researchers did not note any non-compliance with fluid-consumption measures on the part of subjects or other campers. On completion of activity, subjects reported to researchers located adjacent to the field with their fluid containers. At this time, the remainder of fluid in the bottles was measured with a graduated cylinder to assess total fluid consumed for that session. Fluid-consumption rate was calculated by dividing total fluid consumed by activity time.

Before select practices, subjects’ right forearms were rinsed with distilled water and gauze to remove oil and sediment. An absorbent sweat patch (PharmChem, Inc, Haltom City, TX) was then applied to the forearm. During activity, sweat patches were removed when saturated (after ~30 minutes of activity) and immediately placed in a sealed, sterile vial. All sweat samples were then sent to a remote laboratory for analysis. Samples were centrifuged at the laboratory to extract fluid from the patch for analysis. Sweat samples were analyzed via flame photometry (Instrumentation Laboratory, IL943, Lexington, MA) to determine forearm sweat Na\(^+\) and K\(^+\) in triplicate. This method of measuring sweat electrolyte concentrations is accepted as an accurate assessment of local sweat electrolyte concentration.\(^{22,23}\)

Thirst was measured via a 9-point visible scale with verbal anchors ranging from 1 (not thirsty at all) to 9 (very, very thirsty).\(^{24}\) Thermal sensations were self-reported based on a 17-point scale ranging from 0.0 (unbearably cold) to 8.0 (unbearably hot) with 0.5 point increments.\(^{25}\) RPE measures were obtained using the 15-point RPE scale ranging from 6 (less than very, very light exertion) to 20 (beyond very, very hard exertion).\(^{26}\) These measures were assessed at AM and PM time points and before and after select football sessions. A 14-question modified Environmental Symptoms Questionnaire\(^{27,28}\) (ESQ) was given to subjects at registration and during AM and PM measures daily throughout camp. The brief ESQ has been previously validated.\(^{28}\)

Hydration-awareness and hydration-habits questionnaires were used to assess knowledge and habits of youth sports participants. These questionnaires were given at camp registration and AM on day 5 to establish precamp versus postcamp differences. The hydration-awareness questionnaire is composed of 16 items regarding hydration indices and knowledge. This questionnaire’s score can be totaled at the conclusion because all questions are on a Likert-type scale and are scored out of 10 (total score out of 160). The hydration-habits questionnaire is used to identify hydration/rehydration practices and includes 7 Likert-scale and open-ended questions. At the conclusion of camp, an exit questionnaire was given to subjects to identify barriers to hydration during camp and for self-assessment of their hydration performance. The exit questionnaire also includes both Likert-scale and open-ended questions. The awareness questionnaire has been previously validated by an expert panel and factor analysis.\(^{15}\)
Subjects were stratified for age and football experience, then assigned to either an EI or no-intervention (NI) group. The EI was conducted by a research assistant and took place on days 2, 3, and 4 just after dinner in groups of 2 or 3. It consisted of 4 to 8 minutes of discussing hydration importance, hydration indices (urine color and thirst), and strategies for improving hydration status before, during, and after activity. For example, the first EI session consisted of assessing subjects’ knowledge of hydration indices and common signs and symptoms of dehydration. Subsequent EI sessions included personal data on fluid consumed and sweat rate to help youth quantify their fluid requirements for maintaining hydration status. At the conclusion of every EI session, subjects were asked to give specific examples of how and when they planned to improve their hydration measures for subsequent days, if needed. Subjects came up with their own plans, and researchers did not attempt to influence them on fluid choices (water, sport drink, fruit juice, etc).

Weather conditions for the duration of football activities at camp averaged 25.8°C ± 0.9°C dry bulb, 25.6°C ± 0.5°C wet-bulb globe temperature, with 70% ± 13% relative humidity.

**Data Analysis**

Descriptive statistics were calculated using standard techniques for mean ± SD. Comparisons were made using repeated-measures ANOVA for time-point differences in the EI and NI groups, as well as precamp versus postcamp differences on questionnaires. Follow-up post hoc t-tests with appropriate Bonferroni corrections confirmed time-point and precamp versus postcamp differences. Pearson r correlations were calculated to compare relations between select variables. To identify significant differences in answers on the awareness, habits, and exit questionnaires, answers of 7 to 10 were assigned as “agree,” answers of 1 to 3 were assigned “disagree,” and answers of 4 to 6 were assigned as “neutral.” A χ² analysis was then conducted to identify percentage differences between groups or over time. Significance was set at P < .05 for all statistical tests.

**Results**

**Hydration Status**

There was a main-effect difference in U_{Col} over time (P < .001; η_p² = .267). U_{Col} for day 4 PM (D4 PM) was significantly less than for D1 PM, D2 AM, D3 AM, D4 AM, and D5 AM (P ≤ .002). D2 AM U_{Col} was significantly greater than at D2 PM, D3 AM, D3 PM, and D4 PM (P ≤ .018). D4 PM U_{SG} was significantly less than at D1 PM (P = .005) and D2 AM (P = .015) but was not significantly different from other time points. Overall U_{Osm} values are shown in Figure 1. AM U_{SG} and U_{Osm} values were significantly greater than PM values (P < .05). U_{SG} values and U_{Osm} were significantly correlated (r = .964, P < .001). There was no significant difference in baseline body mass between NI and EI groups (P = .578). There was a significant difference in overall weight shifts between NI and EI when comparing PM with AM losses in mass (P = .010), with NI demonstrating greater body-mass losses.
Figure 1 — Urine osmolality values. D1 = day 1, etc. *D4 PM values were significantly less than D1 PM ($P = .032$). There was a moderate amount of variability ($\eta^2 = .128$) explained with this variable.
Sweat Rates and Fluid Consumption

There were no significant differences between average sweat rate of the NI and EI groups ($P = .307$), with an overall average of $0.78 \pm 0.35 \text{ L/h}$. There was a significant difference between sweat rate during games ($1.30 \pm 0.57 \text{ L/h}$) and practices ($0.65 \pm 0.35 \text{ L/h}; P = .002$; Figure 2). Sweat rates were significantly correlated with baseline body mass (Figure 3). Fluid consumed during football activities did not significantly differ between NI ($0.76 \pm 0.30 \text{ L/h}$) and EI ($0.76 \pm 0.26 \text{ L/h}; P > .05$). Half the subjects consumed more than they lost to sweat, and half dehydrated during activities (Figure 4).

Sweat Electrolytes

There were no statistical differences between NI and EI groups in forearm sweat Na$^+$ ($P = .567$) or K$^+$ ($P = .530$) concentrations. Average forearm sweat Na$^+$ was $32.1 \pm 14.7 \text{ mEq/L}$, and forearm sweat K$^+$ was $8.0 \pm 3.0 \text{ mEq/L}$ (see Figure 5).

Perceptual Measures of Hydration and the Environment

There was a main-effect significant difference in thirst ratings over time ($\eta_p[\eta^2] = .155$). Thirst at D4 AM was significantly less than at D2 PM and D4 PM over the course of camp ($P < .009$). There were no significant differences between NI and EI groups in thirst ratings ($P = .161; \eta_p[\eta^2] = .087$). Thirst responses were not correlated with $U_{\text{Osm}}$ ($r = .04, P > .05$) across EI or NI. Thermal sensation ratings showed a gradual decreasing trend after D3 AM, but differences were not significant between time points ($P > .378$). There were no significant differences between the NI and EI groups in thermal sensations throughout the week of camp ($P = .222; \eta_p[\eta^2] = .059$). RPEs were higher during game activities ($19 \pm 2$) than during practices ($16 \pm 2; P < .05$). RPEs were significantly greater at PM than the AM values ($P \leq .05$). There were no significant differences in RPE between NI and EI groups ($P = .869; \eta_p[\eta^2] = .005$). There was a decreasing trend in ESQ scores as the week progressed from D2 AM (Figure 6).

Hydration Knowledge and Habits

A significant number of campers wished they could have increased fluid consumption during camp ($P = .008$). The Hydration Awareness Questionnaire revealed that a significant number of campers believed that a darker $U_{\text{Col}}$ indicated dehydration precamp and postcamp ($P < .001$). Subjects commonly reported crowded water stations and coaches as hindrances to drinking at camp. Hydration Awareness Questionnaire total scores did not differ precamp to postcamp or between EI and NI ($P > .05$). A significant number of subjects agreed it was important to drink before (93%), during (98%), and after (85%) football activities before camp, with no significant differences between groups or over time ($P > .05; \eta_p[\eta^2] = .215$). A significant number of campers reported that adequate hydration decreases the chances of suffering a heat illness, independent of group assignment or time ($P < .001$). When surveyed for fluid sources, 63% and 54% reported a water bottle from home and team cooler, respectively. The exit questionnaire self-assessment question asking youth how they performed in maintaining their hydration status throughout camp was significantly correlated with $U_{\text{Osm}}$ for the week (Figure 7).
Figure 2 — Sweat rate and fluid consumed for practice versus game activities. Sweat rates were significantly greater in games than in practice activities ($P = .002$). Fluid consumption did not vary significantly between practices and games ($P > .05$).
Figure 3 — Sweat rate and baseline body mass. Sweat rate was significantly correlated with baseline body mass ($r = .630$, $P < .001$).
Figure 4 — Relationship between fluid consumption and sweat rate. A reference line marks a 1:1 ratio between sweat rate and fluid consumption. A mark above the line indicates a subject who did not replace sweat losses with fluid consumption. A mark below the line identifies a subject who consumed more fluid than was lost to sweat. A mark on the line indicates a subject who matched sweat losses exactly with the amount of fluid consumed. Average sweat rate and fluid consumed were not significantly correlated throughout camp ($r = .200, P = .256$).
Figure 5 — Forearm sweat Na⁺ and K⁺ for youth football campers. Average forearm sweat Na⁺ was 32.1 ± 14.7 mEq/L, and K⁺ was 8.0 ± 3.0 mEq/L, as labeled. There were no significant differences between groups or over time (P > .05).
Figure 6 — Scores on the modified Environmental Symptoms Questionnaire. There was a decreasing trend over time without significant difference between groups ($P > .05$). The effect size for this trend was very large, $\eta^2 = .254$. D1 = day 1, etc; NI = no intervention; EI = educational intervention.
Figure 7 — Perceived hydration performance and urine osmolality. There was a significant correlation between subjects’ response to the question “How well did you do this week at maintaining your hydration status?” and urine osmolality ($r = -0.449$, $P = .009$).
Discussion

We sought to observe and record many hydration variables of youth during football camp during the summer months. This is the first study to report many of these variables in this particular setting with youth ages 9 to 15 years. Based on $U_{\text{Osm}}$ results, subjects reported to camp in a hypohydrated state and remained hypohydrated throughout camp. Participants’ sweat rates were greater in games than in practices, and this was not attenuated by increased fluid consumption. It is interesting that youth were knowledgeable regarding their hydration habits and accurate in their hydration-performance self-assessment. Moreover, EI subjects were somewhat effective in reducing ESQ scores, but this was not significant in other measures over NI. The major finding associated with our data suggests that youth are most likely unable to accomplish their best because of hypohydration, limiting exercise recovery and performance throughout camp.

Hydration Status

We tracked body-mass changes over time and urinary measures to assess the hydration status of youth football campers. We found that participants arrived at camp hypohydrated based on $U_{\text{Osm}}$ and that this condition did not worsen throughout camp. Clinical significance for $U_{\text{Osm}}$ was further supported with our calculated moderate effect size. Maintenance of hydration status throughout camp is similar to previous work including ad libitum fluid consumption and suggests that athletes of all ages voluntarily remain hypohydrated over time when consistently participating in strenuous exercise in the heat.

Previous research with adolescent and youth athletes reported urine hydration indices of $U_{\text{Col}}$ and $U_{\text{SG}}$. We found that $U_{\text{SG}}$ and $U_{\text{Osm}}$ were closely matched ($r = .964$). Recently, researchers have claimed that $U_{\text{SG}}$ should not be used as a hydration index because of the influence of supplement usage and proteinuria. Our results suggest that, in football players age 9 to 15 years, $U_{\text{SG}}$ is a valid measure of hydration status.

When tracking body-mass changes over time, we compared subsequent values with a single baseline measure obtained at camp registration. This provides valuable information regarding weight maintenance over time. The youth studied here maintained their mass over the course of 5 days of football camp. The lack of significant changes in body mass suggests that their original hydration status was maintained throughout camp. The slight variations observed were most likely results of environmental and exercise-intensity variations throughout the week.

The EI group showed a more favorable maintenance of body mass when we compared PM with AM changes than the NI group. This suggests that between dinner and breakfast, both during and after the evening session, the EI group increased fluid consumption. However, we were unable to quantify fluid consumed because the campers were on their own in dormitories during this time. The EI could be used during future camps to increase awareness of the importance of rehydration for recovery. Our findings regarding body-mass changes showed that the EI group lost less body mass between PM and AM than did the NI group, although our effect size was small in this case. Our findings are in agreement with those of Stover et al, who reported a favorable attenuation of $U_{\text{SG}}$ when a similar
EI was used with high school football players. A focus of the EI was to allow subjects to develop their own rehydration plan to maintain hydration status throughout the week. Researchers did not attempt to influence rehydration fluid choices. The maintenance of mass from PM to AM suggests that the EI seemed effective at altering hydration behaviors and increasing fluid consumption outside of activities. Future research is warranted to further examine a hydration EI with youth.

**Sweat Rate and Fluid Consumption**

Balancing fluid intake with fluid losses can be difficult for any athlete. The subjects in the current study wore a full football uniform for every exercise session. We found that children replaced their fluid losses during practice but were unable to do so during games. Possible explanations for this include self-selected increased exercise intensity, lack of focus on hydration, and increased work-to-rest ratio during games when compared with practices. Although these were observed but not recorded in this study, we assume that they played a role in the increased sweat rate and relatively unchecked drinking behavior during games. Previous research has not compared differences in this manner, so this unique finding may influence coach or parent impact on youth hydration habits in the future. Our results for sweat rates during practices are lower than in previous reports with youth athletes.\(^5\text{-}^{10,12}\) We believe that this is a result of how hard athletes were working during practices when compared with games. Our RPE values were significantly higher during games than during practices.

**Sweat Electrolytes**

This is the first field study to observe youth football players’ Na\(^+\) and K\(^+\). Previous studies in a climatic chamber have reported sweat electrolyte concentrations regarding developmental changes.\(^6,8\) Those authors reported increases in sweat Na\(^+\) based on a progression through puberty and adolescence. Normal forearm sweat electrolyte concentrations reported for adults are 42.2 ± 25.8 and 5.93 ± 1.30 mmol/L for Na\(^+\) and K\(^+\), respectively.\(^27\) Although no age differences were examined in the current study, our results show a variable forearm sweat Na\(^+\) for athletes age 9 to 15 years. Sweat K\(^+\) values were consistent with previous reports that this value slightly decreases with age.\(^2,8,17\) Our sweat K\(^+\) values are greater than published adult values,\(^27\) which is similar to preceding study reports.\(^8,17\)

**Perceptual Measures of Hydration and the Environment**

Thirst sensations were decreased on D4 AM when compared with other time points, with a moderate effect size. This suggests a possible attenuation of hypohydration sensitivity over time. Hydration-status measures were not matched with perceptions of thirst. Thirst perception may not be a valid indicator for youth exercising intermittently throughout consecutive days. The EI seemed to heighten youth perceptions of thirst. There was not a significant difference, but this may be clinically relevant because an increased awareness could help optimize rehydration practices.
We used a previously validated modified ESQ to document environment and dehydration symptoms during the week of camp. ESQ responses decreased sooner in the EI group than in NI. This suggests clinical relevance of the EI for youth football players, although we found no significant differences and a large effect size. Those who maintain hydration status should show a decreased ESQ score. Subjects were more aware of their environmental symptoms and made attempts to offset sweat production with fluids consumed. However, we did not find a change in drinking between EI and NI groups. Previous studies have focused on overall ESQ changes from prepractice to postpractices and reported no differences. Future research should observe similar measures to identify the practical nature of an EI.

Hydration Knowledge and Habits

Hydration knowledge and habits have been studied in college athletes. We sought to identify hydration misinformation and deficient hydration practices at the youth level. Our results suggest that most youth could identify the hydration-status indicator of $U_{\text{Col}}$ and rehydration timing before camp. Overall Hydration Awareness Questionnaire and Hydration Habits Questionnaire responses increased during camp, regardless of group. Youth showed that they understand the importance of maintaining hydration to avoid heat illness and performance decrements. This suggests that at some point during puberty or adolescence, a misunderstanding of the importance of hydration develops. Hindrances to hydration noted by campers included an absence of breaks during practice sessions and crowded water stations. It remains important to continue positive education of youth and pubertal athletes, coaches, and parents so that the possibility of acquiring misinformation decreases.

To assess whether subjects could accurately judge how well they maintained their hydration status throughout the week, the exit questionnaire asked a self-assessment question. The answers were significantly correlated with $U_{\text{Osm}}$ for the week. This demonstrates a moderate relationship between youth hydration status and their knowledge of how well they thought they were hydrating. This is consistent with previous reports of a similar comparison. Youth knew how well they did at maintaining their hydration status during camp.

Limitations

This observational field study is the first to report many variables related to youth football camper hydration status, knowledge, and habits. The observational methods of this study limit the strength of conclusions that can be drawn from results. First, our sweat-rate data were calculated from body masses when youth were wearing football pants. Ideally, body mass should be collected with subjects in the nude after having toweled off. This was not possible with youth in a field setting. However, with the exact methods used, our sweat rates for games are very similar to previous reports. Second, the accepted method for measuring sweat electrolyte concentrations is a whole-body wash-down procedure. Again, this was impossible with our subject pool, and our results provide local sweat electrolyte concentrations. Third, the EI’s effectiveness was only tested during practice con-
ditions and showed no significant changes. We were unable to quantify fluid consumption after dinner, before breakfast, or with meals to identify hydration-behavior changes outside of football activities. Finally, our subject pool was relatively small (N = 33), but the feasibility of these methods would have been questionable given more participants. Future studies conducted in either laboratory or field settings should seek to quantify some of the variables introduced in this project.

Conclusion

Subjects arrived at camp and maintained a hypohydrated state for a 5-day football camp including 3 sessions a day. They matched fluid consumption and sweat rate during activities but did not prevent hypohydration outside of practices and games. Youth understood that hydration indices and rehydration timing are important factors in their hydration status. An EI focusing on the importance of hydration status and maintenance provided youth with important information. Whether this helped them maintain their hydration has yet to be determined and requires future attention.

References