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Ad Libitum Fluid Consumption via Self- or External Administration

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Context: During team athletic events, athletic trainers commonly provide fluids with water bottles. When a limited number of water bottles exist, various techniques are used to deliver fluids.

Objective: To determine whether fluid delivered via water-bottle administration influenced fluid consumption and hydration status.

Design: Crossover study.

Setting: Outdoor field (22.2°C ± 3.5°C).

Patients or Other Participants: Nineteen participants (14 men, 5 women, age = 30 ± 10 years, height = 176 ± 8 cm, mass = 72.5 ± 10 kg) were recruited from the university and local running clubs.

Intervention(s): The independent variable was fluid delivery with 3 levels: self-administration with mouth-to-bottle direct contact (SA-DC), self-administration with no contact between mouth and bottle (SA-NC), and external administration with no contact between the mouth and the bottle (EA-NC). Participants warmed up for 10 minutes before completing 5 exercise stations, after which an ad libitum fluid break was given, for a total of 6 breaks.

Main Outcome Measure(s): We measured the fluid variables of total volume consumed, total number of squirts, and average volume per squirt. Hydration status via urine osmolality and body-mass loss, and perceptual variables for thirst and fullness were recorded. We calculated repeated-measures analyses of variance to assess hydration status, fluid variables, and perceptual measures to analyze conditions across time.

Results: The total volume consumed for EA-NC was lower than for SA-DC ($P = .001$) and SA-NC ($P = .001$). The total number of squirts for SA-DC was lower than for SA-NC ($P = .009$). The average volume per squirt for EA-NC was lower than for SA-DC ($P = .020$) and SA-NC ($P = .009$). Participants arrived (601.0 ± 21.3 mOsm/L) and remained (622.3 ± 38.3 mOsm/L) hydrated, with no difference between conditions ($P = .544$); however, the EA-NC condition lost more body mass than did the SA-DC condition ($P = .001$). There was no main effect for condition on thirst ($P = .147$) or fullness ($P = .475$).

Conclusions: External administration of fluid decreased total volume consumed via a decreased average volume per squirt. The SA-DC method requires fewer squirts within a specific time frame. Fluid breaks every 15 minutes resulted in maintenance of euhydration; however, loss of body mass was influenced by fluid administration. Athletic trainers should avoid external administration to promote positive hydration behaviors. When fluid is self-administered, individual bottles may be the best clinical practice because more volume can be consumed per squirt.

Key Words: hydration, water bottles, fluid breaks, disease transmission

Key Points

- External administration of fluid, with the mouth not contacting the bottle, resulted in less fluid being consumed. Clinicians should not hold and squirt water bottles for athletes.
- Self-administration of fluid, whether the mouth was or was not in direct contact with the bottle, promoted adequate fluid consumption.
- Self-administration of fluid with the mouth in direct contact with the bottle requires fewer squirts and supplied more volume per squirt and is, therefore, the best clinical practice to encourage appropriate fluid consumption.

Factors underlying exertional heat illnesses include exercising in a hypohydrated state, cardiovascular fitness, degree of heat acclimatization, somatotype, sweat rate, sweat profile, and equipment requirements, as well as duration and intensity of play.[1–3] Although many factors may predispose an individual to develop an exertional heat illness, exercising in a hypohydrated state compromises the thermoregulatory system, whereas excessive hydration can threaten the central nervous system. Adequate hydration is vital for optimal heat exchange and maintaining physical performance while avoiding the dangers of hyponatremia.[2]

The effects of hydration fluid characteristics, such as fluid temperature and flavoring, on ad libitum consumption and hydration status have been evaluated in seminal studies,[4–7] leading to a variety of marketing and clinical applications, such as fluid containers, beverage flavoring, and accessibility. Accessibility or proximity of the fluid source to the athlete or participant has been explored preliminarily,[8–11] with results indicating that distance from the individual may have an effect on consumption. Additionally, various prescribed hydration interventions, such as education,[12,13] precalculated amounts of fluids based on sweat rate,[12] and distribution of guidelines,[14] have been examined in different active populations, demonstrating success in minimizing significant hypohydration. Lastly, hydration behaviors, including average fluid intake surrounding exercise, in a variety of sport populations[10,15–18] have been identified as concerns; pressuring from coaches can compromise the optimal environment to promote adequate fluid consumption.

Although a variety of hydration concerns occur in athletes, hypohydration before, during, or after exercise (or a combination of these) is common among team-sport athletes, including those in football,[10,15,19] soccer,[20–22] and cross-country,[23] and may be linked to the efficiency of the hydration delivery mechanism. Secondary administration of fluids (eg, an athletic trainer squirting fluid from a water bottle) is frequently used to ensure delivery to many athletes during short practice and play breaks. This method is preferred because it is cost-effective compared with handing water bottles to individual players and is more hygienic than self-administration of fluid from communal bottles. What remains unclear is how the secondary administration of fluids compares with other intake mechanisms and if any of these other mechanisms are sufficient to minimize hypohydration. Therefore, the purpose of our study was to investigate the effect of a fluid-administration intervention on fluid consumption, hydration status, and perceptual feelings of thirst and fullness. We hypothesized that (1) self-administration with mouth-to-bottle direct contact (SA-DC) would result in the consumption of more fluids than self-administration with no mouth-to-bottle contact (SA-NC), which itself would result in more fluid consumption than external administration with no mouth-to-bottle contact (EA-NC); (2) EA-NC administration would result in hypohydration; and (3) EA-NC administration would be related to feeling more thirsty and less full than SA-DC or SA-NC administration.

METHODS

Experimental Design

A randomized crossover study design was used to determine the effect of fluid administration on fluid consumption, hydration status, and thirst perception during a bout of exercise. Fluid administration was the independent variable, with 3 levels: SA-DC (ie, squirting the water bottle for oneself as the water-bottle dispenser makes contact with the mouth); SA-NC (ie, squirting for oneself but keeping the water bottle 1–3 in [2.54–7.62 cm] away from the mouth, so that the mouth did not make contact with the dispenser), and EA-NC (ie, someone else squirting for the participant and keeping the water bottle 1–3 in away from the participant's mouth, so that the mouth did not make contact with the dispenser). Participants requested fluids either verbally or via body language (eg, chin elevated) in the EA-NC condition. Only 1 squirt at a time was provided by the research assistant. If the participant wanted additional squirts, he or she was required to request more after each squirt. A *squirt* represented the water dispensed once the research assistant's hand pressed the water bottle and after the water pressure decreased and an additional squeeze was needed. Participants experienced all 3 conditions (Figure 1) in random order on different days ($\leq$4 days between conditions). The research setting was a local township park, with data-collection sessions scheduled by the researchers.

Dependent variables for fluid consumption consisted of volume consumed per fluid break (VC/FLB), number of squirts per fluid break (Sq/FLB), squirt volume per fluid break, total number of squirts (TSq), total volume consumed (TVC), and average volume per squirt (AVSq). Hydration measures were urine osmolality, urine specific gravity, body-mass loss (BML), sweat loss, and sweat rate. Thirst and fullness were the perceptual variables evaluated by visual scale.

Participants

A total of 19 recreationally active individuals (14 men, 5 women, age = 30 $\pm$ 10 years, height = 176 $\pm$ 8 cm, mass = 72.5 $\pm$ 10 kg) from the local university and running club volunteered to participate. Volunteers were between the ages of 18 and 50 years and exercised regularly ($\geq$4 hours a week) for at least 6 months before testing. Individuals meeting these criteria completed a self-administered baseline health history questionnaire; exclusion criteria were a history of heat illness within the last 12 months or a current orthopaedic injury.

Instrumentation and Measurements

Fluid-Consumption Variables. To monitor VC, we assigned individual 1-L water bottles (Gatorade Inc, Chicago, IL) to each participant. The water bottle had a dispenser centered on the removable lid with a 1-way valve. Each water bottle was labeled with the same number given to the participant during the familiarization meeting. Before the FLB, each water bottle was filled to the 1-L mark (ie, level with the cap opening of the water bottle). At the completion of the FLB, we retrieved each water bottle. A 1000-mL measuring cup in 10-mL increments was used to record the fluid remaining in each water bottle, which was subtracted from 1000 mL to calculate the VC. To determine the number of squirts used by participants during the FLB, we assigned a research assistant to each exercise station. During the FLB, we recorded the number of squirts each individual received (SA-NC and EA-NC) by counting the visible squirts leaving the dispenser. For SA-DC, squirts were recorded by counting the number of hand squeezes used by the participant.

Applying the VC and the number of squirts, we calculated the following variables: (1) volume per squirt per condition by FLB, (2) TSq, (3) TVC, and (4) AVSq.

Hydration Variables. Urine osmolality was measured using a freezing-point depression osmometer (model 3320; Advanced Instruments Inc, Norwood, MA), which was calibrated before each data-collection session per the manufacturer's instructions. Each sample was tested in duplicate, but if the results were greater than 5 mOsm apart, we analyzed the sample in triplicate. The mean of the 2 results was used for analysis.[24] To measure urine specific gravity, a clinical refractometer (model A300CL; ATAGO Inc, Bellevue, WA) was used to analyze samples.[24] The refractometer was calibrated before each data-collection session per the manufacturer's instructions. A scale (model BWB-800; Tanita Corporation, Arlington Heights, IL) was used to measure participants' mass (seminude: athletic shorts for both sexes and sports bra for women).[3,24,25] We calculated participants' BML by measuring the difference between preexercise mass and postexercise mass.[3] Other variables calculated using BML were sweat loss (BML + VC) and sweat rate ([BML + VC]/hours exercised).[3] To negate the need to measure urine output, the preexercise urine sample was collected before the mass measurement, and during postexercise measurements, mass was recorded before obtaining a urine sample.

Perceptual Variables. To assess perceived thirst, we used a 9-point visual scale with verbal anchors ranging from 1 (*not thirsty*) to 9 (*very, very thirsty*).[26] A 5-point visual scale with verbal anchors from 1 (*not full at all*) to 5 (*extremely full*) measured the perceived sensation of fullness.[27]

Procedures

After clearance, participants received an explanation of all procedures and risks associated with the research protocol. Once comfortable with the details of the study, participants signed an informed consent form approved by the university's institutional review board, which also approved the study. Before testing, each participant met with investigators to become familiar with the procedures. During this meeting, we provided a detailed explanation of each exercise station and each fluid-administration method. Pictures and written descriptions, as well as demonstrations performed by 1 of the investigators, were supplied. Participants were encouraged to practice unfamiliar exercises, particularly squirting (SA-NC) and receiving a squirt (EA-NC) from a water bottle, to establish comfort and ease before testing.

We used a local park for data collection. Wet bulb globe temperature averaged 22.2°C ± 3.5°C and ranged from 13.2°C to 28.9°C, representing moderate to warm conditions. These conditions qualify for green to red flag conditions per the American College of Sports Medicine guidelines.[1] Upon arrival for the first data-collection session, participants randomly selected the order of conditions (SA-DC, SA-NC, EA-NC) and their starting exercise station from a box. Once we assigned the condition and exercise station, each participant used the park restroom to provide a preexercise urine sample. After collecting the urine sample, we recorded each participant's mass and asked that he or she complete a daily health questionnaire to allow us to identify any potential illnesses

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Figure 1. Experimental conditions. A, Self-administration with mouth-to-bottle direct contact, B, Self-administration with no contact, C, External administration with no contact.

or issues that might delay or risk his or her participation (eg, illness within the last 24 hours). Urine specific gravity was used when needed to ensure that all participants were hydrated (<1.024)[3] before each data-collection session. However, no participants needed to be rescheduled.

Participants began the exercise protocol with a 10-minute dynamic warmup. Each participant performed the warmup at the same time; 1 investigator offered instruction and demonstration. Immediately after the warmup, we administered perceptual scales for thirst and fullness. Once all participants responded to both scales, a 3-minute FLB was provided. During each FLB, VC and the number of squirts were recorded. After the first FLB (FLB1), participants reported to their randomly assigned starting exercise station; the stations were divided into five 15-minute blocks of exercise, with various tasks and intermittent rest. Rest at these exercise stations did not give participants the opportunity to consume fluids. On completing each exercise station, participants reported their perceived thirst and fullness, followed by fluid variable recording (FLB2–FLB6). After each FLB, participants rotated in a clockwise direction toward the next exercise station. Each cycle of 15 minutes of exercise followed by a 5-minute FLB was repeated until participants had completed all 5 stations. After FLB6, each participant walked back to the park restrooms for a postexercise weigh-in and urine sample.

Exercise Protocol

All exercises within each station were repeated until 15 minutes had elapsed. Participants were encouraged to continuously perform each exercise but could self-pace each repetition. At station 1, participants jogged up and down a hill (~45°) for 2 minutes, followed by a 1-minute rest. For station 2, participants performed 2 minutes of jumping jacks, 1 minute of up/downs, and 1 minute of crunches, followed by 1 minute of rest. Station 3 consisted of ladder drills for 2 minutes, 1 minute of lunges, 1 minute of push-ups, and 1 minute of rest. At station 4, participants jogged back and forth between cones for 4 minutes. The arrangement of cones represented the points of a star, with a cone also positioned in the center. We instructed participants to jog toward the center cone, backpedal toward the starting cone, and then jog clockwise to the next outside cone to repeat the jogging pattern. After the 4-minute jog was 1 minute of rest. Station 5 entailed 1 minute of mountain climbers, 1 minute of bear crawls, 2 minutes of jumping rope, and 1 minute of rest. We informed participants of the remaining time frames to encourage maintenance of pace. Together, the 5 stations resulted in 75 minutes of interval exercise.

Data Analysis

We calculated descriptive statistics for each variable. A repeated-measures 3 × 6 analysis of variance (ANOVA) was used to assess condition (SA-DC, SA-NC, EA-NC) by time (FLB1–FLB6) for VC, squirt, and volume-per-squirt data. A 1-way ANOVA was conducted to analyze the total measurements calculated for the same variables. When sphericity was not present, we used a Greenhouse-Geisser adjustment. If interactions were significant by 1-way ANOVA, paired *t* tests with a Bonferroni correction were calculated for post hoc analysis. Another repeated-measures 3 × 2 ANOVA was used to analyze condition (SA-DC, SA-NC, EA-NC) by time (preexercise versus postexercise) for osmolality and urine specific gravity, and a 1-way ANOVA was used to analyze sweat loss, sweat rate, and BML by condition (SA-DC, SA-NC, EA-NC), with a Tukey post hoc test used to determine condition differences. The procedure for fluid-consumption variables was also conducted for perceptual variables. Significance was set a priori at $P < .05$.

RESULTS

Fluid-Consumption Variables

We observed no significant interaction between condition and time for the amount of VC by participants during FLBs ($F_{1,10} = 1.930$, $P = .103$, $1 - \beta = .603$). There were, however, main effects for condition ($F_{1,2} = 12.514$, $P < .001$, effect size (ES) = 0.994) and time ($F_{1,5} = 12.248$, $P < .001$, ES = 0.405; Figure 2). Participants' VC was lower during FLB1 compared with all other FLBs (69 ± 59 mL versus 153 ± 99 mL, $P < .003$) and lower during FLB4 than FLB3 ($P = .003$). The TVC for EA-NC was lower than for SA-DC ($t = –4.120$, $P = .001$) and SA-NC ($t = –3.932$, $P = .001$; Figure 3). The TVC for SA-NC was not different from that for SA-DC ($t = –2.107$, $P = .049$) when accounting for a Bonferroni adjustment.

A significant condition-by-time interaction was present for Sq/FLB ($F_{1,10} = 8.021$, $P < .001$, ES = 0.308), reflecting main effects for condition ($F_{1,2} = 19.931$, $P < .001$, ES = 0.525) and time ($F_{1,5} = 4.141$, $P = .002$, ES = 0.187). Participants used fewer squirts during FLB1 compared with all other FLBs ($P < .003$). The TSq for SA-DC was lower than for SA-NC (30 ± 14 mL versus 35 ± 15 mL, $t = –2.951$, $P = .009$).

The AVSq by condition for each FLB indicated no significant interaction ($F_{1,10} = 1.774$, $P = .184$, $1 - \beta = .345$); however, main effects were noted for condition ($F_{1,2} = 5.588$, $P = .026$, ES = 0.237) and time ($F_{1,5} = 3.961$, $P = .039$, ES = 0.180). Participants consumed a significantly lower AvSq during FLB1 compared with FLB 3 and FLB5 ($P < .003$). The AVSq for EA-NC was lower than for SA-DC ($t = –2.549$, $P = .020$) and SA-NC ($t = –2.930$, $P = .009$; Figure 4). However, the SA-NC group results did not differ from those of the SA-DC group ($t = –1.999$, $P = .061$).

Hydration Measures

Descriptive data for each variable by condition are shown in the Table. With no significant interaction between condition and time for osmolality ($F_{1,2} = 0.173$, $P = .769$, $1 - \beta = .071$), we verified that participants arrived hydrated and remained hydrated throughout the exercise protocol. No main effect for condition was observed ($F_{1,2} = 0.620$, $P = .544$, $1 - \beta = .145$). Preexercise osmolality (601.0 ± 327.6 mOsm/L) was not different from postexercise osmolality (622.3 ± 255.0 mOsm/L), so there was no main effect of time ($F_{1,1} = 0.280$, $P = .603$, $1 - \beta = .079$). With no significant interaction between condition and time for urine specific gravity ($F_{1,2} = 0.063$, $P = .939$, $1 - \beta = .059$), we confirmed that participants arrived hydrated and remained hydrated throughout the exercise protocol, mimicking the osmolality findings. No main effect for

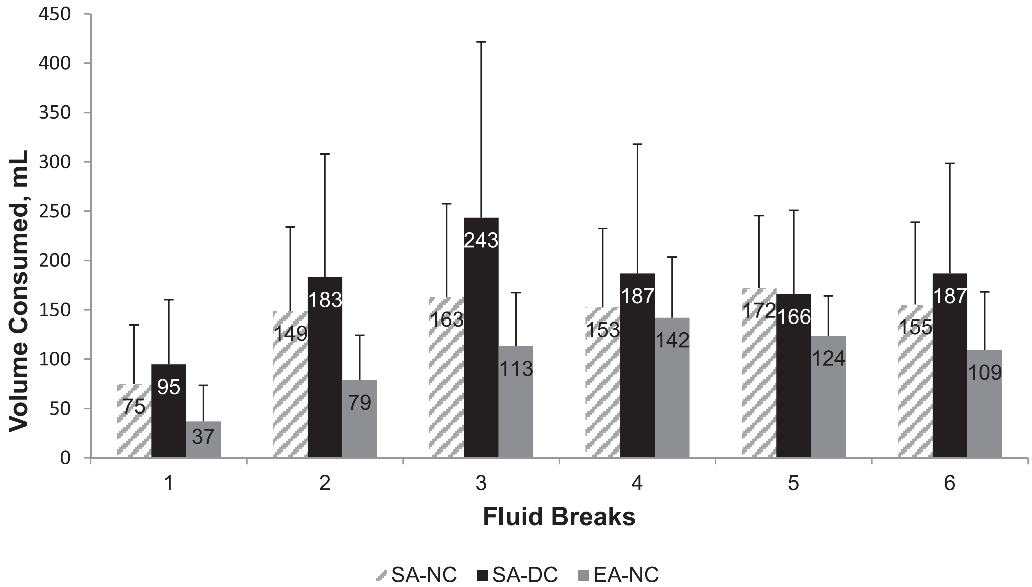

Figure 2. Volume consumed per fluid break (FLB) by condition. Abbreviations: SA-NC, self-administration with no contact between mouth and bottle; SA-DC, self-administration with mouth-to-bottle direct contact; EA-NC, external administration with no contact between the mouth and the bottle. FLB1 was less compared with all other FLBs ($P < .003$). FLB4 was less than FLB3 ($P = .003$).

condition was evident ($F_{1,2} = 0.709$, $P = .499$, $1 - \beta = .160$). A main effect of time occurred ($F_{1,1} = 6.245$, $P = .022$, ES = 0.258): preexercise urine specific gravity (1.017 ± 0.008) was different from postexercise urine specific gravity (1.020 ± 0.007). A main effect for condition was present for BML ($F_{1,2} = 6.408$, $P = .004$, ES = 0.263). Participants in the EA-NC group lost more than SA-DC participants ($P = .041$) but this result was not different from the SA-NC participants ($P = .480$). We noted no BML difference between SA-NC and SA-DC ($P = .385$). No condition main effect for sweat loss ($F_{1,2} = 0.505$, $P = .608$, $1 - \beta = .127$) or sweat rate ($F_{1,2} = 0.505$, $P = .608$, $1 - \beta = .127$) was demonstrated between SA-NC, EA-NC, and SA-DC.

Perceptual Variables

No significant interaction occurred between condition and time for thirst (SA-NC = 7 ± 5, EA-NC = 7 ± 5, SA-DC = 6 ± 5; $F_{1,10} = 2.117$, $P = .06$, $1 - \beta = .706$). A main effect was present for time ($F_{1,5} = 16.213$, $P < .001$, ES = 0.474) but not for condition ($F_{1,2} = 2.027$, $P = .147$, $1 - \beta = .390$. The participants' perception of thirst during FLB1 (3 ± 2) was different from all other FLBs ($P < .003$), and FLB4 (4 ± 2) was different ($P < .003$) from FLB3, FLB5, and FLB6 (identical means for each: 5 ± 2). Condition and time interacted significantly for fullness ($F_{1,10} = 3.103$, $P = .012$, ES = 0.147). There was no main effect for condition ($F_{1,2} = 0.760$, $P = .475$, $1 - \beta = .169$) or time ($F_{1,5} = 2.448$, $P = .08$, $1 - \beta = .550$).

DISCUSSION

Although numerous authors have evaluated factors influencing the quantity of fluids consumed during exercise, to our knowledge self-administration versus external administration has not been investigated.

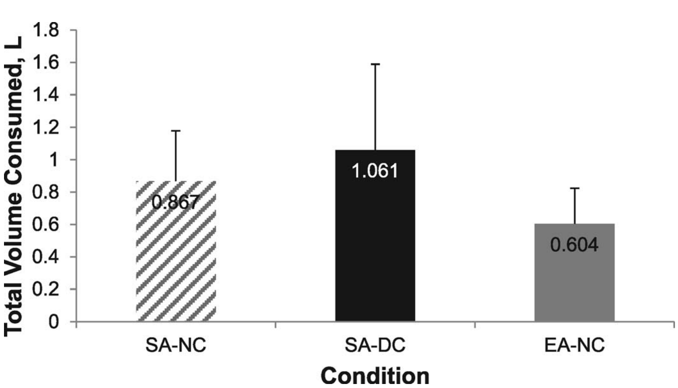

Figure 3. Total volume consumed by condition. Abbreviations: SA-NC, self-administration with no contact between mouth and bottle; SA-DC, self-administration with mouth-to-bottle direct contact; EA-NC, external administration with no contact between the mouth and the bottle. EA-NC was less than SA-DC and SA-NC ($P = .001$).

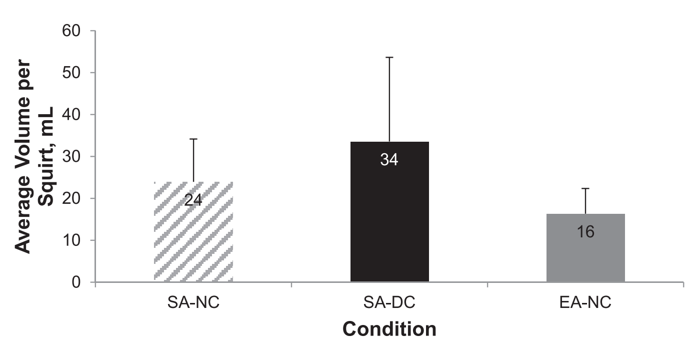

Figure 4. Average volume per squirt by condition. Abbreviations: SA-NC, self-administration with no contact between mouth and bottle; SA-DC, self-administration with mouth-to-bottle direct contact; EA-NC, external administration with no contact between the mouth and the bottle. EA-NC was less than SA-DC and SA-NC ($P = .020$, $P = .009$, respectively).

Table. Hydration Variables by Condition

Variable	Group (Mean ± SD)		
	Self-Administration With Direct Mouth Contact	Self-Administration With No Mouth Contact	External Administration With No Mouth Contact
Osmolality preexercise, mOsm/L	617 ± 309	577 ± 366	610 ± 350
Osmolality postexercise, mOsm/L	640 ± 275	578 ± 241	648 ± 257
Urine specific gravity preexercise	1.018 ± 0.008	1.016 ± 0.009	1.018 ± 0.008
Urine specific gravity postexercise	1.019 ± 0.008	1.019 ± 0.008	1.020 ± 0.007
Body-mass loss, kg	0.8 ± 0.6	1.0 ± 0.5	1.2 ± 0.5[a]
Sweat losses, L	1.8 ± 0.5	1.9 ± 0.5	1.8 ± 0.4
Sweat rate, L/h	1.2 ± 0.3	1.2 ± 0.3	1.2 ± 0.3

[a] External administration with no mouth contact was greater than self-administration with direct mouth contact ($P = .001$).

Fluid Consumption

During all FLBs, participants consumed less fluid via EA-NC than via SA-DC or SA-NC. Holding a water bottle increases the sensory feedback to the central nervous system, which may make it easier to receive squirts, in turn promoting greater VC. A connection between grip force and sensory feedback has been previously reported.[28] In contrast, sensory feedback was not provided in the EA-NC condition; therefore, individuals were forced to rely solely on visual feedback. Additionally, not only would a participant's proclivity to ask for fluids affect the external administration, but his or her postexertion breathing rate might have impeded the ability to receive fluids. Differences in VC among conditions may also be attributed to the comfort level of receiving fluid via the different methods. Results of a laboratory study comparing plastic and glass bottles, cans, and drink boxes of various sizes indicated that participants' comfort in receiving fluids influenced fluid-consumption volume; annoyances with container shapes and difficulty holding the glass bottles were associated with less VC.[29] Similarly, various comfort levels and container perceptions in our study may have influenced the results.

Participants in the SA-DC group may not have consumed more fluids than SA-NC participants, which may have been a function of the study context; a more realistic environment including physiologic and psychologic distractions (eg, being physically jostled, whistles triggering auditory reflexes) might have increased fluid consumption. There may also be an anatomic advantage to SA-DC because the masticatory, buccinator orbicular oris, tongue, and palatine muscles,[30] along with the intrinsic and extrinsic hand musculature responsible for squeezing, help draw fluids from the bottle. However, with SA-NC (and EA-NC), the only muscles that aided with fluid removal from the water bottle were those involving the hand.

In the EA-NC condition, participants depended on the administrator of the squirts to recognize verbal or body language cues and needed to indicate how many squirts were desired. In the SA-NC condition, squirts were not dependent on an administrator but required hand musculature strength to provide adequate pressure to bridge the gap between the water-bottle lid and the mouth without touching. In our non–time-sensitive study, participants during the SA-DC trial used fewer TSq (30 ± 14) than during the SA-NC trial (35 ± 15), in conjunction with greater TVC, indicating that this fluid-administration method was more efficient. All FLBs lasted 5 minutes and the number of squirts ranged from 0 to 13, which allowed fewer squirts to be taken in tighter time frames. Sport dynamics can significantly decrease this time frame for both the player and the fluid administrator. Additionally, the water bottles were maximally filled for every FLB, making the process easier. In an actual game or practice, water bottles may not be filled to capacity and this may affect the number of squirts and the force needed for squirting.

Aragon-Vargas et al[31] evaluated the fluid intake of soccer players during competitive play. To account for fluids consumed, the number of "gulps" was counted. The authors characterized 1 gulp as equaling 30 mL consumed; however, they did not indicate how this was determined. We were able to calculate AVSq, which ranged from 16 to 34 mL. The AVSq was different between conditions, because participants during the EA-NC trial received a lower volume per squirt and ultimately had a lower VC than during SA-NC and SA-DC trials. For EA-NC, each investigator was assigned to as many as 5 participants. Practically, this may be similar to practices and games, in which the ratio of athletes to fluid providers is much greater than 5:1. With a greater number of athletes vying for a squirt, the frequency and duration of squirts are likely to be affected, in turn influencing the VC.

Self-administration, however, did not pose a sense of competition, because each individual was responsible for his or her own squirts, rather than depending on someone else. Giving individuals their own water bottles to drink from allows them to control the force and duration of each squirt, thus providing the opportunity for more fluid per squirt, which, over the duration of activity, results in greater VC. Overall, the TSq the participants received was not different, although TVC and AvSq were different. This can be attributed to self-control versus external control over the water bottle, which may have influenced the efficiency of the squirt in reaching the mouth. This may explain the lack of difference between SA-NC and SA-DC within this variable.

Hydration Measures

The hydration behaviors of athletes have been extensively evaluated.[10,16,17,19,23] Athletes often report to practices and competitions in various levels of hypohydration. In contrast, our participants arrived and remained hydrated throughout the exercise protocol, as shown by osmolality and urine specific gravity. Our participants' hydration status may be attributed in part to the environmental conditions being relatively mild, to the frequency and duration of FLBs provided, and to the easy access to the water bottles. The frequency of FLBs within our study (ie, every 15 minutes) mirrors the current suggestions outlined in fluid-replacement position stands.[2,3] It is important to note that even with FLBs every 15 minutes, hyperhydration did not occur after the exercise protocol.

Body-mass loss was greater in the EA-NC compared with the SA-DC condition, as confirmed by TVC, TSq, and AVSq. Unlike FLBs during practices and games, in which numerous distractions are present, our participants were able to focus solely on consuming fluids. However, the change in urine specific gravity from preexercise to postexercise and the greater BML indicate the potential for significant alterations in hydration status with the use of EA-NC if exercise time is longer, intensity increased, FLBs decreased, or distractions added.

Fluid administration had no effect on sweat loss or sweat rate. Environmental conditions were relatively consistent across data-collection days, and the within-subject study design can help explain the lack of differences among conditions. Both the sweat loss and sweat rate observed in our study were similar to the results of other authors[22,31] who assessed sweat variables. The VC replaced 50% (EA-NC) to 91% (SA-DC) of sweat losses, which are typical in exercising individuals.[22,31] The self-paced exercise intensity and ratio of rest/FLBs may have contributed to participants' maintenance of hydration status across time.

Perceptual Variables

Fluid administration had no effect on thirst or fullness. Maresh et al[32] demonstrated that hypohydrated individuals felt thirstier before the exercise protocol and drank more fluids than the euhydrated group. These results indicate that dehydration before exercise heightens thirst-driven drinking. Engell et al[26] reported similar results, indicating that fluid intake directly correlates with hypohydration level. Our participants reported and remained euhydrated throughout the exercise protocol and experienced only few to moderate feelings of thirst. The hydration status of our participants coupled with their perceptual responses means it is likely that thirst and fullness did not drive fluid consumption. Rather, the type of fluid administration influenced the VC.

Practical Applications

Athletic trainers should avoid EA-NC and should use methods of self-administration to optimize hydration behaviors. If concerns arise about athletes getting their hands wet and having their performance affected, putting the water bottle inside a towel, a "koozie," or another type of insulation should be considered. If water breaks are limited and illness transmission is a fear, teams that use water bottles should encourage SA-NC. Whenever plausible, athletic trainers and coaches should provide enough water bottles so that each individual can use the SA-DC condition, which will encourage positive hydration behaviors. When maintenance of euhydration is difficult, athletic trainers should work with administrators to provide FLBs every 15 minutes and make water bottles easily accessible. These methods, in conjunction with ad libitum consumption, encourage appropriate hydration behaviors while avoiding overhydration.

CONCLUSIONS

When participants received fluid via external administration with the mouth not contacting the bottle, they drank less fluid, whereas self-administration, regardless of condition, promoted adequate fluid consumption. The SA-DC condition required fewer TSq and had a greater AvSq, so it should be considered the best clinical practice to encourage appropriate fluid consumption. The EA-NC condition did not provide a suitable volume per squirt. Fluid breaks every 15 minutes fostered euhydration overall, but EA-NC did increase BML compared with SA conditions because of decreased TVC results.

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