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No Performance or Affective Advantage of Drinking versus Rinsing with Water during a 15-km Running Session in Female Runners

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ABSTRACT

International Journal of Exercise Science 11(2): 910-920, 2018. The advantage of ingesting fluids during endurance exercise lasting < 90 min has recently been challenged, but literature confirming or disputing this case is limited, particularly for female athletes. This study examined the effects of consuming water versus mouth rinsing with water during a running time trial. Recreationally active female runners (n = 19) completed two, 15-km time trials on an outdoor course in temperate environment (~20ºC; 87% RH) separated by at least one week in a randomized cross-over study design. Participants consumed 355 ml of water (DW) during their run or mouth rinsed (MR) with water from a handheld water bottle every 3 km for 5 s with physiological, perceptual, and affective variables assessed. DW or MR did not affect completion time (79.8 ± 8.1 min and 79.2 ± 8.2 min, $p = 0.23$), HR ($p = 0.35$), or RPE ($p = 0.73$), respectively. Sweat losses were greater ($p = 0.03$) for DW: 1.47 ± 0.34 L compared to MR: 1.28 ± 0.27 L; however, thirst sensation was not significantly different for MR: 6.7 ± 1.4 compared to DW: 6.2 ± 1.6. A significant effect was exhibited for time ($p < 0.01$) but not condition for Feeling Scale and Felt Arousal Scale or Energetic and Tense Arousal. Carrying only one smaller fluid container for MR versus a larger or multiple water bottles/backpack systems used for water consumption can reduce fluid load carried during extended duration runs without altering performance or affect for runs of 1.0-1.5 h. MR may also be beneficial to decrease thirst without ingesting fluid for runners that limit exercise fluid consumption because of gastrointestinal discomfort concerns.

KEY WORDS: Hydration, endurance performance, affect, perceived exertion

INTRODUCTION

There is considerable debate over the most appropriate fluid intake strategies for endurance athletes (2, 25). The American College of Sports Medicine (ACSM) guidelines recommend individuals drink to avoid losing more than 2% of body mass during endurance exercise (25). However, the results of a meta-analysis by Goulet et al. (15) contends that a loss in up to 4% body mass does not mitigate cycling time trial performance in ecologically valid conditions (15). In temperate, and even hot environmental settings, most runners attain sweat losses significantly exceeding 2% body mass (20, 21), but are unlikely to surpass 4% loss in body mass for events of half-marathon distance (19). Training or competition scenarios in this 2-4% body mass loss range create the most confusion in giving appropriate advice to runners to optimize performance.

Dion et al. (12) demonstrated that although consuming water to maintain < 2% body mass loss provides cardiovascular and thermoregulatory advantages, this strategy does not improve half-marathon treadmill running performance in the heat (30 °C) compared to drinking ad libitum. The volume of water ingested when limiting body mass loss to < 2% was 3.5 times greater than consumed when runners drank ad libitum (12). Carrying the volume of fluid required by Dion et al. (12) to meet suggested ACSM guidelines would require a considerable number of water bottles to be carried or a backpack style hydration vest for an unassisted run. Likewise, ingesting close to 2 L of fluid from standard 237 mL race aid stations style cups during competition would be untenable for most runners without pace mitigation. Both strategies would likely inhibit optimal running economy and performance, however a handheld water bottle could be a practical alternative.

When less than optimal fluid intake is incurred between training bouts, thirst sensation increases and performance decreases during runs in warm environments (9, 10). It is unknown if mouth rinsing alone would alleviate thirst/mouth dryness and curtail performance decrement under these conditions. However, if runners begin training bouts or competition expected to elicit 2-4% body mass loss euhydrated, simply using carried fluid to rinse in the mouth to reduce thirst sensation might be sufficient to maintain optimal performance and easy to carry. There appears to be only one investigation that has examined the effects of rinsing versus ingesting water during endurance exercise. Arnaoutis et al. (3) found that consuming 100 mL of water improved cycling time to exhaustion performance when compared to mouth rinsing or a control treatment, despite no physiological or perceptual benefit. On the other hand, Backhouse et al. (4) found that consuming water before and every 20 minutes during a 90 min run at 70% VO_2 max resulted in a trend of increasing perceived pleasure from pre-run versus a pattern of increasing displeasure when no water was consumed. Like Arnaoutis et al. (3), heart rate and RPE were not different between sessions despite the prolonged duration of exercise, but thirst rating increased at 40 min of exercise for the no consumption group versus ingestion trial (4).

The effects of rinsing versus ingesting water are not well understood, therefore, the purpose of the study was to examine 15-km time trial performance and physiological and affective domain outcomes when consuming versus mouth rinsing with water in female runners in which environmental conditions and run duration were expected to elicit sweat losses between 2-4% of body mass. An additional aim of this study was to further examine the accuracy in which female runners estimate their sweat losses.

METHODS

Participants

Recreationally trained female runners (n = 23) between the ages of 18 and 45 (26 ± 6.5 y) who completed 34 ± 11 km of running per week with an average best time of 116 ± 9 min (n = 17) for half marathon (21.1 km) were recruited for this study. However, data from 4 participants were excluded from further analysis due to significant environmental and sweat loss differences between outdoor running trials. Each participant read and signed an informed consent form prior to participation. All procedures were approved by the local Institutional Review Board prior to participants signing informed consent. During the screening session height (165 ± 5 cm) and weight (60.3 ± 7.1 kg) were measured (Seca 700, Chion, CA). Body fat % (22 ± 4%) was estimated using bioelectrical impedance analysis (BF 306, OMRON, Bannockburn, IL).

Protocol

A randomized cross-over study design was used for this study. Two treatment sessions that included a 15-km outdoor time trial separated by 9 ± 3 days were completed. Water was chilled (5-6° C) before the trials and warmed with the environment during the run with no intervention to keep the water chilled once running began. During the time trials, participants either consumed water (DW) or mouth rinsed with water (MR). Participants were instructed to drink ~ 90 ml of water at 3, 6, 9, and 12 kilometers for a total of 355 ml or rinse for 5 s every 3 kilometers from a hand-held water bottle (Amphipod, Inc., Seattle, WA) without stopping. Before beginning the run, participants were informed of where they were to drink or rinse using a map. They were reminded of the specific location after each lap. To help approximate the volume of water to be consumed, the bottle was demarcated with a marker into 5 even portions. Participants were allowed to maintain their normal physical activity throughout the study but were asked to avoid any strenuous exercise that would cause soreness or severe tiredness 24 hours prior each session and refrain from alcohol, and coffee consumption. They were also asked to consume a similar dinner the night before each trial and 1000 ml of water to ensure similar euhydration levels the following morning.

All trials commenced between 6:30-9:00 am depending on each individual's schedule, approximately 45-60 minutes after the participants consumed a standardized breakfast consisting of a granola bar, banana, and 500 ml of water at home. After, reporting to the lab participants provided a urine sample to determine urine specific gravity (USG) and urine color. Urine color was recorded using an 8-point scale (1) and USG was measured with a manual refractometer (ATA-2771, ATAGO U.S.A. Inc., Bellevue, WA). After subjects provided a urine sample, nude body mass was measured to the nearest 0.1 kg (BF-679W/BF-680W, TANITA, Arlington Heights, IL). Participants were then fitted with a heart rate (HR) monitor (Polar Team^2, Polar Electro, Kempele, Finland) before walking to the start/finish line of the running course located outside the laboratory. HR was monitored throughout the time trial and session HR was recorded as participants finished 15-km using the Polar Team^2 software system. The 15-km time trial was performed on a well-marked, mainly flat outdoor 5-km course (3 laps). All of the run was performed on either concrete walkways or asphalt roads. Temperature and relative humidity were recorded at the start of each trial using a mobile weather application (The Weather Chanel App, Atlanta, GA). Time to complete each lap and overall time were assessed with a standard stopwatch. Participants had five minutes to recover after 15-km time trial before completing body mass measurement to determine sweat loss. During recovery, participants walked back to the laboratory and were allowed to stretch keeping it consistent between trials.

Participants completed the Feeling Scale (FS) and Felt Arousal Scale (FAS) before, at the 5-km and 10-km mark, immediately after finishing, and 15 minutes post-trial. A large FS and FAS was visually presented to the participants at the beginning/end of each lap. Participants were instructed to verbally rate their FS and FAS to investigators as they passed without stopping. The FS (16) was used to assess the affective valence of participants during exercise on an 11-point scale (+5 – very good to -5 – very bad and 0 – neutral). The FAS (26) measures arousal on a 6-point scale (1 – low arousal to 6 – high arousal). The Activation-Deactivation Adjective Checklist (AD ACL) (27) was administered before and immediately after each trial to assess levels of activation and arousal using a self-rated test with 20 adjectives on a four point scale (1 – not at all and 4 – very much so). The AD ACL determines two bipolar dimensions: energetic and tense arousal. The FS and FAS as well as the energetic and tense arousal were used to measure the circumplex model of affects (24).

Stomach fullness and thirst sensation were collected before and after each trial. Stomach fullness was measured on a scale 0-10 (0 – empty/extremely hungry and 10 – extremely full) and the thirst sensation was measured on a scale 0-9 (0 – not thirsty at all and 9 – very, very thirsty) (13). Session rate of perceived exertion (RPE) was measured immediately after the run was completed on a 6-20 scale (6).

After each trial, participants were asked to verbally estimate how much sweat they thought they lost during the run rounded to the nearest 30 mL. Participants were presented with an empty experimental water bottle and informed that the water bottle used during the run held 360 mL of water for a visual reference.

Statistical Analysis

Repeated measures ANOVA (time to complete each 5-km loop, thirst sensation, stomach fullness, FS and FAS) and paired-samples t-test were used to analyze differences in dependent variables (USG, urine color, body weight, total running time, HR, session RPE, sweat rate and sweat loss) between DW or MR. All statistical analyses were performed using SPSS Version 22.0 (SPSS Inc., Chicago, IL, USA). Mauchlys's Test of Sphericity was used to test the assumption of sphericity. Data are presented as mean ± standard deviation, with the significance level set at $p < 0.05$.

RESULTS

Runners reported to the laboratory equally euhydrated based on USG (DW = 1.010 ± 0.007; MR =1.008 ± 0.006; $p = 0.21$ and urine color (DW = 2.8 ± 1.3; MR =2.5 ± 1.3; $p = 0.13$). Pre-run body mass was lower for the DW session (DW = 59.7 ± 7.1; MR = 60.0 ± 7.1 kg; $p = 0.03$). There was no significant difference in temperature (20.1 ± 3.0 ºC and 19.8 ± 2.6 ºC, $p = 0.68$), relative humidity (85.3 ± 9.4% and 86.6 ± 10.4%, $p = 0.68$), session HR (180 ± 16 bpm and 178 ± 14 bpm, $p = 0.35$), or session RPE (16.0 ± 2.0 and 16.4 ± 1.7, $p = 0.73$) between DW and MR conditions respectively. Likewise, there were no differences in overall time trial performance (79.8 ± 8.1 and 79.2 ± 8.2 min, $p = 0.23$) for DW and MR conditions, respectively. Individual 15-km time trial results are displayed in Figure 1. Individual data indicated that there were 4 runners that ran 2% faster during drinking and 8 runners that ran 2% faster during rinsing. There was no significant treatment effect ($p = 0.23$) for 5-km split times; however, the main effect for lap number approached significance ($p = 0.07$) for individual 5-km split times at 1st 5-km (26.2 ± 2.6 and 26.1

± 2.7), 2nd 5-km (26.4 ± 3.1 and 26.1 ± 2.9) or 3rd 5-km (27.1 ± 3.0 and 26.8 ± 2.9) for DW and MR conditions, respectively.

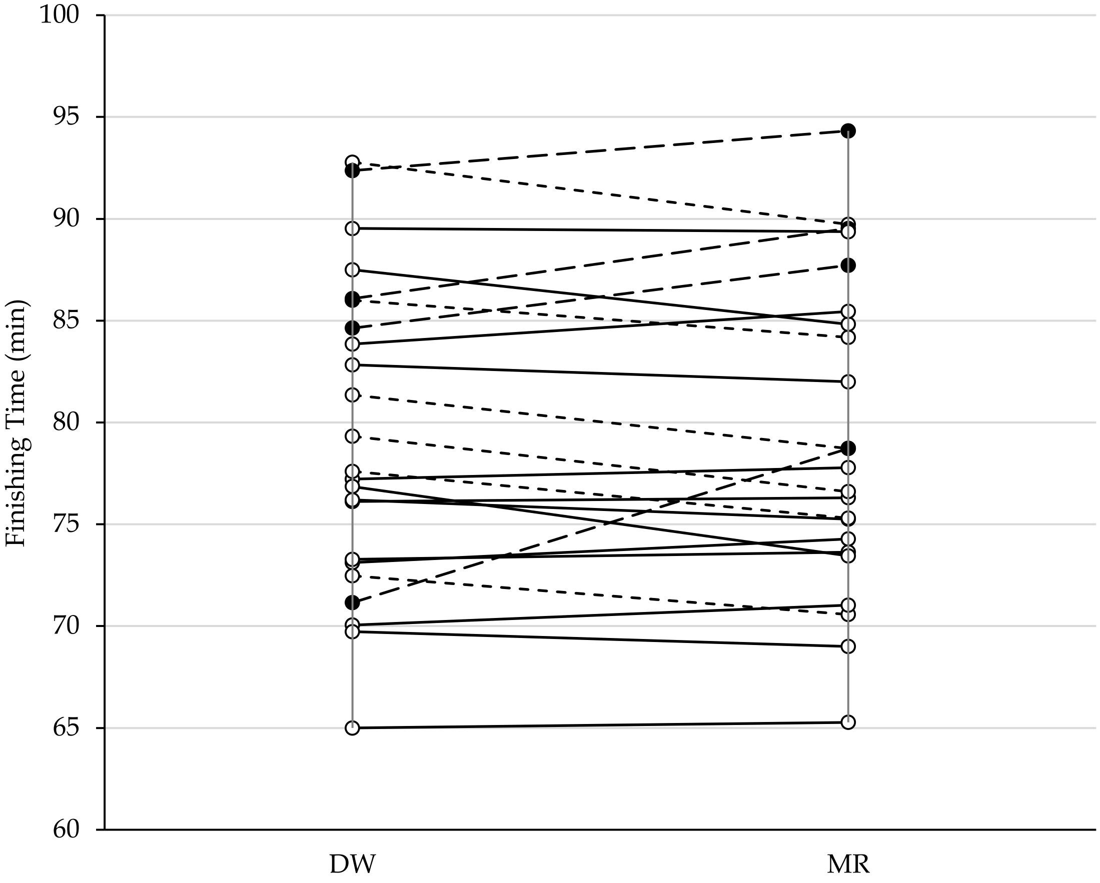

Figure 1. 15-km Time trial individual data (n = 19). DW – drinking water, MR – mouth rinsing. Solid lines represent <2% change in performance between trials. Long dash, solid fill marker represent >2% decrease in performance during MR versus DW. Short dash, no fill markers represent >2% decrease in performance during DW versus MR.

Participants experienced significantly greater sweat loss (*p* = 0.03), sweat rate (*p* = 0.03) and % body weight loss (*p* = 0.01) during DW (Table 1). There was no significant difference in estimated absolute sweat loss (*p* = 0.34) or percent of actual sweat loss (*p* = 0.57) between DW and MR conditions; however, participants significantly (*p* < 0.001) underestimated how much sweat they actually lost in each treatment session (Table 1).

Table 1. Hydration and sweat loss estimate outcomes (n = 19; M ± SD).

				Post-run Sweat Loss Estimation	
	Sweat Loss (L)	Sweat Rate (L/h)	Body mass loss (%)	Absolute (L)	% of Actual Sweat Loss
DW	1.44±0.34*	1.05±0.24*	2.4±0.6*	0.69±0.92†	47.8±56.0
MR	1.23±0.28	0.93±0.23	2.1±0.5	0.54±0.58†	42.8±44.1

DW – drinking water, MR – mouth rinsing. *Significantly different from MR $p < 0.05$. †Significantly different within treatment versus actual sweat loss $p < 0.05$

There was a significant main effect for time ($p < 0.001$) but not for treatment ($p = 0.10$) or interaction time by treatment ($p = 0.70$) observed for thirst sensation (Table 2). Thirst did not differ between pre- or post-run between treatments, however, thirst ratings increased with time as would be expected. There was a significant main effect for time ($p < 0.001$) but not for treatment ($p = 0.92$) observed for stomach fullness (Table 2). Stomach fullness did not differ between DW and MR treatment conditions, however, it decreased over time. In addition, a significant time by treatment interaction was observed ($p = 0.04$) where greater decrease in stomach fullness was observed in MR conditions compared to DW.

Table 2. Thirst and stomach fullness responses (n = 19; M ± SD).

	DW		MR	
	Pre	Post	Pre	Post
Thirst Sensation	3.6±1.9	6.2±1.6†	4.1±1.6	6.7±1.4†
Stomach Fullness	6.7±1.4	5.2±1.8†	7.2±1.4	4.6±1.3†

DW – drinking water; MR – mouth rinsing; Thirst Sensation Scale (0-7); Stomach Fullness Scale (0-10). †Significantly different within treatment from pre-run $p < 0.05$

There were no significant differences in condition or condition by time effect for FS and FAS; however, there was a significant time effect ($p < 0.001$). Univariate analyses revealed that this was due to changes in both FS ($p < 0.001$) as well as FAS ($p < 0.001$). For the FS, compared to baseline there was a non-significant trend towards an increase in negative valence at 10-km ($p = 0.06$) and 15-km ($p = 0.08$), but affect valence became more positive at 15 min post-run ($p = 0.003$). FAS was found to increase at every time point following baseline ($p < 0.001$). See Figure 1 for a graphical depiction of the results for FS and FAS. Energetic and tense arousal exhibited no significant condition or condition by time interaction, but the main effect for time was significant ($p < 0.001$). This was a result of significant changes in energetic arousal ($p < 0.001$) and tense arousal ($p = 0.01$) over time. When plotted on the circumplex model there was a significant increase in valence and arousal (see Figure 2).

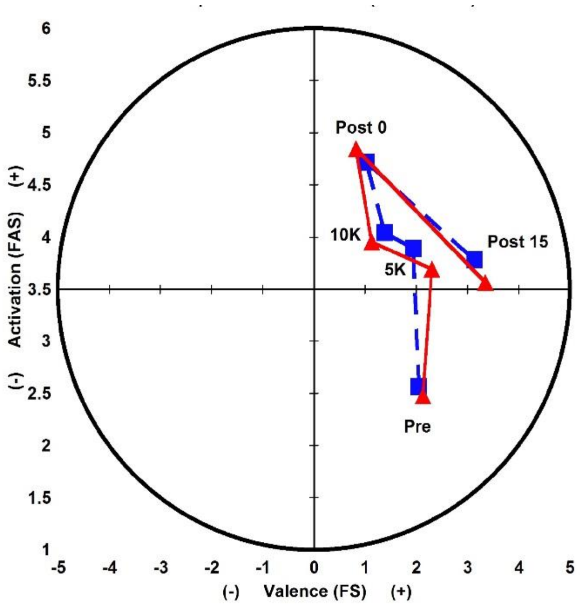

Figure 2. Feeling Scale (FS) and Felt Arousal Scale (FAS) responses to drinking vs rinsing over time. Solid and dashed line represents MR - mouth rising and DW - water drinking, respectively.

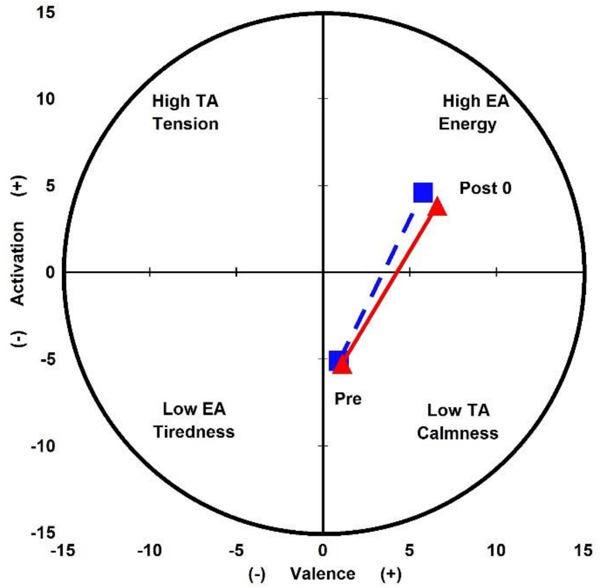

Figure 3. Energetic Arousal (EA) and Tense Arousal (TA) responses to drinking vs rinsing over time. Solid and dashed line represents MR - mouth rising and DW - water drinking, respectively.

DISCUSSION

It is unequivocal that regardless of environmental conditions during longer races (e.g. the marathon), where sweat losses can easily exceed 4% body mass, that nearly all runners will choose to and should drink during competition. This is also true during shorter distance races such as a half-marathon that are conducted in the heat (7, 12, 19). However, during running bouts that will elicit greater than 2% loss in body mass, but not more than 4% loss in body mass, the efficacy for fluid ingestion to improve endurance performance is unclear. Thus, the purpose of this study was to examine differences in physiological and affective responses and performance under such training conditions for well-trained but recreational female runners when drinking versus mouth rinsing with water. The main finding of the current study was that ingestion of fluid was not advantageous compared to mouth rinsing during a 15-km outdoor running time trial (Figure 1).

The current authors are aware of only one other investigation (3) in which water ingestion versus mouth rinse has been examined. Arnaoutis et al. (3) found improved cycling performance in 10 trained, but non-elite men when consuming only 100 ml of water compared to rinsing with water. Arnaoutis et al. (3) postulated the act of swallowing and ingestion of chilled fluids could activate oral-pharyngeal receptors and in turn prolong exercise capacity. While the authors' hypothesis was confirmed in contrast to the findings of the current investigation, it is critical to examine methodological differences implemented. Arnaoutis et al. (3) study completed their performance task following a 10-hour fast and a pre-performance test that consisted of 4 bouts of low intensity running or cycling for 25 min followed by 5 min of passive rest to elicit 2% dehydration prior to performance testing (3). In total, the dehydration protocol included 100 min of exercise and 20 minutes of passive rest in a hot environment (31 ˚C). The performance task conducted was also a time trial to exhaustion which have been shown to have much higher coefficient of variations than simple time trials (18). In contrast, the present study attempted to replicate a more ecologically valid scenario in regards to training or competition conditions. Sweat losses were induced during the simulated competition protocol only. Runners also began exercise euhydrated and consumed a light breakfast 45-60 minutes before the run. Although the time trial to exhaustion in (3) was not performed under hot conditions, it is plausible the 2 h of thermoregulatory challenge prior to the performance task initiated an increased central drive attributed to an oral-pharyngeal response of cold fluid ingestion. However, under such training or race conditions it seems unlikely most runners would fail to ingest fluids if available, but there is no evidence that this ergogenic effect exists during hard runs of 70-90 min in temperate environmental conditions.

A concerted effort was made to create a drinking volume that would optimize the opportunity for fluid ingestion to improve performance while limiting risk of stomach discomfort. The volume of fluid selected was also chosen to minimize running economy and kinematic impact from carrying a greater fluid mass. Dion et al. (12) found considerably greater abdominal discomfort when participants consumed water ad libitum versus drinking to keep body mass loss below 2% during a treadmill half-marathon in the heat (12). As would be expected, participants felt less stomach fullness from the beginning to the end of the running session regardless of treatment difference (Table 2). The faster pace of the male runners in (12) resulted in similar duration of exercise to the current study. Despite drinking on average 225 mL and 1,705 mL more compared to the present study in the to-thirst and maintaining less than 2% body weight loss, respectively, Dion et al. (12) did not find a significant difference in perceived thirst until the 20-km mark of the half marathon. Likewise, simply rinsing fluids resulted in no difference in thirst sensation difference (Table 2) in the current study. Akin to thirst sensation and stomach discomfort, fluid ingestion failed to reduce cardiovascular drift or increase session RPE in the present study. These results support previous investigations that suggest fluid intake has little to no effect on cardiovascular responses or perceived exertion under similar exercise tasks and conditions (3, 5, 8, 14, 23).

A study by de Araujo et al. (11) demonstrated that water activates both the primary and secondary taste cortex. When individuals are thirsty, both consuming water and delivering water into the mouth produced feelings of pleasantness and showed activation in the orbitofrontal cortex (11). Thus, the reward of both drinking water and rinsing with water activate the same part of the brain. This may help to explain why participants did not feel different during the run, which may have a positive impact on performance as well. Similar to Hall et al. (16), participants tended to feel worse and more aroused during exercise (16). After exercise, participants felt better and levels of arousal decreased with ingestion resulting in no improvement in affective domain responses (Figures 2 and 3).

Application of nearly all of the current guidelines for hydration strategies promoted by the ACSM (25) require accurate estimation of sweat losses assessed by change in pre- to post-exercise body mass, but this practice is not common in the running community (22). Previous studies suggest that most, but not all runners will adequately rehydrate between training bouts and that the majority of runners underestimate their sweat losses by ~50% (20,21). This phenomenon was further confirmed in the current study with nearly identical levels of underestimation of sweat losses (Table 1) in a large group of trained but non-elite female runners and highlights the need for greater promotion of the concept of implementing sweat loss assessment techniques to optimize between bout fluid intake strategies and prevent over or underestimation of fluids during long duration runs.

The major limitation of this study is that environmental conditions could not be standardized between trials. However, the exclusion of data from participants that ran under significantly different temperatures and humidity has hopefully mitigated this limitation. Specific dietary and training habits may not have been similar between trials, as participants were not asked to record to ensure compliance. Participants did not engage in formal 15-km training nor ran the distance very often, which could have affected the results. In addition, some participants had only 6-7 days to recover in between the trials, however, similar recovery time was previously used for a half marathon distance by Dion et al. (12). Therefore, considering a shorter distance in the present study the time in between the trials would be sufficient enough to recover for most participants and would not have an effect on performance. Lastly, the inability to monitor whether participant consumption of water during the rinsing trial may have influenced their physiological and psychological responses.

In conclusion, ingestion of fluid during runs of 70-90 min that produce greater than 2 but less than 4% loss in body mass from sweating did not improve run performance, alter heart rate, stomach discomfort, and thirst sensation, or improve affective domain responses versus rinsing when runners began exercise in a euhydrated state. Carrying fluid for rinsing versus consumption can reduce the volume of fluid to be transported by the runner. Assessment of change in body mass during runs can help runners identify their fluid consumption needs between training bouts. All runners in this investigation began exercise euhydrated. Future investigations examining the effects of mouth rinsing versus fluid ingestion when inadequate between bout fluid replacement takes place is warranted.

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