Awareness of water losses does not impact thirst during exercise in the heat: a double-blind study (PREPRINT)

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The purpose of this study was to identify if awareness of water loss could impact thirst perception during exercise in the heat. Eleven males participated in two sessions in random order, receiving true or false information of their water losses every 30 minutes. Thirst perception (TP), actual dehydration, stomach fullness, and heat stress were measured every 30 minutes during intermittent exercise until dehydrated by ~4% body mass (BM). Post exercise they ingested water *ad libitum* for 30 minutes. Preexercise BM, TP, and hydration status were not different between sessions ($p>0.05$). As dehydration progressed during exercise TP increased significantly ($p= 0.001$), but it was the same for both sessions ($p=0.447$). Post-exercise water ingestion was almost identical ($p=0.949$) between sessions. In this study, thirst was a good indicator of fluid needs during exercise in the heat when no fluid was ingested, regardless of receiving true or false water loss information.

Keywords: thirst perception, dehydration, voluntary fluid intake

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Key points:

1. Thirst perception during exercise in the heat is not influenced by the received information about water losses even when percentage of dehydration is more than 3% body mass.
2. Thirst perception can be used as a parameter of fluid needs as long as no liquid is ingested during exercise.

INTRODUCTION

Hydration is always a factor to take into consideration when exercising, especially in the heat, where liquid intake is very important; thirst, as a mechanism of hydration control during exercise, has been widely studied, but whether it is good enough to drive hydration is still controversial (7,12–14).

Thirst can be easily affected by environment, dehydration levels, and especially by drinking (11), studies have clearly shown that the major issue with thirst-driven intake is the rapid decrease of the desire to drink, even when people replace less than 60% of what they lost (2,5).

Manipulation of thirst perception has been studied to see how it can affect performance (1,9), using protocols to control thirst through saline infusions and mouth rinsing. However, we don't know if thirst can be affected by received information or if people can change the perception of thirst because they know how much their water losses are.

Therefore, the aim of the study was to identify if thirst perception (TP) can be affected by awareness of water losses during exercise in the heat.

METHODS

The current investigation used a double-blind design to determine whether thirst perception (TP) can be affected by received information about water losses during exercise in the heat. Subjects completed two randomly assigned sessions. Experimental testing procedures required subjects to exercise in the heat until they reached ~4%BM. Subjects were asked to complete the thirst perception scale every 30 minutes from the onset of exercise until they reached the target level of dehydration, and then to drink as much as they wanted for 30 minutes.

Subjects

Eleven apparently healthy, physically active males provided written informed consent prior to participation in this study. The protocol was approved by the Institution Ethics Committee.

Procedures

In one session subjects received information about their real water losses (RI) and in the other session they received information corresponding to 60% of their real water losses (FI), which is the average voluntary drinking reported in other studies; sessions were randomly assigned. Each participant arrived in the laboratory after an overnight fast, performed the baseline procedures, exercised in the heat, and rehydrated *ad libitum*. At different points during the protocol, self-reported measures were obtained for thirst, fullness and heat perception.

On testing days participants reported to the laboratory and voided their bladders completely. Urine was collected and analyzed with a refractometer for urine specific gravity (manual refractometer ATAGO® model URC-Ne, Minato-ku, Tokyo, Japan, with a spectrum of 1.000 to 1.050). Urine osmolality (U_{osm}) was also measured via freezing point depression (Advanced Instruments 3250 osmometer; Norwood, MA). Nude baseline body weight was measured to the nearest 10 g (Accura® scale, model DSB291, Qingpu, Shanghai, China).

Self-reported thirst was recorded with a visual analog scale. The scale consisted of a continuous 100 mm line with a mark on the left end indicating "not at all" and on the right "extremely", responding to the question "how thirsty do you feel?". Perceived heat sensation was measured with an analog scale with a score from "1: incredibly cold" to "8: incredibly hot". Finally, for the feeling of fullness, the question was: "how full do you feel?" with a score between 1 (not at all) and 5 (very, very). Each participant ingested a standardized breakfast after baseline measurements (750 kilocalories: 24.6% fat, 20.7% protein, and 54.7% carbohydrate; 250 mL of fluid, 1500 mg sodium). After resting for thirty minutes, baseline measurements were taken, and the exercise session started.

On both sessions each participant exercised intermittently (30 min bicycle-30 min treadmill, at 70-80% HRmax) in the heat (WBGT= 28.8±0.1°C and 28.9±0.3°C, for RI and FI, respectively), to a target dehydration near 4% body mass (BM). Subjects were weighed every 30 minutes to monitor their water losses; after every weighing, subjects received information according to the session. Thirst perception was measured every 15 minutes after they received information. Water ingestion during exercise was not allowed. Heat stress was monitored with a Questemp36® monitor. (3M, Oconomowoc, WI, USA).

Upon exercise termination, participants were instructed to drink as much as they needed from previously weighed bottles, while monitoring water intake with an OHAUS® Compact Scales, model CS2000 (Parsippany, NJ, USA) food scale, every 15 minutes for a total of 30 minutes. Urine specific gravity (USG) and osmolality (U_{osm}), fullness, heat sensation, and thirst perception (TP) were measured pre- and post-exercise, and post-rehydration.

Statistical analysis

Mean and standard deviation were used for descriptive statistics. A t-test was performed to identify differences between sessions for each variable (body mass, USG, Uosm, thirts, WBGT, fullness, and heat sensation). One-way analyses of variance were performed to see differences over time for each variable (Urine osmolality, thirst, heat sensation, and fullness). Where ANOVA showed a statistically significant main effect, Tukey's *post hoc* tests were performed to compare time differences.

Results

Participants were 23.0±3.0 years old, 1.75±0.07 m tall, and weighed 76.7±4.9 kg. Pre-exercise conditions were the same for both sessions, see table 1.

Participants exercised for 110.0±24.8 vs. 115.0±22.3 minutes (t=-1.27; p=0.232) during the RI and FI sessions and achieved a body mass loss of 76.7±5.2kg and 76.8±5.2kg (t= -0.389; p=0.706) respectively, which represent an actual dehydration of 3.88±0.43 vs. 3.81±0.38 (t=-0.30;p=0.756), respectively. Subjects ingested the same amount of water at the end of both sessions (1220±249 mL and 1228±422 mL; t=-0.66, *P*=0.949).

Table 1. Pre-exercise conditions for each session

Variable	Real Information (S1)	False Information (S2)	t	p
Body Mass (kg)	77.1±4.9	77.1±5.0	-0.389	0.706
USG (a.u)	1.017±0.007	1.017±0.007	0.135	0.895
Uosm (mmol·kg^{-1})	654.3±296.4	663.2±297.4	0.279	0.786
Thirst perception (mm)	12.8±10.8	14.1±7.5	-1.38	0.199
WBGT (°C)	28.8±0.1	28.9±0.3	-0.814	0.461
Fullness	2.9±1.0	2.9±0.5	-1.27	0.232
Heat sensation	3.8±1.0	3.7±1.0	1.02	0.860

Figure 1 shows urine osmolality between conditions over time, pre-exercise (RI:654.3±296.4 and FI: 663.2±297.4), postexercise (RI:630.1±295.5 and FI: 579.1±279.3) and rehydration (RI: 695.2±259.5 and FI: 665.9±288.5). Uosm was no different between sessions (f=0.134; p=0.722) also, there is no difference over time (f=0.65; p= 0.804) and no interaction (f=0.243; p=0.633)

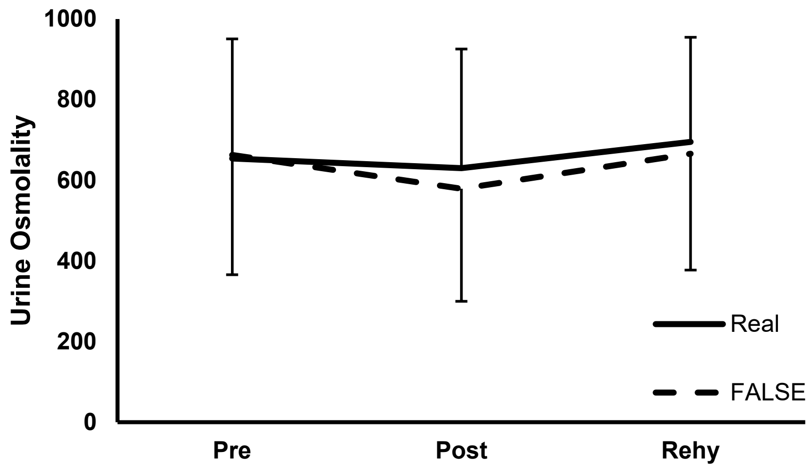

Figure 1. Urine osmolatity values (mean ± s.d), no difference between sessions (p=0.722) or time (p= 0.804).

Thirst perception shows no difference between sessions (F=0.661; p=0.447). There is a difference over time (F=44.6; p= 0.001) from pre-exercise, but no interaction (F=0.382; p=0.559). Fullness shows no differences between sessions (F=3.74; p=0.205) nor time (F=3.74; p=0.304). Meanwhile, heat sensation does not differ between sessions (F=0.982; p=0.360) or over time (F=2.88; p=0.140). Figure 2, A, B and C, respectively.

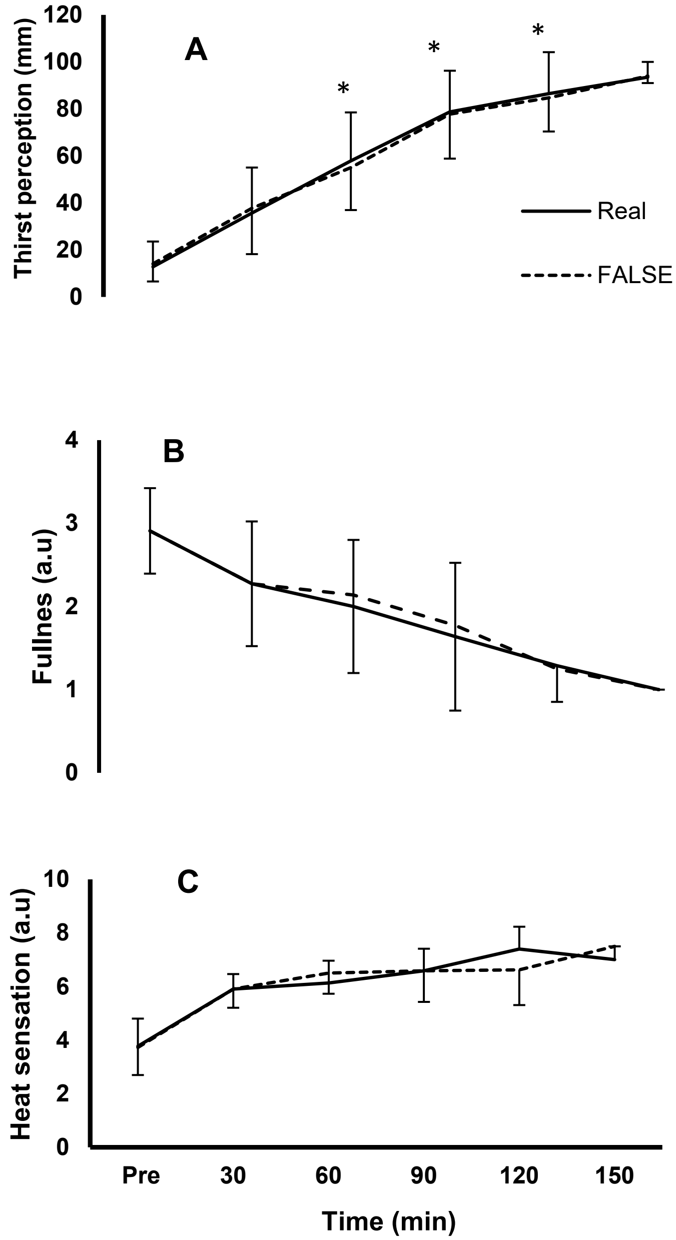

Figure 2. Values shown are mean ± s.d. A. Thirst perception shows no difference between sessions (p=0.447). There is a difference over time (p= 0.001) from pre-exercise, but no interaction (p=0.559). B. Fullness: no differences between sessions (p=0.205) nor time (p=0.304). C. Heat sensation did not differ between sessions (p=0.360) or over time (p=0.140).

DISCUSSION

The aim of the study was to identify if thirst perception (TP) can be affected by awareness of water losses during exercise in the heat. The main finding of this study was that thirst perception during exercise in the heat was not influenced by true or false information about water losses. After exercise, subjects drank one-third of their losses (≈1.2 L), a large volume for 30 minutes of rehydration, independently of the information they received.

This study design differs from others because we manipulated thirst through the information of water losses of the subjects, contrary to others that manipulate thirst with saline infusions, mouth rinse or small quantities of water (1). We also focused only on thirst perception during exercise and not on performance as other studies (2,4,8,11,15); this could be relevant because an important proportion of the physically-active population may be relying on thirst to drive their hydration. This study confirms that thirst perception can detect dehydration and it will go higher as the level of dehydration increases, but thirst perception stops working as soon as subjects drink anything (2–5,10).

Even when WBGT and exercise intensity were high, thirst perception between sessions was the same and had the same behavior over time, regardless of receiving true or false information about water loss. It should be noticed that in this study drinking during exercise was not allowed; we expect that this behavior can change when drinking or mouth rinsing is allowed, as others have shown (6).

Thirst perception is widely used as a reference of hydration needs, especially in physically active persons (not necessarily athletes). Moreover, thirst can be used as a parameter as long as no liquid is ingested during exercise. From this particular study, it may be added that internal signals seem to be adequate to indicate dehydration, despite inaccurate external information that people may receive about their hydration status.

In conclusion, thirst perception (TP) was not affected by received information about water losses during exercise in the heat. This might suggest that awareness of water losses during exercise cannot override the dehydration-induced hypothalamic signal for thirst.

CONFLICT OF INTEREST

Authors declare no conflict of interest

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