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Water Temperature Affects Athletes Drinking Behavior during Self-Paced Cycling in Hot Environment

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ABSTRACT

Carvalho MV, Mendes TT, Andrade MT, Ramos GP, Maia-Lima A, Pereira ER, Amorim FT, Silami-Garcia E. Water Temperature Affects Drinking Behavior of Athletes during Self-Paced Cycling Exercise in the Heat. JEPonline 2016;19(6):137-144. The purpose of this study was to compare the athletes’ water behavior when receiving cool or warm water during a 40 km self-paced cycling in a hot environment. Ten male cyclists who exercised an average of 250 km·wk⁻¹ were subjected randomly to two experimental conditions during which they ingested water *ad libitum* at 10 or 37°C in a hot environment (35°C and 60% URA). Cold water influenced drinking behavior and increased total volume ingested and volume of water ingested per aliquot. However, the voluntary frequency of drinking was unchanged. During self-paced exercise in warm environment, the temperature of the water changes its palatability, stimulating higher fluid ingestion, but it does not affect the frequency of drinking.

Key Words: Voluntary Drinking Behavior, Water Temperature, Heat, Cycling
INTRODUCTION

Thirst is a basic instinct of survival regulated through complex mechanisms capable of determining the water volume to be ingested (2,8,16). Thirst sensation can be defined as an individual, motivational, and behavioral state of seeking and ingesting water (14) that is commonly referred as *ad libitum*.

The desire to drink water is influenced by environmental, social, and behavioral factors in association with palatability (regarded as beverage quality, flavor, temperature, smell, and color), food ingestion, degree of gastric distension, mood state, and the moment when consumption is provided or allowed (1,2,17). There is also a number of physiological factors that can affect thirst, namely the increase of plasma osmolality, blood volume, and blood pressure reduction (14,21) and dry mouth sensation (3). However, the degree of relevance of the latter factors is yet to be determined.

Cool fluids show better palatability and, therefore, would be more efficient for rehydration (1, 2). Greater voluntary cool (15°C) water intake, when compared to hot (40°C) water, has been shown during both interval (6) and continuous (23) running exercise in a hot environment. In fact, Mündel et al. (13) also reported greater 4°C water ingestion than 19°C water during fixed intensity cycling exercise in a hot environment. Such inclination for cooler fluid ingestion was also found during post-exercise water ingestion by Sandick and colleagues (20).

Although previous studies showed that water intake amount is influenced by fluid temperature during continuous and interval fixed intensity exercise, to the best of our knowledge the effect of drinking water temperature on fluid intake behavior (number of aliquot ingested and volume of water per aliquot) during self-paced exercise in a hot environment remains unknown. Therefore, the purpose of this study was to compare the athletes’ water behavior when receiving cool or warm water during a 40 km self-paced cycling in a hot environment.

METHODS

Subjects

Ten healthy male athletes (road cyclists, triathletes, and mountain bikers) who exercised an average of at least 250 km·wk⁻¹ were subjects in this study. This study was approved by the University Human Research Ethics Committee (n° 194/08) and was conducted in accordance to the Declaration of Helsinki. Volunteers’ physical characteristics are shown on Table 1.

Table 1. The Subjects’ Physical Characteristics.

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Body Mass (kg)</th>
<th>Height (cm)</th>
<th>Body Fat (%)</th>
<th>VO₂ Max (mL·kg⁻¹·min⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25.5 ± 1</td>
<td>68.9 ± 2.7</td>
<td>173 ± 1</td>
<td>7.3 ± 0.6</td>
<td>67.2 ± 1.8</td>
</tr>
</tbody>
</table>

Procedures

During the subjects’ first visit to the lab, they were subjected to an anthropometric evaluation followed by an incremental test to determine their maximum oxygen consumption (VO₂ max) (10). Skinfold thickness was measured using a skinfold caliper (Lange®, USA). The subjects
were asked to refrain from alcohol and caffeine ingestion and to maintain the same diet over the last 24 hrs prior to study getting underway. During their second visit to the lab, subjects performed a familiarization trial with all procedures that would be employed during the experimental trials.

Each subject performed two trials in a randomized and balanced design separated by at least 7 days. All trials were conducted in the morning and took place in an environmental chamber (WMD 1150-5, Russells Technical Products®, USA) where temperature and relative humidity were controlled (35°C and 60% relative humidity). Exercise consisted of a 40 km cycling time trial. After an overnight fast the subjects reported to the laboratory at 7:30 a.m. They were given a standard breakfast and were asked to drink 500 mL of water. The subjects’ personal bicycles were positioned and calibrated on an electromagnetic cycle trainer (T1684 Flow Trainer, Tacx®, Holland) inside the environmental chamber. All subjects received water ad libitum at 10°C (AL10) in one trial and water ad libitum at 37°C (AL37) in the second trial. Individual plastic bottles were kept outside the environmental chamber. The bottles were made available for the subjects 30 sec after they asked for water. The volume of water ingested in each request for water (aliquot) and the total water intake were recorded.

Statistical Analyses

Data normality was confirmed using a Shapiro-Wilk test. A Student’s t test was used to compare total amount of ingested water, number of aliquots, and ingested volume per aliquot. All procedures were performed using the SigmaPlot software, version 11.0, and significance level was set at P<0.05. Data are presented as mean ± standard deviation.

RESULTS

The time to complete the 40 km time trials was not different between the conditions AL10 and AL37 (93.0 ± 11.0 vs. 94.4 ± 12.9 min, respectively), but there was a difference between total amount of water ingested for cold (1.1 ± 0.4 L) and warm water (0.8 ± 0.7 L) (Figure 1).

![Figure 1. Amount of Water Ingested during the Self-Paced 40 km Cycling during the Two Different Exercise Trials with the Ingested Water at 10°C (AL10) and 37°C (AL37). *P<0.05, difference between AL10 and AL37.](image-url)
Although the ingested volume per aliquot was higher when cool water was given to the subjects compared to the hot water ($P < 0.05$), the number of aliquots ingested was not different between both conditions (Figure 2).

![Figure 2. Number of Aliquots (A) and Volume Ingested per Aliquot (B) during the Self-Paced 40 km Cycling in a Hot Environment with *ad libitum* Water Intake at $10°C$ (AL10) and $37°C$ (AL37). $^{*} P < 0.05$, difference between AL10 and AL37.](image)

The number of aliquots ingested and the volume ingested per aliquot did not show a significant interaction between the distance and experimental manipulations. The number of aliquots ingested showed a significant main effect over time and a greater frequency of water consumed in time points 16 to 24 and 24 to 32 km when compared with 0 to 8 km and volume ingested per aliquots shows a significant effect for experimental manipulation and a greater volume ingested per aliquots at AL10 was found (Figure 3).

![Figure 3. Number of Aliquots Ingested (A) and Volume Ingested per Aliquot (B) in Self-Paced 40 km Cycling in a Hot Environment with *ad libitum* Water Intake at $10°C$ (AL10) and $37°C$ (AL37). $^{*} P < 0.05$ for difference of 0 to 8 km.](image)
DISCUSSION

The purpose of this study was to investigate the effects of water temperature on the drinking behavior of athletes during 40 km of self-paced cycling performed in a hot environment. It was found that both total ingested volume and ingested volume per aliquot were higher when water temperature was cool, but number of aliquots was not affected by water temperature.

Several factors could influence the athletes’ desire to ingest liquids during exercise. In the present study, the subjects had free access to water bottles every time they wanted one. Yet, despite the fact that the ingested volume of water at 10°C was greater than at 37°C, the number of aliquots was similar under the two conditions. Our data suggest that the athletes were thirsty during several moments of the exercise of which the act of drinking avoided the dry mouth sensation, as proposed by Brunstrom et al. (3) and, in addition, the temperature of water did not influence the number of aliquots.

Furthermore, the greater volume of cold water found in this study is in agreement with the findings of other papers by Hubbard et al., Mündel et al., and Szlyk et al. They have also shown a higher volume of ingested cool water compared to hot water during fixed intensity running. Compared to exercising in a hot environment, there is a positive, pleasant sensation associated with the ingestion of cool water and negative, unpleasant sensation when ingesting warm water (6).

It is believed that the favorite water temperature for ingestion is culturally conditioned (19), perhaps, between 5°C and 16°C. For certain, many athletes may find it difficult to ingest extremely cold liquids, which agrees with the findings of Marins et al. (9) who reported that although more than 70% of the triathletes, cyclists, and long distance runners interviewed did not have a preferred liquid temperature, they classified extremely cold water as unpleasant. Yet, Mündel et al. (13) observed preference for even cooler water temperatures (4°C) during a fixed intensity exercise at 65% of maximum power in a hot environment (33.9°C).

In the present study, exercise performance was not different between the two experimental conditions. Other studies also have shown similar performance in situations where water temperature was different (7,18). However, improved exercise performance have also been showed when cold water or ice slurry was ingested (4,13,24). In these studies, improvement in performance was probably the result of a pleasure sensation caused by the cold water ingestion (1,2).

Warm water ingestion is a usual circumstance during prolonged exercise in warm or hot environments when athletes carry their own water bottle. However, information about voluntary ingestion pattern during self-paced exercise is scarce. Our data suggest the maintenance of number of aliquots and a reduction in ingested volume when water is warm.

CONCLUSIONS

In conclusion, warm water temperature ingestion reduces fluid ingestion but does not affect frequency of drinking during a 40 km self-paced cycling time trial in a hot environment.
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