The Effect of Time of Day on Cold Water Ingestion by High-Level Swimmers in a Tropical Climate

Olivier Hue, Roland Monjo, Marc Lazzaro, Michelle Baillot, Philippe Hellard, Laurent Marlin, and A. Jean-Etienne

The authors tested the effect of cold water ingestion during high-intensity training in the morning vs the evening on both core temperature (TC) and thermal perceptions of internationally ranked long-distance swimmers during a training period in a tropical climate. Nine internationally ranked long-distance swimmers (5 men and 4 women) performed 4 randomized training sessions (2 in the evening and 2 in the morning) with 2 randomized beverages with different temperatures for 3 consecutive days. After a standardized warm-up of 1000 m, the subjects performed a standardized training session that consisted of 10 × 100 m (start every 1′20″) at a fixed velocity. The swimmers were then followed for the next 3000 m of the training schedule. Heart rate (HR) was continuously monitored during the 10 × 100 m, whereas TC, thermal comfort, and thermal sensation (TS) were measured before and after each 1000-m session. Before and after each 1000 m, the swimmers were asked to drink 190 mL of neutral (26.5 ± 2.5°C) or cold (1.3 ± 0.3°C) water packaged in standardized bottles. Results demonstrated that cold water ingestion induced a significant effect on TC, with a pronounced decrease in the evening, resulting in significantly lower mean TC and lower mean delta TC in evening cold (EC) than in evening neutral (EN), concomitant with significantly lower TS in EC than in EN and a significant effect on exercise HR. Moreover, although TC increased significantly with time in MN, MC, and EN, TC was stabilized during exercise in EC. To conclude, we demonstrate that a cold beverage had a significant effect on TC, TS, and HR during training in high-level swimmers in a tropical climate, especially during evening training.

Keywords: acclimation, thermoregulation, endurance, performance, training prescription

The tropical climate has been shown to decrease aerobic performance. The processes involved in this alteration are unclear, but several mechanisms have been proposed, including thermoregulatory anticipation, decreased power output, and cardiovascular adjustments. In any case, the clear consensus is that the tropical climate is deleterious for those who are unacclimated, acclimated, and even native to the climate. At the same time, this climate has been shown to offer a good means to stimulate rapid adaptive processes that are conserved once back in a neutral climate. It therefore can be used to augment aerobic performance in highly trained athletes and is now regularly used as a training environment by national teams.

Precooling or cooling protocols, such as water immersion or cold air exposure, are among the strategies used to decrease the deleterious effect of the hot environment on aerobic performance. Although they may be successful, they are time-consuming and logistically very difficult to apply in real sports contexts. Cold fluid consumption thus seems to be most appropriate. In a systematic review, Burdon et al noted that, although the study findings are mixed, cold fluids generally seem to attenuate the core temperature and improve exercise performance in the heat. Those authors nevertheless emphasized that further research using well-trained athletes and fluid ingestion replicating competition scenarios is required.

As an endurance activity, swimming in a tropical climate is challenged by both the environmental and water temperatures. Swimming in high-temperature water increased heart rate, skin circulation, and esophageal temperature to the same extent as running in a hot environment. Furthermore, because Hobson et al recently demonstrated significantly longer aerobic exercise in the morning than in the early evening in a hot, humid climate in relation with lower core temperature (TC) in the morning, the effects may be exacerbated when training or competition takes place in the evening as opposed to the morning. Because they swim regularly in hot water, open-water swimmers are even more subject to the potentially deleterious effects of this environment.
The aim of the current study was thus to investigate the effect of cold water ingestion during high-intensity training on both the $T_C$ and thermal perceptions of internationally ranked long-distance swimmers during a training period in a tropical climate. We hypothesized that the effect of cold water ingestion would favorably affect the $T_C$ and be optimal during evening training, reducing the heat stress as reflected by both $T_C$ and thermal perceptions.

Material and Methods

Subjects

Nine internationally ranked long-distance swimmers (5 men and 4 women ranked 2–16 at the 2011 Long Distance Swimming World Championship; Table 1) participated in this study. All were members of the French team training for 21 days in Martinique (French West Indies; mean wet-bulb-globe temperature [WBGT] 27.5 ± 2.3°C, 73% ± 10% relative humidity) and swimming twice a day (morning 6:30 AM to 9 am; evening 5–7:30 PM) in an outdoor 50-m swimming pool (mean water temperature 29.5 ± 0.5°C). They were studied through 4 randomized training sessions (2 in the evening and 2 in the morning) drinking 2 randomized beverages with different temperatures (neutral 26.5 ± 2.5°C and cold 1.3 ± 0.3°C) for 3 consecutive days (days 8–10 of the 21-d training period). The morningness/eveningness of the subjects was assessed with the self-assessment questionnaire of Horne and Ösberg\textsuperscript{15} (Table 1). At the time of the study, the swimmers had trained for 106 km in a tropical climate. All gave informed written consent, and the protocol was approved by the ethics committee of Guadeloupe University and was conducted according to the Declaration of Helsinki. Body mass, height, and fat body mass are presented in Table 1.

Exercise Intervention

The study took place during the usual training schedule and covered 4 swimming sessions: 2 in the morning (morning with cold [MC] and neutral [MN] beverage) and 2 in the evening (evening with cold [EC] and neutral [EN] beverage). The swimmers performed a standardized warm-up of 1000 m and were then asked to swim a standardized training session that consisted of 10 × 100 m (start every 1'20") at their best velocity obtained in 2011 for the 5000-m freestyle. The swimmers were then followed for the next 3000 m of the training schedule, which was standardized by the national coach. During the 10 × 100 m, heart rate (HR) was monitored continuously using a portable telemetry unit (Suunto) recording every 5 seconds. The data were analyzed with Suunto software (Suunto memory belt, Suunto, Vantaa, Finland). $T_C$ was measured before and after each 1000-m session up to 5000 m with a CorTemp 2000 ambulatory remote sensing system (HQ Inc, Palmetto, FL) using pills that were given at least 3 hours before each training session, as recommended by HQ Inc. Before and after each 1000-m session and before drinking the cold or neutral beverage, the subjects were asked to rate both their thermal comfort on a modified 4-point scale (from 1, comfortable, to 4, very uncomfortable) and their thermal sensation on a modified 7-point scale (from 1, slightly cool, to 7, extremely hot).\textsuperscript{16} Body mass was assessed (± 0.1 kg) before and after the training sessions (Planax Automatic, Teraillon, Chatoux, France). The subjects were weighed in the same conditions before and after exercise. Body fat content was estimated from skinfold thickness, expressed in millimeters, representing the sum of 4 different skin areas (biceps, triceps, subscapula, and suprailliac) measured on the right side of the body with a Harpenden skinfold caliper following the method described by Durnin and Rahaman.\textsuperscript{17} The

<table>
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<tr>
<th>Table 1</th>
<th>Anthropometric Characteristics of the 9 Swimmers</th>
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<td></td>
<td>Age (y)</td>
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<tr>
<td>Men</td>
<td></td>
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<tr>
<td>25.5</td>
<td>180</td>
</tr>
<tr>
<td>25.5</td>
<td>184</td>
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<tr>
<td>30.5</td>
<td>186</td>
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<td>24</td>
<td>180</td>
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<tr>
<td>21</td>
<td>184</td>
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<tr>
<td>Women</td>
<td></td>
</tr>
<tr>
<td>20.5</td>
<td>169</td>
</tr>
<tr>
<td>21</td>
<td>174</td>
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<tr>
<td>20.5</td>
<td>174</td>
</tr>
<tr>
<td>22.5</td>
<td>176</td>
</tr>
<tr>
<td>Mean</td>
<td>23.4</td>
</tr>
<tr>
<td>SD</td>
<td>3.3</td>
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\textsuperscript{a} Place obtained on the 2011 Open Water World Championship.
equation of Durnin and Rahaman\textsuperscript{17} was used to determine the percentage of fat body mass. The WBGT index was monitored for the duration of the exercises (QUESTemp\textsuperscript{5} 32 Portable Monitor, Quest Technologies, Oconomowoc, WI). The swimming pool water temperature was recorded at 1 m deep at the beginning of, during, and at the end of each session (YSI 409B, Yellow Springs Instruments, Yellow Springs, OH).

Before and after each 1000 m, the swimmers were asked to drink 190 mL of neutral (26.5 ± 2.5°C) or cold (1.3 ± 0.3°C) water packaged in standardized bottles. They were asked to follow their usual diet before each session and to refrain from alcohol for 24 hours before the first session and during the 3-day experiment.

**Statistical Analysis**

Each variable was tested for normality using the skewness and kurtosis tests, with acceptable \( z \) values not exceeding +1 or –1. Once the assumption of normality was confirmed, parametric tests were performed. The variables \( T_C \), delta \( T_C \), thermal comfort, thermal sensation, performance, and HR were analyzed with a 3-way analysis of variance (ANOVA) with repeated measures (time of day × exercise duration × beverage condition). Pairwise contrasts were used when necessary to determine where significant differences occurred. Other data (water temperature, WBGT, and weight) were analyzed using a 2-way ANOVA (time of day × condition). Data are displayed as mean ± SD, and statistical significance was set at \( P < .05 \).

**Results**

**Environmental Conditions**

The swimming water temperature in the morning was significantly lower (\( P < .0001 \)) than in the evening, whereas WBGT was not significantly different between the morning and evening (Table 2).

**Performance**

There were no statistical differences between the 10 × 100-m sessions, which were performed at 95.0% to 96.2% of the swimmers’ speeds during their best 5000-m freestyle in 2011 (ie, a mean of 66.6 ± 2.5 s/100 m; Table 2).

**Weight**

Swimmers’ weight was significantly lower (\( P < .03 \)) after than before the tests but was not affected by beverage (\( P = .40 \)) or time of day (\( P = .41 \)) (Table 2).

**\( T_C \) and Delta \( T_C \)**

\( T_C \) at rest was significantly higher in the evening than in the morning (Figure 1, Table 2). During exercise there was no difference in \( T_C \) between morning (37.0 ± 1.0°C) and evening (37.0 ± 1.1°C; \( P = .80 \)). \( T_C \) increased during exercise (exercise-duration effect, \( P < .0001 \); Figure 1) in MN, EN, and MC but not in EC, resulting in a time-of-day × exercise-duration effect (\( P < .005 \)). There was a significant difference (\( P < .04 \)) in \( T_C \) after consumption of a cold (36.9 ± 1.1°C) versus neutral beverage (37.1 ± 1.1°C). This produced a significant interaction between beverage temperature and exercise duration (\( P < .02 \)). The effect of cold beverage consumption on \( T_C \) tended to be different in the morning versus evening (time-of-day × beverage effect, \( P < .08 \); Figure 2), where EC (36.8 ± 1.2°C) was significantly different (\( P < .04 \)) from EN (37.2 ± 1.1°C) but not MC versus MN (\( P = .71 \)). Therefore, we noted a global interaction of time of day × exercise duration × beverage temperature on thermal comfort (\( P < .04 \); Figure 1).

**Table 2. Environmental Conditions, Performance, and Mean Heart Rate During the Tests; Difference in Weight Between the Tests; and Core Temperature at the Beginning of the Tests for the Different Drink Conditions, Mean ± SD**

<table>
<thead>
<tr>
<th></th>
<th>Morning</th>
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<tbody>
<tr>
<td></td>
<td>Neutral</td>
<td>Cold</td>
<td>Neutral</td>
<td>Cold</td>
</tr>
<tr>
<td>Swimming water temp. (°C)</td>
<td>29.1 ± 0.1</td>
<td>29.9 ± 0.1</td>
<td></td>
<td></td>
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<tr>
<td>Wet-bulb-globe temp. (°C)</td>
<td>27.6 ± 2.4</td>
<td>25.6 ± 0.9</td>
<td></td>
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</tr>
<tr>
<td>10 × 100-m time (s)</td>
<td>69.6 ± 1.8</td>
<td>70.1 ± 2.2</td>
<td>69.2 ± 1.6</td>
<td>69.2 ± 1.5</td>
</tr>
<tr>
<td>Heart rate (beats/min)</td>
<td>142 ± 15*</td>
<td>143 ± 15*</td>
<td>141 ± 13</td>
<td>138 ± 13</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>before 70.9 ± 8.7</td>
<td>70.7 ± 8.1</td>
<td>71.1 ± 8.3</td>
<td>71.0 ± 8.6</td>
</tr>
<tr>
<td></td>
<td>after 70.6 ± 8.2</td>
<td>70.3 ± 8.3</td>
<td>70.5 ± 8.3</td>
<td>70.5 ± 8.5</td>
</tr>
<tr>
<td>Core temp. (°C)</td>
<td>36.4 ± 0.9</td>
<td>36.5 ± 1.0</td>
<td>36.8 ± 1.0</td>
<td>36.9 ± 1.1</td>
</tr>
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<sup>a</sup>Significantly different from evening cold. <sup>b</sup>Beverage × time-of-day effect. <sup>c</sup>Significant difference between before and after. <sup>c</sup>Significant difference between morning and evening.
Figure 1 — Core temperature ($T_c$) kinetics during the 5000-m test. Filled boxes, evening neutral; filled circles, morning neutral; open boxes, evening cold; filled boxes, evening neutral. *Different from morning cold. †Different from evening cold. ‡Different from morning neutral.

Figure 2 — Mean core temperature ($T_c$) noted in the morning (M) and in the evening (E). *Significantly different from evening neutral.
Delta T_C was significantly influenced by exercise duration (P < .0001; Figure 3), beverage temperature (P < .03; +0.3 ± 0.7°C and +0.6 ± 0.5°C for delta T_C for cold and neutral beverage, respectively) and time of day (P < .005; +0.2 ± 0.4°C and +0.7 ± 0.4°C for delta T_C in the evening and the morning, respectively; Figure 4). Delta T_C tended to be differently affected in the morning and the evening (time-of-day × beverage effect, P < .06; Figure 2), with a delta T_C significantly different in EC and EN (–0.1 ± 0.7°C and +0.6 ± 0.4°C, for EC and EN, respectively, P < .04).

Figure 3 — Delta core temperature (T_C) kinetics during the 5000-m test. Abbreviations: MN, morning neutral; MC, morning cold; EN, evening neutral; EC, evening cold. *Different from morning cold. aDifferent from evening cold.

Figure 4 — Mean delta core temperature (T_C) noted in the morning and in the evening. *Significantly different from evening neutral.
HR

HR was significantly affected by the beverage × time-of-day effect \( (P < .05) \), with a mean HR significantly lower in EC than in MN \( (P < .005) \) and MC \( (P < .008; \text{Table 2}) \).

Thermal Comfort and Thermal Sensation

Thermal sensation was significantly affected by time of day \( (P < .001, 2.7 \pm 0.9 \text{ and } 3.3 \pm 1.3 \text{ in the morning and in the evening, respectively}) \) and beverage (time-of-day × beverage effect, \( P < .04; \text{Figure 5} \)), resulting in a nonsignificant difference in the morning between neutral and cold \( (2.9 \pm 1.1 \text{ and } 2.5 \pm 0.8 \text{ in MC and MN, respectively, } P < .3) \) but significantly lower thermal sensation in the evening \( (2.9 \pm 1.1 \text{ and } 3.6 \pm 1.5 \text{ in EC and EN, respectively, } P < .008; \text{Figure 5}) \). Exercise duration \( (P < .0001) \), time of day × exercise duration \( (P < .002) \), and time of day × exercise duration × beverage \( (P < .001) \) also negatively influenced thermal sensation (Figure 5).

Thermal comfort was significantly affected by the time-of-day × beverage effect \( (P < .05) \), resulting in a significant higher thermal comfort in MC than in MN \( (2.1 \pm 0.9 \text{ and } 1.8 \pm 1.1 \text{ in MC and MN, respectively, } P < .02) \) but no significant difference between EC and EN \( (1.9 \pm 1.0 \text{ and } 2.1 \pm 0.9 \text{ in EC and EN, respectively, } P < .08) \). Exercise duration \( (P < .0001) \) and exercise duration × time of day \( (P < .003) \) also had significant effects on thermal comfort (Figure 6).

Discussion

The most important finding of this study is that cold water ingestion induced a significant effect on \( T_C \) during training in high-level swimmers in a tropical climate, especially in the evening: Mean \( T_C \) and mean delta \( T_C \) were significantly lower in EC than in EN, concomitant with significantly lower thermal sensation in EC than in EN and a significant effect on exercise HR. No effect of beverage temperature on \( T_C \) was observed for the morning condition.

Environmental Conditions, Acclimated Swimmers, and Exercise Intensity

Some of the reasons that certain studies may not have found a beneficial effect of cold beverages on \( T_C \) include low stressful environmental conditions, \( 12 \) unacclimatized and not well-trained participants, \( 12 \) and insufficient intensity from the exercise stimulus. \( 12 \)

In this study, the environmental conditions were 27.6 ± 2.4°C in the morning and 25.6 ± 0.9°C in the evening. These WBGTs are not very high but represented the outdoor environmental stress at the moment of the test. Because both living in a tropical environment (not only training in it) and water temperature have been demonstrated to physiologically stress swimmers \( 2,3,10 \), the mean combination of the environmental temperature of 27.5 ± 2.3°C and relative humidity of 7% ± 10% recorded

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**Figure 5** — Mean thermal sensation noted in the morning (M) and in the evening (E). *Significantly different from neutral.
during the period the swimmers were in Martinique, in addition to the water temperature of 29.5 ± 0.1°C, may have provided enough environmental stress to induce acclimation in our swimmers.

Heat acclimation refers to an increase in heat tolerance while working or exercising under stressful conditions. Acclimation processes are enhanced in well-trained subjects, especially those with high VO\textsubscript{2max}, and are facilitated by continuous daily 100-min exercise. Most of these physiological processes of heat acclimation (ie, increased cardiac output, stroke volume, sweat rate, and blood plasma volume; decreased heart rate, core temperature, and mean skin temperature at rest; decreased rectal temperature at rest; and increased oxygen consumption at a given work rate along with earlier sweating during exercise) have been demonstrated to be established within 8 days in the tropical climate in similar athletes (ie, high-level triathletes) and in the exact same area and season. If a particularly interesting question concerns the extent to which swimming affects the process of acclimating to a tropical climate, the thermal balance of swimmers is well known to be regularly challenged because of the high heat-transfer coefficient of water, and swimming in high-temperature water is known to increase HR in relation with hyperthermia and increased skin circulation and esophageal temperature to the same extent as running in a hot environment. We recently demonstrated that the performance of acclimated swimmers may be affected when swimming in hot water, but we also demonstrated that unacclimated swimmers training in a tropical environment presented physiological adjustments resulting in increased performance in neutral climate.10 Our high-level swimmers had trained twice a day for 7 days in a tropical climate, had high aerobic condition, and had swum more than 100 km in the 7 days. We could therefore hypothesize that they had developed the physiological adjustments usually noted after such a time spent training in tropical conditions and thus could be considered as both acclimated subjects and acclimated swimmers.

Finally, the high swimming intensity (especially during the 10 × 100 m) combined with the environmental conditions (ie, the environmental and swimming pool temperatures) represented a stressful environment.

Time of Day

The effect of time of day on performance in a tropical climate has been extensively studied for anaerobic exercise, but there are few data on the time-of-day effect on aerobic performance. Recently, Hobson et al demonstrated significantly longer cycling exercise in a hot,
humid climate (35°C, 60% relative humidity) in relation with lower skin and core temperatures and lower HR in the morning (6:45 AM) than in the early evening (16:45 PM), which certainly delayed the rise in $T_C$ to the critical point that stops exercise. Similar to the findings of Hobson et al, our subjects presented higher $T_C$ in the evening than in the morning at the beginning of the tests in both beverage conditions and had significantly ($P < .001$) different mean $T_C$ in EN (37.2 ± 1.1°C) and MN (37.0 ± 1.1°C), but the increase through the exercises was similar in the neutral conditions (+0.6 ± 0.5°C in both MN and EN) and both performance and HR presented no differences in neutral conditions. The subjects in the study of Hobson et al were living in neutral environment and thus were not affected throughout the day and night by tropical climate; thus they were unacclimated. Our results suggest that in subjects acclimated to tropical environment, although resting $T_C$ is affected by the time of day (ie, higher in the evening than in the morning), as observed by Racinais et al, there are no concomitant effects on performance, as performance was not lower in the evening, or on HR, which was not higher for similar exercise performance in the evening. The finding of Hobson et al that aerobic performance is lower in the evening due to higher $T_C$ was not observed in our study. Instead, we demonstrated similar HR at imposed swimming velocity in 8-days-acclimated subjects during aerobic swimming exercise in the morning and evening.

**Cold Beverage**

In the introduction, we noted that cold fluid absorption seems to be the most appropriate strategy to decrease the deleterious effect of hot environment on aerobic performance. Our results (a mean $T_C$ 0.2°C lower and a delta $T_C$ 0.3°C lower in cold conditions) agree with those usually noted in the literature: Lee et al demonstrated longer exercise time and lower rectal temperature in subjects drinking cold (4°C) than in those drinking warm (37°C) beverages during cycling to exhaustion in a hot environment. Burdon et al noted a positive effect of cold beverages on endurance performance during cycling, and in a recent review Burdon et al concluded that cold beverages may attenuate the $T_C$ rise and improve exercise performance in the heat. However, some questions remain: How much cold beverage, how often, and how cold? Lee et al found no difference in exercise capacity between fluid intake at 10°C and 37°C but demonstrated significant effects with a beverage at 4°C. Siegel et al demonstrated that, compared with 4°C water, −1°C ice slurry increased submaximal endurance running time in the heat and decreased rectal temperature. We chose cold water because using an ice slush is far from easy in ecological conditions (ie, when working with high-level athletes) and, as noted by Burdon et al, “research . . . replicating competition scenarios is required.” However, our beverage temperature was clearly colder than that usually noted in the literature: Instead of 4°C, it was 1.3°C, which is approximately the temperature obtained using ice cubes and water to produce a slushy-like beverage. We assume that this lower temperature did not have a negative impact on gastric emptying; although Sun et al reported that the ingestion of cold (4°C) orange juice led to slower gastric emptying than thermonutral juice, other studies suggest that colder (5–12°C) fluid intake results in faster emptying rates, and most studies show low to moderate effects on gastric emptying.

The debate remains about the amount of water that should be drunk. As reported by Burdon et al, fluid-ingestion protocols vary widely, from regular consumption of a standardized bolus not adjusted for body weight or body surface to ad libitum consumption or a large single bolus at 1 point during exercise. From a physiological point of view, consuming large amounts of cold fluid is believed to create a heat sink, which should theoretically result in attenuation of the heat accumulated over exercise and reduce the rise in $T_C$. However, athletes do not usually drink a large volume of water in 1 bolus but, rather, tend to drink intermittently during exercise, and it has been demonstrated that emptying is more rapid with smaller volumes, resulting in more rapid rehydration.

**Cold Beverage × Time of Day**

The observation that the cold beverage had a more significant impact in the evening seems obvious, and 2 explanations are possible. First, thermal stress was higher in the evening (ie, higher $T_C$ at the beginning of the tests and higher swimming water temperature), as reflected by thermal sensation, which was significantly higher in the evening than the morning. Generally, studies conducted in stressful environmental conditions have reported significant effects of beverage temperature on $T_C$ whereas those conducted in lower stressful environmental conditions all failed to show a significant effect. The increasing $T_C$ through the day, resulting in higher thermal sensation, combined with the higher water temperature, most likely created favorable conditions for the cold beverage to induce significant effects. Second, it is possible that the difference between the quality of the breakfast taken 1 hour before the morning swimming sessions and the meal taken 1 hour before the evening sessions interfered with the effect of the cold water ingestion. Although care was taken to ensure that the swimmers took the pills at least 3 hours before the test sessions, as recommended by the pill manufacturer, a large volume of warm liquid was taken in the morning (ie, coffee or milk) but not in the evening, which might have prevented the cold beverage from decreasing both $T_C$ and thermal sensation in the morning. However, Sun et al noted that even with a large bolus of warm liquid (ie, 400 mL at 50°C), the maximal intragastric temperature occurred within 1 minute and returned to within 1°C of body temperature 20 minutes after ingestion. Moreover, both the $T_C$ and thermal sensation (2.0 ± 0.5 and 2.4 ± 0.6 for thermal sensation in the morning and the evening, respectively, $P < .05$) noted in the morning at the beginning of the tests were significantly lower than those noted
in the evening, suggesting that the fluid intake during the morning breakfast did not interfere with $T_C$ or thermal sensation.

To conclude, we demonstrate that a cold beverage taken in ecological conditions (ie, small volumes taken regularly during training sessions) had a significant effect on $T_C$, thermal sensation, and HR during both training and high-intensity training in high-level swimmers in a tropical climate. The effects were optimal in the evening, certainly in relation with a more stressful environment and/or sensation. Because the aim of using cold water is to decrease the impact of stress to improve performance, studies exploring the effect of cold water ingestion on performance during real competitive events are needed, in both acclimated and unacclimated high-level subjects.

**Perspectives**

The tests we conducted were done during training sessions in a tropical environment. Reports obtained from our high-level swimmers (and reinforced by the thermal comfort and thermal sensation measured) are that in the more stressful conditions (ie, in the evening) the cold water induced better thermal sensations, decreasing the sense of effort. We concluded that measures have to be taken during open-water world races to confirm these subjective results. We also concluded that if it decreases $T_C$, such cold water ingestion could protect international swimmers from thermal accident usually noted during international open-water races in warm water.

**References**

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Cold Water Ingestion and Time of Day


