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J. Ty Hopkins
tyhopkins@byu.edu

Iain Hunter
iain_hunter@byu.edu

See next page for additional authors

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Authors
J. Ty Hopkins, Iain Hunter, and Douglas J. Casa
Warming Up With an Ice Vest: Core Body Temperature Before and After Cross-Country Racing

Iain Hunter*; J. Ty Hopkins*; Douglas J. Casa†

*Brigham Young University, Provo, UT; †University of Connecticut, Storrs, CT

Iain Hunter, PhD, contributed to conception and design; acquisition and analysis and interpretation of the data; and drafting, critical revision, and final approval of the article. J. Ty Hopkins, PhD, ATC, contributed to analysis and interpretation of the data and critical revision and final approval of the article. Douglas J. Casa, PhD, ATC, contributed to analysis and interpretation of the data and drafting, critical revision, and final approval of the article.

Address correspondence to Iain Hunter, PhD, Brigham Young University, 120D RB, Provo, UT 84602. Address e-mail to iain.hunter@byu.edu.

Context: Athletes running in a hot, humid environment may have an increased risk of heat illness. In the 2004 Olympic Games, American and Australian athletes were provided with ice vests designed to cool their bodies before performance. The vest appeared to be effective in keeping body temperatures down and improving the performance of the marathoners. However, body temperatures have not been reported when the vest was used before an actual competition.

Objective: To determine if wearing the Nike Ice-Vest decreased core temperature (Tc) before and during athletic performance in warm (26°C to 27°C), humid (relative humidity = 50% to 75%) conditions.

Design: A 2 × 3 mixed-model design was used to compare groups (ice vest, no ice vest) across changes in temperature from baseline (10 minutes and 1 minute before the race and immediately after the race).

Setting: 2005 Big Wave Invitational 4-km race in Hawaii and 2005 Great American 5-km race in North Carolina.

Patients or Other Participants: Eighteen women from a National Collegiate Athletic Association Division I cross-country team who participated in either the Big Wave Invitational or the Great American Race.

Intervention(s): Four hours before the start of the race, the athletes ingested radiotelemetry temperature sensors. One hour before the start of the race, Tc was recorded, and half of the athletes donned a Nike Ice-Vest, which was removed immediately before the race.

Main Outcome Measure(s): Additional Tc readings were taken at 10 minutes and 1 minute before the start of the race and immediately after the race.

Results: Ten minutes before the start of the race, Tc was elevated by 0.84°C ± 0.37°C in the no-vest group, compared with 0.29°C ± 0.56°C in the ice-vest group (P < .01). This difference in Tc persisted at 1 minute before the start. Immediately after the finish, the increase in Tc averaged 2.75°C ± 0.62°C in the no-vest group and 2.12°C ± 0.62°C in the ice-vest group (P < .01).

Conclusions: Wearing an ice vest before cross-country performance in warm, humid conditions allowed athletes to start and finish the competition with a lower Tc than did those who did not wear a vest.

Key Words: thermoregulation, heat illness, cooling, environmental physiology

When athletes run in a hot and humid environment (wet-bulb globe temperature greater than 27.7°C), running performance may suffer and the risk of heat illness may increase as a result of increased body temperature.1 In the 2004 Summer Olympic Games in Athens, Greece, a few American athletes (distance runners) and all Australian Olympic athletes were fitted with Nike Ice-Vests (prototype; Nike, Inc, Portland, OR) designed to lower body temperature before performance. Although the finding was anecdotal and the vest only one of many strategies used by the American runners to enhance performance in the heat, this intervention appeared effective among the marathoners who used the vests. Deena Kastor and Meb Keflezighi of the United States, who wore the vests before competition, both earned Olympic medals, exceeding most people’s expectations.

Many authors2–7 have investigated the effect of various precooling methods in a laboratory setting. The results of precooling on performance and heart rate have been mixed, but decreases in body temperature were consistently found. However, the length of time the cooling effect lasts seems to be inconsistent. This may be due to the type of cooling method used or perhaps to insufficient statistical power to detect differences.

One group8 evaluated a cooling interval in athletes running a 2-mi (3.22-km) race outdoors after a 90-minute run in the heat and documented lower heart rates after the race, lower core body temperatures, and improved running time. However, no authors have investigated the application of an ice vest during the prerace routine and measured its effect on core temperature (Tc) before, during, and after a race in the field. Our purposes were to determine the effectiveness of the Nike Ice-Vest in reducing Tc before cross-country racing and to assess whether any Tc changes were still present immediately after the race.
METHODS

Subjects

Eighteen female athletes from a National Collegiate Athletic Association Division I cross-country team (age = 20.0 ± 1.8 years, height = 1.68 ± 0.06 m, mass = 57.0 ± 2.3 kg) were tested during the 2005 Big Wave Invitational 4-km race in Hawaii (8 athletes, environmental temperature = 27°C, humidity = 45%) and the 2005 Great American 5-km race in North Carolina (10 different athletes, environmental temperature = 26°C, humidity = 72%).

Procedures

Subjects were assigned to a cooling (CL) or control group and assigned a number based upon times from a preseason time trial, as follows: subject 1 (control), subject 2 (CL), subject 3 (CL), subject 4 (control), and so on. Subjects ingested a radiotelemetry temperature sensor (HQ Inc, Palmetto, FL) 4 hours before each race. One hour before the start of the race, Tc measurements were taken, and half the subjects put on a wet Nike Race-Day Tee and a Nike Ice-Vest (Figure 1). Subjects in the CL group wore the tee and ice vest until 1 minute before the start of the race. Subjects in the control group wore their typical prerace clothing. No instruction was given to the athletes with regard to their specific warm-up regimen other than to follow their usual routine. The Tc measurements were taken at 10 minutes and 1 minute before the start of the race. Immediately after finishing the race, all subjects had Tc measurements taken within 20 seconds.

Instrumentation

The Nike Ice-Vest includes 20 pouches for ice packs. Fully loaded with ice packs, the vest weighs 4.4 kg. The inner layer of the vest is Nike Dri-Fit material, which provides a layer between the skin and the ice packs. Adjustable straps allow for a relatively tight fit to avoid excessive movement of the vest while the athlete warms up. A wet Race-Day Tee was worn under the vest, following Nike’s recommendations.

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RESULTS

We did not compare race times because the race lengths were slightly different. Also, many factors contribute to race performance, and subject numbers were not high enough to detect any expected differences in performance time. However, as reported in Table 1, the times for each group were similar, and the conclusions were due to the vest and not to differences in performance. Even though the 2 races were in different locations with different weather conditions, the results led to similar conclusions. Also, no significant differences were found in Tc measurements between races (P = .21). Thus, the data from the 2 races were combined into 1 analysis.

At all measurement times after the initial Tc reading, the Nike Ice-Vest with the wet Race-Day Tee limited Tc increases due to the warm-ups and races compared with wearing no vest (Figure 2 and Table 2). Differences between groups were more pronounced during the Big Wave Invitational, but average differences were significant even when the races were investigated individually. Greater variability in Tc was observed in the postrace readings among both groups (Table 2). Initial temperatures averaged 37.3°C ± 0.2°C and 37.4°C ± 0.2°C (2-sample t test, P = .13). Race times ranged from 14:25 to 15:34 minutes in the Big Wave Invitational and from 17:00 to 19:31 minutes in the Great American Race.

DISCUSSION

The ice vest slowed the increase in Tc throughout cross-country warm-up and racing among the participants of this study. With the reduced thermal strain, greater blood flow may be available for transport of oxygen to muscle. Sweat rate will likely be decreased during performance when the ice vest is used during the warm-up, and with a decreased sweat rate, blood volume should be better maintained, improving oxygen delivery to muscles. The greater blood flow and blood volume should lead to a better performance.2 In previous laboratory studies, subjects performing endurance runs showed reduced Tc among precooled (ice-vest and water-submersion) groups.2,4-7,9,10 Many of these authors also noted reduced heart rates while the subjects were running at equal speeds. The reduced heart rate is consistent with the potentially decreased sweat rate and lesser need for blood flow for thermoregulation.

Individual reactions to thermal stress vary. In our study, 4

Table 1. Performance Times for Each Group by Race (Minutes: Mean ± SD)

<table>
<thead>
<tr>
<th>Race</th>
<th>CL Time (min: s)</th>
<th>Control Time (min: s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-km Big Wave Invitational</td>
<td>14:58 ± 0:13</td>
<td>18:15 ± 0:42</td>
</tr>
<tr>
<td>6-km Great American Race</td>
<td>15:01 ± 0:30</td>
<td>18:27 ± 0:56</td>
</tr>
</tbody>
</table>

Statistical Analysis

We calculated a 2-way analysis of variance with repeated measures on time to detect differences in Tc changes between the vest and no-vest groups at 10 minutes and 1 minute before the race and immediately afterward. A Tukey post hoc comparison was used to test for differences in Tc between groups at each measurement time, with alpha set at .05.

Figure 1. Nike Ice-Vest. The vest contains 22 pouches, which hold tight-fitting ice packs. A zipper and straps help keep the vest from moving around too much while the athlete warms up.
women had increases of more than 3°C in Tc from the initial reading to the postrace reading. Three others showed Tc increases of less than 2°C throughout the race. One possible reason for some of the variability in temperature responses may be fitness levels, because athletes with greater fitness levels are often better at dissipating heat from the body.\textsuperscript{11–13} Although these athletes were all Division I cross-country athletes, interindividual differences may still be enough to affect thermoregulation. Body fat, skin, muscle, and other tissues may also influence the effectiveness of the vest. Athletes who have difficulty dissipating heat from the body may benefit more than others from wearing an ice vest. An additional potential benefit that extends beyond the physiologic function and exercise performance enhancement issues of high-level athletes is that reduced core body temperature before the start of a race may decrease the likelihood of an exertional heat illness.

One issue in wearing the vest during a warm-up is the mass of 4.4 kg. Because the vest is relatively heavy, it must fit quite tightly to avoid any excessive movement during running. A few athletes mentioned how the vest fit tightly around the underarm and was somewhat uncomfortable. Modifications may need to be made in the warm-up because of the extra weight and tightness of the vest.

Analyzing both races together somewhat limited our results, given that temperature, humidity, and race distances were slightly different at each location. However, average Tc measurements were no different between races at any of the measurement times ($P = .21$); we pooled data from both races. Although we recorded race times, subjects were too few to allow us to accurately determine whether the ice vest had an effect on performance or simply prevented Tc from rising as much as it normally would.

We did not investigate performance in our subjects, but other authors\textsuperscript{2,4,5,7,8,10,14–16} have tested the effects of precooling on performance, observing improved performance. Improved performances in these studies involved running a fixed distance with a lower metabolic cost or running a fixed speed for a longer time after precooling. Underwater submersion, ice vests, and water-circulating suits were used to cool the body in these studies. However, other authors\textsuperscript{6,17–21} found decreased performance when subjects used a cooling vest before participating. Generally, the performance improvements were observed in studies of endurance events, whereas performance decrements were observed in short, power events. In the future, researchers will need to determine whether the ice vest has any performance benefits.

Wearing an ice vest before cross-country performance limited the increases in Tc before the races, and the effect of the precooling persisted after the races finished. Subject numbers were too low to determine any performance improvements due to the ice vest. However, one potential limitation of performance, elevated Tc, was identified and was shown to be limited by using the ice vest.

**REFERENCES**

16. White AT, Davis SL, Wilson TE. Metabolic, thermoregulatory, and per-

**Table 2. Temperature Changes from Initial Reading (°C: Mean ± SD)**

<table>
<thead>
<tr>
<th>Group</th>
<th>10 Minutes Before Start of Race</th>
<th>1 Minute Before Start of Race</th>
<th>At Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice vest</td>
<td>0.29 ± 0.56</td>
<td>0.39 ± 0.41</td>
<td>2.12 ± 0.62</td>
</tr>
<tr>
<td>No vest</td>
<td>0.84 ± 0.37</td>
<td>0.86 ± 0.32</td>
<td>2.75 ± 0.62</td>
</tr>
<tr>
<td>$P$ value</td>
<td>.013</td>
<td>.008</td>
<td>.023</td>
</tr>
</tbody>
</table>


