Cool Shirt™ Use as an Ergogenic Aid in Distance Runners Training in North Louisiana

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ABSTRACT

Brooks KA, Nipper M. Cool Shirt™ Use as an Ergogenic Aid in Distance Runners Training in North Louisiana. JEPonline 2011;14(6):1-7. Distance runners compete in a variety of environments, including hot humid conditions for extended periods of time that can have a negative influence on running performance. The purpose of this study was to investigate the effects of a Cool Shirt™ worn by male and female distance runners training in a hot, humid environment. Fourteen distance runners (9 males and 5 females) participated in the study. The subjects signed an informed consent form. A parent or guardian signed for all minor participants. All testing was carried out at the Human Performance Laboratory at the University of Louisiana at Monroe. Maximum oxygen consumption (VO₂ max) was measured using open circuit spirometry. On two separate occasions, the subjects returned to the laboratory to run 85% of the subject’s predetermined VO₂ max on the treadmill either in a hot humid environment wearing a Cool Shirt™ or in a temperature controlled environment. Heart rate (HR), Borg’s Rate of Perceived Exertion (RPE), temperature of the auditory canal (Tₐ), time to exhaustion, and sweat rate were measured. The findings indicate that there were no significant differences in HR, RPE, sweat rate, or run to exhaustion time between the Cool Shirt™ run and the control run.

Key Words: Environmental Physiology, Heat, Endurance Runners
INTRODUCTION

Distance running is a sport in which athletes may train and compete 12 months a year for optimal results. This includes training and competition in the hot summer months in physiologically challenging humid environments, which influences running performance. In a recent study, Ely et al. (7) has shown that there is a progressive slowing of marathon performance when the wet bulb globe test increases from 5°C to 25°C. It has been proposed that high body core temperature is the main limiting factor in endurance performance in hot environments (5,8,15). In fact, it well-established that a core temperature of ~40°C causes fatigue during exercise (2,8). Exercise induced hyperthermia increases cardiovascular stress as indicated by the decrease in stroke volume (SV) and the increase heart rate (HR) during moderately intense exercise. The result is that cardiac output (Q) may be compromised (2), thus influencing the quantity of oxygen available at the active tissues. Also, Gonzalez-Alonso and colleagues have reported a decrease in central blood volume (CBV), SV, and Q (~1.01 L.min⁻¹) during exercise in a 43°C environment compared to a 26°C environment at 63% to 73% VO₂ peak (8).

While elevated temperatures result in cardiac strain and reduction in exercise performance, decreasing the temperature to maintain core temperature relative to the homeostatic temperature has been shown to improve performance. Rowell et al. (8) found that alterations in CVB, central venous pressure (CVP), SV, and HR with heat stress could be restored by pumping cold water through a suit worn by the participants. A reduction in the core temperature prior to or during exercise has been shown to improve endurance (4,16). Because precooling has been shown to improve endurance performance, cooling during training and competition may be possible. In fact, several methods of cooling have been used to correct for the elevated environmental temperature and the negative effects on endurance performance (2,9). These methods include, but are not limited to, cold air exposure, cold and cool water immersion, ice packing and commercially available ice jackets, and Cool Shirts™.

It is also known that time to exhaustion is influenced by alterations of the initial body temperature (4,8,11). Precooling has been shown to lower core body temperature (3,4,6,11,12,14,17), increase capacity for heat storage (3), and allowing greater amounts of time before core temperatures reaches a critical level (2,4,16) of 38°C to 40°C (8). It has been well documented that precooling can enhance endurance performance (2,4,10,16). Booth et al. (4) found that endurance running performance in hot humid conditions was significantly increased after a whole body precooling maneuver was performed. Precooling is known to reduce HR at rest (2,4) and during exercise (2,16) for approximately 5 to 10 min (12). The decrease in HR may help to contribute to an improvement in SV, cardiac efficiency, and therefore time to exhaustion.

Most methods of precooling are not feasible for use by athletes in many situations; cold air, water and ice water immersion require bulky or expensive equipment. Equipment or facilities are not always adequate or available for use at competitions. Cooling vests have become commercially available for use by persons competing, exercising, or working in the heat. Arngrimsson et al. (2) found that the use of a cooling vest during a 38-min warm-up improved 5000 meter run time in a hot ambient environment (32°C, 50% relative humidity). Cooling vests have also been shown to result in lower perceived thermal comfort ratings and lower Borg RPE ratings when used for active warm-up (2). Arngrimsson et al. (2) found that significantly more weight was lost during 5000 meter run without the use of a vest, which suggested that more fluid is lost due to sweating without the use of an ice vest (2). This finding indicates that precooling helps to decrease fluid loss by decreasing the performer’s core body temperature.
The purpose of this study is to examine the commercially available Cool Shirt™ to determine if the technology prolongs distance runners’ time to exhaustion while running in a hot humid environment. A second purpose is to determine if there are any physiological differences between males and females when using the Cool Shirt™ by males and females. The finds should provide the scientific and athletic communities with useful information regarding training and competing in hot humid environments.

METHODS
Subjects
Fourteen (n=14) male and female distance runners aged 14 to 45 from the geographic area of Monroe, LA were recruited to participate in this study. The subjects were recruited from schools participating in the Louisiana High School Athletic Association (LHSAA) competitive high school cross country and track teams and the National Collegiate Athletic Association (NCAA) Division I cross country and track teams or participation in the Ouachita Valley Road Runners Club events. The subjects signed an informed consent form approved by the Institutional Review Board of the University of Louisiana at Monroe. Minors had a parent or legal guardian grant permission.

Procedures
Maximal oxygen consumption (VO₂ max) was measured using open circuit spirometry. The subjects reported to the Human Performance Laboratory on three separate occasions. During the first visit, the subjects were familiarized with running on the treadmill and, then, they did a graded exercise test to determine their VO₂ max. A Quinton Q-Stress system (Quinton Corporation, Bothell, Washington) was used to monitor electrocardiogram (ECG) and HR. Oxygen consumption was monitored using a MedGraphics Ultima Metabolic Cart (Medical Graphics Corporation, St Paul, Minnesota). During the graded exercise test, the subjects ran at their self-reported training pace while the grade of the treadmill ergometer was increased 2% in 2-min intervals. Anthropometric measurements were also assessed on the first visit. These measurements included three-site skinfold assessment (Jackson-Pollock method), height, and weight.

During the second and third visits to the laboratory, the subjects ran to volitional fatigue on the treadmill in an environment with a temperature of 30°C and 84% relative humidity. Run to exhaustion time was measured while the subjects ran on a treadmill ergometer at the speed and grade at which 85% VO₂ max was maintained in regards to the previous VO₂ max test. During the run, the subjects’ HR and RPE were monitored in 3-min intervals. All subjects received verbal encouragement during the runs. The subjects were weighed wearing dry running shorts before and after running to monitor weight loss due to sweating. Then, the subjects were randomly assigned to either the cooling run or the control run. During the cooling visit, the subjects wore a Cool Shirt™ for the duration of the treadmill run. During the control visit, the subjects ran without wearing the Cool Shirt™.

Statistical Analyses
SPSS 13.0 was used to analyze the data. Paired sample t-tests and independent sample t-test were conducted to compare the means. An alpha level of p<0.05 was considered statistically significant.

RESULTS
Fourteen subjects (9 males and 5 females) agreed to participate in this study. The subjects were categorized as elite (n = 8) and sub-elite (n = 6) distance runners. The running experience for all
subjects was 63.1 ± 40.9 months. The elite distance runners were categorized based on their participation in the Louisiana High School Athletic Association or the National Collegiate Athletic Association cross country and track programs. The sub-elite subjects were recruited from the Ouachita Valley Road Runners Club. The mean age for the subjects was 23.6 ± 9.6 yrs of age with a \( \text{VO}_2 \text{max} \) of 56.7 ± 9.9 mL•kg•min\(^{-1} \). The group height was 169.21 ± 9.41 cm with a weight of 64.8 ± 11.5 kg. Skinfold measurements were taken and evaluated using the American College of Sports Medicine (ACSM) three-site standards; chest, abdomen, and thigh for men and triceps, suprailliac, and thigh for women. Body density was calculated from the ACSM three-site skinfold equation for men and women, respectively. Descriptive statistics are presented in Table 2, and a summary of results is presented in Table 3.

### Table 2. Sub-Elite vs. Elite Results

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Age</th>
<th>Sex (M:F)</th>
<th>( \text{VO}_2 \text{max} )</th>
<th>Mean Weight (kg)</th>
<th>Mean Body Fat %</th>
<th>Time to exhaustion (min)</th>
<th>HR at fatigue</th>
<th>Change in mass (kg)</th>
<th>Auditory Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elite (Cool Run)</td>
<td>16.75 ± 1.50</td>
<td>9 : 5</td>
<td>62.59 ± 4.674</td>
<td>65.35 ± 10.03</td>
<td>12.62%</td>
<td>11.20</td>
<td>196.6</td>
<td>.26 ± .13</td>
<td>1.15 ± .79</td>
</tr>
<tr>
<td>Elite (Control)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10.68</td>
<td>188.3</td>
<td>.29 ± .10</td>
<td>1.08 ± .56</td>
</tr>
<tr>
<td>Sub-Elite (Cool Run)</td>
<td>32.83 ± 7.76</td>
<td>9 : 5</td>
<td>48.77 ± 9.7</td>
<td>64.1 ± 14.4</td>
<td>16.80%</td>
<td>13.44</td>
<td>185.6</td>
<td>.27 ± .12</td>
<td>1.16 ± .87</td>
</tr>
<tr>
<td>Sub-elite (Control)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12.26</td>
<td>190.3</td>
<td>.27 ± .12</td>
<td>1.1 ± .60</td>
</tr>
</tbody>
</table>

### Table 3. Summary of Results

<table>
<thead>
<tr>
<th>Test</th>
<th>Time to exhaustion (m)</th>
<th>RPE 3 m</th>
<th>RPE 6 m</th>
<th>RPE 9 m</th>
<th>RPE 12 m</th>
<th>RPE 15 m</th>
<th>HR at Fatigue</th>
<th>Mass Change (kg)</th>
<th>Auditory Change (^°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>With CoolShirt</td>
<td>12.65</td>
<td>9.64 ± 2.06</td>
<td>13.3 ± 1.7</td>
<td>15.8 ± 2.1</td>
<td>15.6 ± 2.3</td>
<td>19 ± 1.40</td>
<td>187.14 ± 10.86</td>
<td>.28 ± .11</td>
<td>1.1 ± .66</td>
</tr>
<tr>
<td>Control Run</td>
<td>11.90</td>
<td>9.9 ± 2.10</td>
<td>13.6 ± 2.1</td>
<td>16.5 ± 1.86</td>
<td>18.6 ± .89</td>
<td>18.5 ± 2.12</td>
<td>193.93 ± 7.49</td>
<td>.26 ± .12</td>
<td>1.18 ± .695</td>
</tr>
</tbody>
</table>

A significant difference (\( P = .019 \)) was found in the subjects' \( n = 14 \) HR response at volitional fatigue between the control run with a mean of 187.14 ± 10.86 beats•min\(^{-1} \) and the Cool Shirt™ run with a mean of 193.93 ± 7.49 beats•min\(^{-1} \). No other variables were significantly different. In regards to the statistical analysis of the elite and sub-elite groups, there was a significant difference (\( P = .004 \)) in the \( \text{VO}_2 \text{max} \) between the two groups. The means for the two groups were 62.6 beats•min\(^{-1} \) for the elite group and 48.8 beats•min\(^{-1} \) for the sub-elite group. Significant differences were also found between the two groups in RPE during the control run at 3-min (\( P = .000 \)), 6-min (\( P = .015 \)), and 9-min (\( P = .004 \)) with the elite group reporting a higher RPE at each interval. No other significant differences were found between elite and sub-elite runners between the control and Cool Shirt™ runs.
In statistical analyses between male and female runners, significant differences were found in two areas. Body density ($P = .001$) was higher in male subjects (1.07 ± .01) compared to the female subjects (1.05 ± .007). Significant differences ($P = .013$) were also found in the pre-run and the post-run mass difference between the male (.33 ± .09 kilograms) and female (.19 ± .07 kilograms) subjects. No other significant differences were discovered.

**DISCUSSION**

The findings in the present study suggest that a Cool Shirt™ worn in a hot humid environment has no effect on run to exhaustion time. The elevated HR at volitional fatigue while wearing the Cool Shirt™ may be related to a greater physiological strain due to the design of the shirt itself. For example, the materials used to create the Cool Shirt™ may have paradoxically prevented effective cooling of the user. The cotton material used may have increased absorption of the user’s sweat and, therefore, may have contributed to more energy expenditure needed to support the weight of the shirt. Cotton fabric may be less effective in transferring heat and wicking away moisture, thus providing for less of a cooling effect than modern performance fabrics such as Coolmax, Nike Dri-Fit, and Under Armor. In fact, some subjects complained that the shirt was heavy and made them perceive that they were hotter than they would have been had they worn their normal workout clothing while some subjects praised the shirt for the cooling properties. Still other subjects stated that the cooling tubing did not touch their skin due to the shirt not fitting in a skin tight manner, and that the ECG electrodes and wires prevented the shirt from contacting the skin. More research is needed to determine if the weight of the shirt outweighs the likelihood of possible benefits to the user. Hence, given the current state of development, this product does not appear feasible for use during endurance training and competition. With the development of a smaller portable storage tank and pump along with the development of a shirt with lighter, more technical materials, it is possible that the anticipated ergogenic effects could be realized. More research is needed in this area to confirm the feasibility, use, and benefits. Use of the Cool Shirt™ as a precooling protocol may be a more applicable and more efficient use of the current product.

This study did find a significant difference ($P = .013$) in the pre-run and post-run mass difference between male and female distance runners during runs in a hot humid environment. This could be because of a greater lean mass and higher sweat rate reported in male subjects compared to female subjects (13). As would be expected, body density the between male (1.07 ± .0107) and the female (1.05 ± .0071) subjects was significantly different ($P = .001$). No differences in time to exhaustion occurred with the use of the Cool Shirt™ between the male and the female subjects. This finding indicates that the Cool Shirt™ provided a similar lack of physiological benefits for both males and females.

**CONCLUSIONS**

Wearing the Cool Shirt™ in a hot, humid environment during an endurance run or competition has no physiological benefit in elite and sub-elite distance runners. Time to exhaustion, RPE, and HR were not significantly different between the groups. The VO$_2$ max was different between the two groups. The VO$_2$ max of the elite group was 62.59 ± 4.67 mL•kg•min$^{-1}$ while the VO$_2$ max of the sub-elite was 48.77 ± 9.72 mL•kg•min$^{-1}$. This finding supports the faster running competition performances in the elite group as compared to the sub-elite group, but the higher VO$_2$ max value had no bearing on the Cool Shirt™ performance.
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