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Comparison of Whole-Body Cooling Techniques for Athletes and Military Personnel

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ABSTRACT

International Journal of Exercise Science 10(2): 294-300, 2017. The purpose of this study was to evaluate cooling rates of The Polar Life Pod®, a military protocol and cold water immersion. A randomized, repeated measures design was used to compare three treatment options. Participants exercised in an environmental chamber, where they followed a military march protocol on a treadmill, followed by the application of one of three treatments: Cold water immersion tub (5 – 10 °C), Polar Life Pod® (5 – 10 °C), Ice sheets at onset (5 – 10 °C). Mean cooling rate for CWI was 0.072 ºC/min, 0.046ºC/min for ice sheets, and 0.040ºC/min for The Polar Life Pod®. There was a significant difference between conditions (F2,26=13.564, p=0.001, ES=0.511, 1-β=0.969). There was a significant difference in cooling rate among The Polar Life Pod® and CWI (p = 0.006), and no significant difference among The Polar Life Pod® and Ice Sheets (p = 0.103). There was a significant difference of time to cool among the three conditions $F_{2,26} = 13.564$, $p = 0.001$, ES = 0.401, 1-β = 0.950. Our results support multiple organizations that deem CWI as the only acceptable treatment, when compared to the cooling rates of The Polar Life Pod® and ice sheets.

KEY WORDS: Heat exhaustion, heat stroke, cooling rate

INTRODUCTION

Heat illness has been researched extensively, in an effort to reduce fatalities both in the military and in athletics. Heat exhaustion and exertional heat stroke (EHS) are the two most severe conditions with the most serious symptomology. Heat exhaustion is defined as temperature of <40ºC (more commonly 37ºC-39ºC), and no severe central nervous system dysfunction (3, 12), while EHS, is defined as a core body temperature (CBT) >40ºC associated with central nervous system (CNS) disturbances and multiple organ system failure (1, 6, 11, 12, 13).

Previous literature has demonstrated the magnitude of the problem by documenting the fatalities that have occurred due to EHS. Over a period of 15 years, 92 athletes died of EHS (8), while 18% of military hospitalizations were due to EHS (9). In an effort to reduce these fatalities, clinicians must implement the fastest cooling mechanisms available.

Several professional organizations including the National Athletic Trainers Association (NATA), American College of Sports Medicine (ACSM), and the Inter-Association Task Force (1,2,3) have support cold water immersion (CWI) as the standard of care. Despite these recommendations, some health care practitioners have chosen to use other mechanisms of cooling due to accessibility. One of these other modalities recently marketed to clinicians is The Polar Life Pod® (PLP), which may be utilized by athletic trainers as a treatment option for EHS.

Currently, military clinicians use a protocol in which ice sheets are applied to the axillae, groin, and neck to the heat stricken soldier (10). However, this protocol has never been evaluated for effectiveness in cooling soldiers. Therefore, the purpose of this study was to evaluate cooling rates of PLP, the military protocol and CWI.

METHODS

Participants

Eighteen subjects participated in this study (mean age=23.7±4.3y; male=9, females=9). Demographic information can be found in Table 1. Participants completed a health history questionnaire during an informational session. Participants were excluded if they had a history of heat illness within the last 6 months, history of cardiovascular disease, stroke, musculoskeletal problems, gastrointestinal disorders, esophageal or bowel strictures, GI surgery, Raynaud's Disease or abnormalities in swallowing. Participants were also excluded if they exercise for more than 150 minutes per week, as they are at a higher risk for developing EHS (4) and also the population to benefit the most from the findings. Individuals over 40 were excluded from our study as they are excluded from enlisting in the Military services and would not benefit from our findings. This study was approved by Indiana State University's Institutional Review Board.

Table 1. Demographic Data of Participants

Demographics	Mean ± Standard Deviation
Mass	58.9 ± 16.9
Height	72.6 ± 25.3
Resting HR	77.9 ± 12.0
Systolic BP	120.5 ± 13.7
Diastolic BP	78.6 ± 10.1

Protocol
We used Jonah® capsules (ingestible telemetric sensor) to measure core temperature during and after each treatment. VitalSense® Physiological Monitor (Mini Mitter Co., Bend, OR) were used to receive transmissions from the capsules to log measurements. Participants swallowed the capsule 5-8 hours prior to each data collection session. Each session consisted of three periods, pre-exercise, exercise, and cooling. During the pre-exercise period, we prepared participants for the exercise period. The participants reported to the exercise physiology lab where they rested in a chair while we took baseline core body CBT, heart rate, blood pressure, and rate of perceived exertion (Borg's Scale, range 6-20). We assessed body weight and height during this initial session. We also asked each participant to provide a urine sample to test for hydration status. After the baseline measurements, participants put on the Army Combat Uniform, consisting of a hat, t-shirt, jacket, and pants.

During each of the three sessions, participants completed an exercise period in a hot, humid environment (Table 2) with a 35 lbs (15.9 Kg) rucksack (backpack) at an Infantry standard pace (4 mph for 90 minutes or until CBT reaches 104°F (40.0°C)). As participants were marching, we monitored CBT to avoid risk of exertional heat illness (>104˚F, 40°C). Data were recorded by hand onto a data collection form (CBT, heart rate, Borg Scale, and fluid consumed).

Table 2. Environmental and Hydration Characteristics of Each Condition

	Cold Water Immersion	Ice Sheets	The Polar Life Pod®
Change in Hydration (USG)	-0.0068 ± 0.01	0.0081 ± 0.01	0.0584 ± 0.25
Fluid Consumed (oz.)	13.0 ± 3.5	11.8 ± 4.3	11.6 ± 6.8
WBGT Exercise	31.0 ± 4.5	28.9 ± 2.6	27.9 ± 4.3
WBGT Cooling	22.1 ± 2.4	21.5 ± 1.6	21.5 ± 1.9
Exercise Time (min)	33.7 ± 12.0	31 ± 9.5	30.5 ± 7.1
Peak Temperature (ºC)	38.6 ± 0.4	38.6 ± 0.5	38.4 ± 0.7

Participants walked from the heat chamber to the "wet" room, remove the Military uniform, and entered a CWI tub (5-10°C, 41-50°F) wearing shorts (and a tank top or sports bra) only (within 5 min). Participants remained immersed up to the mid-chest (nipple line) until CBT decreases (37.5 °C, 99.5). Researchers circulated the water to improve conductivity. We monitored the time necessary to return to normal CBT. We monitored CBT and heart rate throughout the cooling period every 1 min. Participants exited the immersion tub, dried off and we continued to monitor CBT to avoid hypothermic over cooling. The cooling period was terminated when participants achieve 37.5 °C (99.5 °F). A final urine sample and weight measurement was taken. If the participant lost greater than 2% of his or her body weight, they were instructed to hydrate while they rested. There was a minimum of 48 hours between each session.

The Polar Life Pod® (The Polar Life Pod®, Inc) is proposed to work by using ice and 30-60 gallons of water to immerse the athlete until the chest, neck, and partial head coverage in an attempt to cool them. Upon achieving necessary body temperature, participants walked from the heat chamber to the "wet" room, removed the Military uniform, and entered the PLP (5-10°C, 41-50°F) wearing shorts (and a tank top or sports bra) only (within 5 min). The PLP was filled with ice, followed by the participant laying supine in the pod, and 40-80 gallons of water was pumped into the PLP using the hose access port. Water temperature was monitored (and maintained) using a thermometer placed in the water-resistant port on the PLP (5-10°C, 41-50°F). We monitored CBT and heart rate throughout the cooling period every 1 min until the CBT decreased to 37.5°C (99.5°F).

For the last trial, participants walked from the heat chamber to the "wet" room, remove the Military uniform, and laid supine on the ice sheet wearing shorts (and a tank top or sports bra) only (within 5 min). Participants laid on their back, as the researcher placed the ice sheets in each armpit, in each groin, and on the head and neck. We maintained the temperature of the sheets in a bucket of ice and water (41-50°F, 5-10°C). The ice sheets were replaced as they warmed (approximately 3 minutes).

Statistical Analysis
We performed a repeated measure, within subjects, one-way analysis of variance on cooling rate as the primary outcome measure. We also compared exercise and cooling environmental conditions to ensure that conditions were consistent using the same statistical methods. Pairwise comparisons were included in the analysis and significance was set at $\alpha<0.05$ a-priori. IBM SPSS 23 was used to analyze the data. We used means and standard deviations for the descriptive statistics as well as the inferential statistics.

RESULTS

Mean cooling rate for CWI was 0.072 ± 0.04ºC/min, 0.046ºC ± 0.05/min for ice sheets, and 0.040ºC ± 0.08/min for PLP. The average water temperature was 10.97 ± 1.66, 2.89 ± 2.90, and 13.82 ± 2.61, respectively. The water temperature of the ice sheets was measured prior to application to the skin. There was a significant difference between conditions ($F_{2,26}=13.564$, $p=0.001$, ES=0.511, $1-\beta=0.969$). There was a significant difference in cooling rate among PLP and CWI ($p = 0.006$), and no significant difference among PLP and Ice Sheets ($p = 0.103$). There was a significant difference of time to cool among the three conditions $F_{2,26} = 13.564$, $p = 0.001$, ES = 0.401, $1-\beta = 0.950$.

The environmental temperatures were consistent among conditions, both for the exercise protocols and cooling sessions. The mean WBGT during exercise was 29.511ºC and 21.702ºC during cooling. There was no significant difference among WGBT among conditions $F_{1,14} = 228.078$, $p = 0.149$, ES = 0.129, $1-\beta = 0.370$. There was no significant difference among condition and environment $F_{2,28} = 7.582$, $p = 0.369$, ES = 0.067, $1-\beta = 0.192$.

There was a significant difference among WBGT during exercise and cooling $F_{1,14} = 228.078$, $p = 0.000$, ES = 0.942, $1-\beta = 1.000$. The average exercise time of participants was 31.23 minutes. There was no significant difference among exercise time and the three conditions $F_{2,26} = 0.203$,

$p = 0.785$, ES = 0.015, $1-\beta = 0.076$. The average peak temperature was 38.5ºC. Overall, there was no significant difference in terms of peak temperature among all three conditions $F_{2,26} = 0.357$, $p = 0.703$, ES = 0.027, $1-\beta = 0.101$.

DISCUSSION

Researchers have recommended cooling rates between 0.08ºC/min and 0.15ºC/min are acceptable in the treatment of EHS (14). Our results support multiple organizations (1,2,3,4) that deem CWI the only acceptable treatment modality, when compared to the cooling rates of PLP and ice sheets. Researchers have demonstrated that clinicians admit to using alternative methods of whole body cooling, such as removing clothing and moving to the shade (5). Additionally, secondary school athletic trainers have indicated CWI as their treatment of choice only 49.7% of the time (5). Our results, as well as previous extensive literature validating CWI as the gold standard (1, 2, 3, 4), do not support clinicians' alternative treatment choices including that of ice sheets or PLP.

The PLP, while proposed to immerse the patient up to the head (16), through observation by the researcher, only covered the patient's upper back, shoulders, and legs. Perhaps the slow cooling rate can be attributed to the lack of immersion. Secondly, since the participants body temperature was elevated upon entering PLP the water surrounding the patient warmed more quickly than that of CWI.

Use of the military protocol in the field may be detrimental to patient care, as our results indicate a significantly slow cooling rate (12). Hospitalizations of soldiers suffering from EHS have been documented at a staggering rate, (8) and based on our slow cooling rate, this study gives light to the military mortality rate. During a 22 year period, in the U.S Army, 18% of hospitalizations and 37 deaths were attributed to EHS (9), there is a pressing need to modify these protocols in the near future. Healthcare professionals working not only in athletics, but in the military have a responsibility to use best practices when treating EHS. While the application of ice sheets may be feasible and readily available in the field, our results indicate an unacceptable cooling rate.

We also examined a new product on the market, PLP. Athletic Training is a growing profession, and with that growth comes new technology and resources for athletic trainers to use to enhance their clinical practice. The PLP however, provides a cooling rate similar to that of treatment by water being splashed on the body with fanning and ice pack application with water splashed over the patients with fanning (9). Mean cooling rates were 0.035ºC/min and 0.036ºC/min, respectively (9), while our results demonstrate 0.039ºC for PLP. In a study evaluating a conceptually similar product as PLP, the Body Cooling Unit cooled patients with a body temperature of 39.5ºC at a rate of 0.31ºC per minute (17); however, cooling times ranged from 30-300 minutes (15), which would likely lead to a fatality. The PLP, while similar to the military protocol in terms of mobility and practicality, is not an effective means of treatment for EHS according to our results.

One limitation of this study was the peak body temperature during exercise. The average peak temperature of participants was 38.5ºC. The most recent position statement indicates body temperature is usually, but not always, greater than 40.5ºC (105ºF) (4). While it is important for this study's results to be clinically relevant, it would not have been ethical for participants to reach such a temperature, since the risk of morbidity and mortality increases with higher temperature (4).Additionally, optimal cooling does not occur when temperatures exceed that of 38.5, so we were using best practices.

Athletic trainers must be cognizant of new products on the market, and protocols for treatment that have not been previously evaluated. Our study concludes that CWI is warranted when treating an athlete or soldier with EHS. If full body cooling by CWI is not readily available, researchers in the field recommend partial-body immersion with a tub, or the use of wet towels rotated and placed over the entire body may be used (4). These methods, however, may only be effective if the entire body is covered, versus the major arteries and torso. Perhaps in a situation such as a military ruck march, when the availability of CWI may be limited; ice sheets may be the only obtainable modality, however, steps must be taken to ensure CWI is available to reduce fatality.

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