# Maximizing body cooling using the Polar Skin™ Comprehensive Cooling System after exercise in the heat.

By:
PhysioZing, LLC
629 Cooley St
Suite A
Missoula, MT 59082

Brent Ruby, Ph.D.
Tel: (406) 396-4382
E-mail: brent@physiozing.com

John Cuddy, MS, CSCS
E-mail: john@physiozing.com

Walter Hailes, MS
E-mail: walter@physiozing.com

For:

Per Vivo Labs, Inc.
2002 Brookside Lane
Suite F
Kingsport, TN  37660
(423) 765-4007 x702

## Introduction

PhysioZing was hired by Per Vivo to help design and test a deployment strategy that maximized the cooling ability of the POLAR SKIN™ COMPREHENSIVE COOLING SYSTEM. The product was expertly packaged to maximize transportability and temperature retention in hot environments. The POLAR SKIN™ COMPREHENSIVE COOLING SYSTEM includes 4 POLAR SKIN™ C2E ICE PACKS and 6 POLAR SKIN™ ICE SHEETS (measured 30 in x 36 in). The operating instructions, while similar to established cooling protocols, were not the most effective use of this POLAR SKIN™ COMPREHENSIVE COOLING SYSTEM. After extensive pilot testing of multiple layering techniques and sheet use durations, an effective protocol was established. The treatment protocol was designed so that the participant received cold POLAR SKIN™ ICE SHEETS in rapid succession, thereby providing a POLAR SKIN™ ICE SHEET that was continually cooler than the participant's skin temperature. This rapid refreshing of the POLAR SKIN™ ICE SHEETS provided a constant heat sink on the exterior of the participant. Testing was completed to determine the rate of cooling that could be attained using a developed POLAR SKIN™ COMPREHENSIVE COOLING SYSTEM deployment protocol.

## Methods

Seventeen male participants (22±5 years old, height=181±7cm, body mass=81±11kg, and 14±3% body fat) exercised (walk/run on a treadmill) in a hot room (38.8°C (102°F) and 40% RH). For the first ten minutes participants walked at 10% grade and 3.5 MPH (1.56 m/sec.), and then exercised at a difficult intensity (they were instructed to exercise "hard") based on their own perceived exertion. Participants exercised until a terminal core temperature was attained (38.8°C), which required 20 to 40 minutes of exercise, depending on the intensity of exercise and individual heat acclimation. Once core temperature reached 38.8°C, participants stopped exercising and reclined on a cushioned surface in the environmental chamber. POLAR SKIN™ C2E ICE PACKS (0°C/32°F) were

placed in both armpits and on both upper thighs in the groin area, covering the femoral artery. POLAR SKIN™ C2E ICE PACKS remained in place for the entire 20-minute cooling period. The front of the participant's torso was then covered by a cold POLAR SKIN™ ICE SHEET (0°C/32°F). Each POLAR SKIN™ ICE SHEET remained on the torso for 50 seconds. After 50 seconds the POLAR SKIN™ ICE SHEET was removed and replaced by another POLAR SKIN™ ICE SHEET. Each exchange required approximately 10 seconds. Once each POLAR SKIN™ ICE SHEET was removed, it was placed in an adjacent cooler of ice (approximately 2 lbs.) and water (approximately 3 gallons). Pre-cooled, fresh POLAR SKIN™ ICE SHEETS were used for the first 6 rotations after which, recycled ice bath soaked POLAR SKIN™ ICE SHEETS were applied to both the torso and the legs for the remaining 20-min cooling period. The research team rotated 4 POLAR SKIN™ ICE SHEETS to ensure that participants were continually covered with ice water saturated POLAR SKIN™ ICE SHEETS that had been in the ice bath for 1-minute.

Prior to the trial, participants inserted a rectal thermometer and donned two skin temperature sensors (chest and thigh) so that body temperature could be monitored throughout the exercise and recovery periods.

**Statistical Analysis**

Reductions in core, chest and leg temperatures and temperature gradient during the 20-minute recovery were determined using one-way analysis of variance (ANOVA). Data was analyzed at 5-minute intervals, time points (0, 5, 10,15, and 20 min). A possibility of type I error less that 5% was considered significant ($p<0.05$). All data are reported as mean ± SD, unless otherwise noted.

**Results**

The experimental cooling protocol using the POLAR SKIN™ COMPREHENSIVE COOLING SYSTEM significantly reduced core and skin temperature during the

20 minute cooling period. One participant's chest skin temperature can be seen in Figure 1, which demonstrates the rapid skin cooling after applying the POLAR SKIN™ ICE SHEET and the quick plateau as a result of the body heat transferring to the sheet.

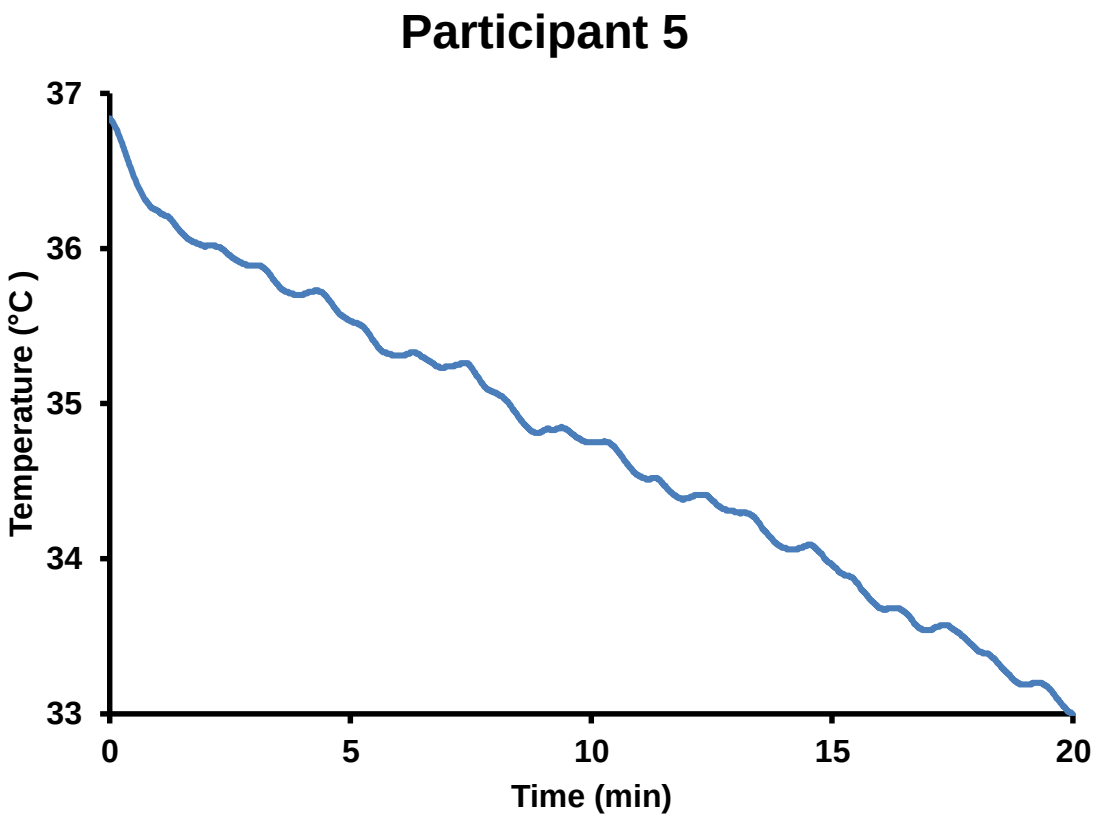


Figure 1. Chest skin temperature of Participant 5 during the 20-minute recovery period. The stepwise nature of the graph demonstrates the cooling effect of applying a POLAR SKIN™ ICE SHEET every minute.

Core temperature (Figure 2) fell 1.0±0.2°C (0.05°C/min) during the 20-minute recovery period with each 5-minute interval measure demonstrating significantly lower values from the previous interval.

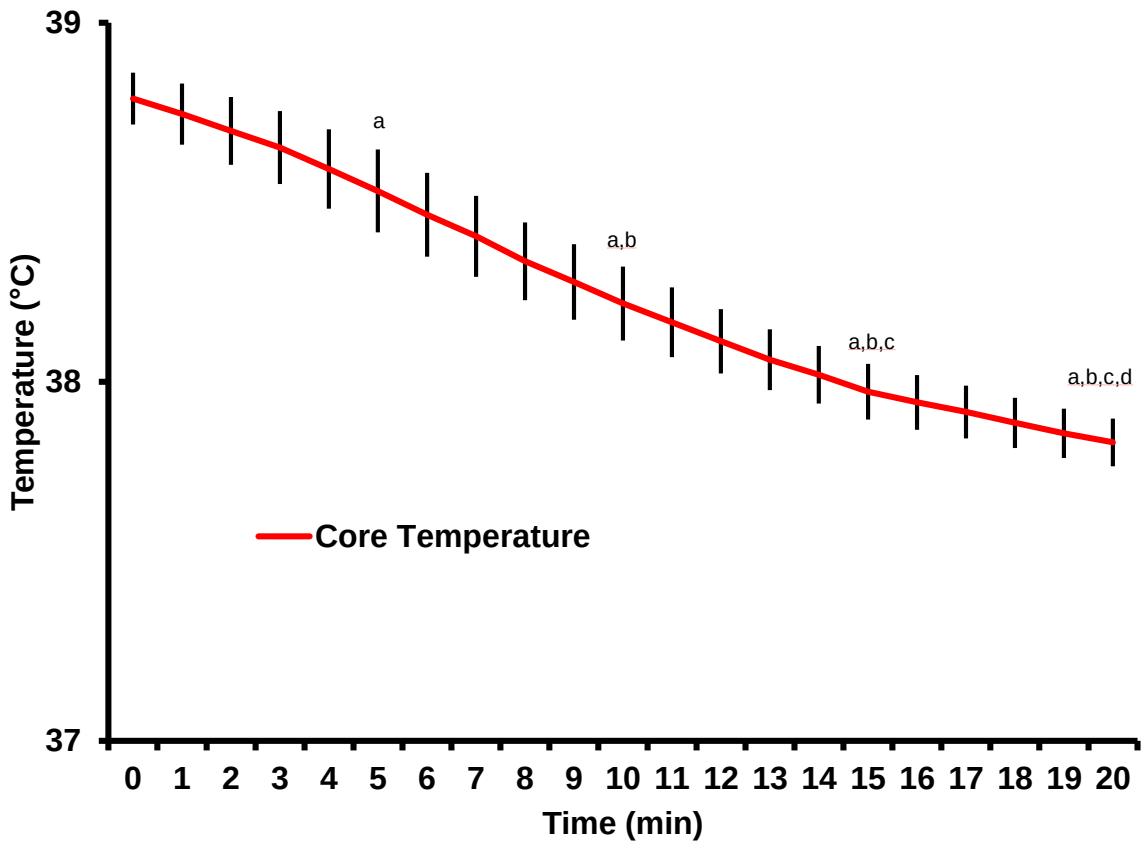


Figure 2. Core temperature data during the 20-minute recovery period. a: different than time point 0, p<0.01, b: different than time point 5, p<0.01, c: different than time point 10, p<0.01, d: different than time point 15, p<0.01

Chest skin temperature (Figure 3) dropped 3.6±0.7°C (0.18°C/min), and leg skin temperature (Figure 3) fell 3.2±0.9°C (0.16°C/min).

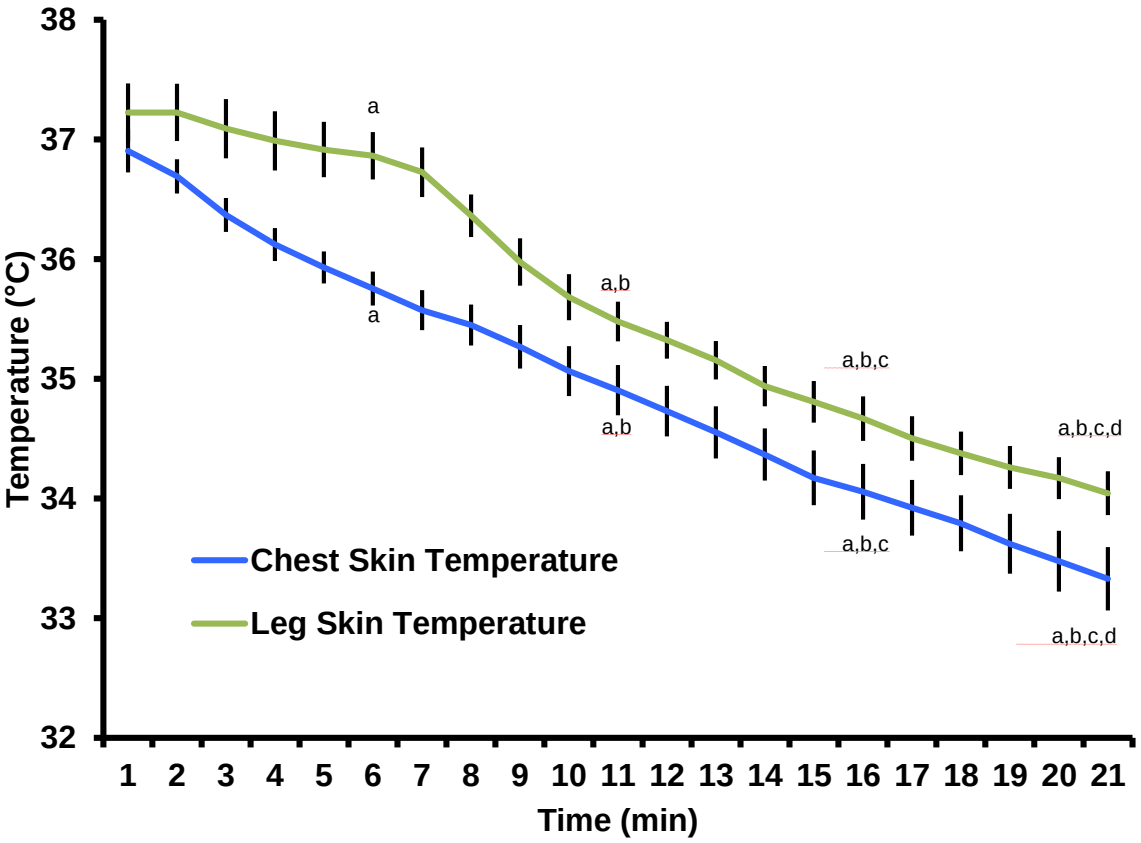


Figure 3. Chest and leg skin temperature data during the 20-minute recovery period. a: different than time point 0, p<0.01, b: different than time point 5, p<0.01, c: different than time point 10, p<0.01, d: different than time point 15, p<0.01

The gradient between the participants' core temperature and chest skin temperature increased reducing the risk of heat injury significantly during the 20-minute recovery. The temperature gradients were; 1.9±0.7°C, 2.8±0.5°C, 3.3±0.8°C, 3.9±0.9°C, 4.5±1.1°C, at time points 0, 5, 10, 15, 20 minutes, respectively.

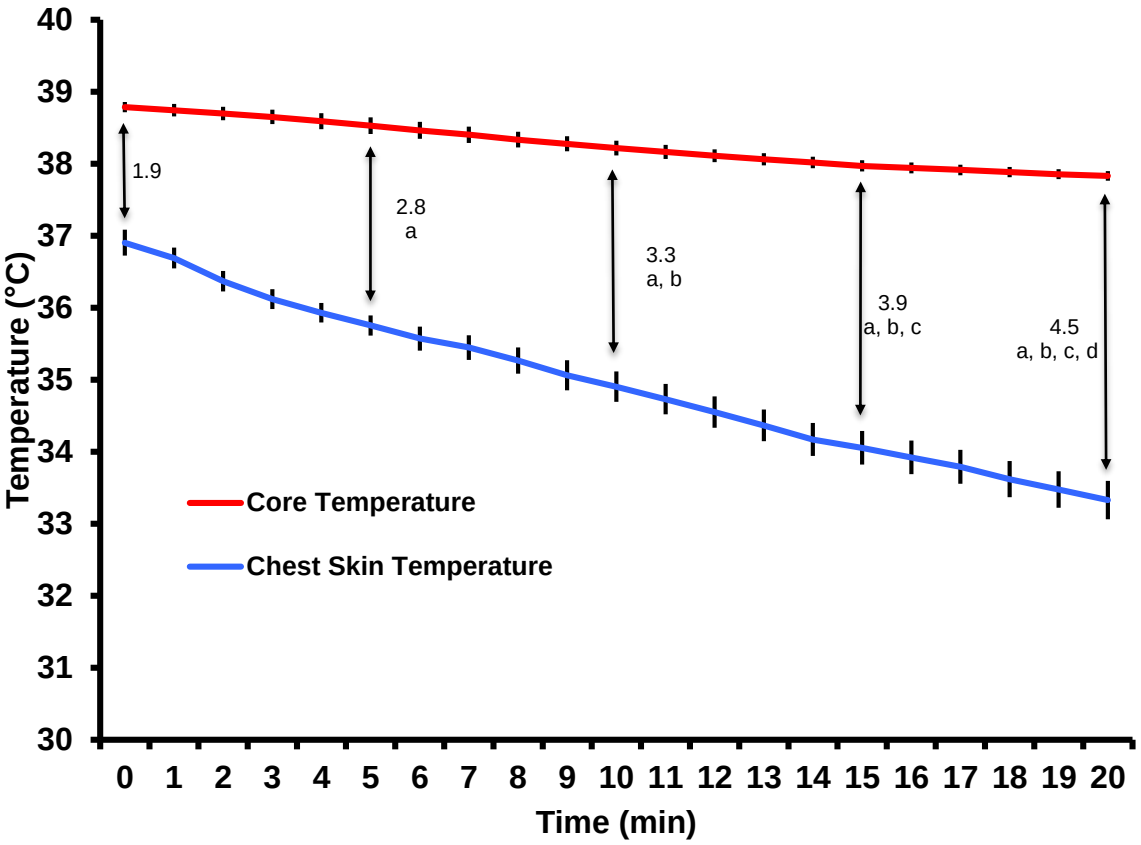


Figure 4. Demonstrates the increasing difference of the chest skin and core temperatures. a: different than time point 0, $p<0.01$, b: different than time point 5, $p<0.01$, c: different than time point 10, $p<0.01$, d: different than time point 15, $p<0.01$

**Discussion**

The placement of the POLAR SKIN™ C2E ICE PACKS and rapid exchange of POLAR SKIN™ ICE SHEETS included in the POLAR SKIN™ COMPREHENSIVE COOLING SYSTEM provided significant cooling of individuals experiencing hyperthermia as a result of exercise.

This rate of core temperature cooling is slightly better than a similar study that used cold-water immersion (Clapp, 2001). In the Clapp et al. study, participants exercised until core temperature reached 38.8°C (the same maximal core temperature used for our protocol). Participants were cooled for 30 minutes using 3 different methods, the most effective method being immersion of the torso in cold water. Their results demonstrated a total core temperature cooling of 1.2±0.46°C in 30 minutes (0.04°C/min). The POLAR SKIN™ COMPREHENSIVE

COOLING SYSTEM protocol developed for the present study, created a total core temperature reduction of 1.0±0.2°C in 20 minutes (0.05°C/min). While the comparison was not done on the same participants, it is clear that the effectiveness of the POLAR SKIN™ COMPREHENSIVE COOLING SYSTEM developed protocol is comparable to data from cold water immersion.

Additionally, as core and skin temperature converge on the same temperature, the risk of heat injury increases. The maintenance or reestablishment of a thermal gradient between core temperature and skin temperature increases the ability of the body to offload heat. Figure 4 demonstrates the increasing temperature gradient between skin and core temperatures as the recovery period progresses. This increasing delta is critical in the removal of heat from the core to the environment and critical to the continued reduction in core temperature.

Finally, it is reasonable to expect a higher rate of cooling as core temperature approaches critical levels (40°C and higher).

**Practical Considerations and Further investigation**

These results demonstrate that a practical, cost-effective treatment tool can effectively reduce core and skin temperature during the initial field care of a heat related injury. Moreover, the logistical requirements associated with the present protocol are less cumbersome and arguably more cost effective compared to constant maintenance of on-location cold-water immersion systems. When considering an emergency procedure standard of practice for the immediate, initial treatment of a heat related injury, these data support the use of the POLAR SKIN™ COMPREHENSIVE COOLING SYSTEM and the above detailed deployment protocol. However, these data must be interpreted within the confines of the current study limitations. To gain additional scientific support for the effectiveness of the POLAR SKIN™ COMPREHENSIVE COOLING SYSTEM a direct comparison with cold-water immersion, the gold standard for rapid body cooling, should be completed. A randomly assigned, counterbalanced crossover designed study will provide objective data comparing the cooling rate of cold-

water immersion directly against the POLAR SKIN™ COMPREHENSIVE COOLING SYSTEM.

**Appendix**

POLAR SKIN™ COMPREHENSIVE COOLING SYSTEM INSTRUCTIONS

1. Remove as much clothing as possible from injured person.
2. Remove POLAR SKIN™ C2E ICE PACKS from silver packaging. Place one POLAR SKIN™ C2E ICE PACKS in each armpit and on the top, inner thigh region.
3. Remove a single POLAR SKIN™ ICE SHEET from silver packaging and cover the injured person's torso and arms from the neck down with the sheet.
    a. Each minute replace the POLAR SKIN™ ICE SHEET with a fresh POLAR SKIN™ ICE SHEET and place the used sheet in a cooler filled with ice water.
    b. Replace POLAR SKIN™ ICE SHEETS once every minute for 6 minutes.
4. After the 6 POLAR SKIN™ ICE SHEETS have been used, begin to deploy the POLAR SKIN™ ICE SHEETS that have been soaking in the ice water and reapply to the injured person two at a time – one to the upper body and one on the legs.
5. Repeat until additional care is available.

**Work Cited**

Clapp AJ, Bishop PA, Muir I and Walker JL. Rapid cooling techniques in joggers experiencing heat strain. Journal of science and medicine in sport / Sports Medicine Australia 2001; 4:160-167