Rectal Temperature Cooling Rates in the Polar Life Pod® are Excellent and Consistent with Stationary Tubs

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Context

- Several tools exist to treat exertional heatstroke (EHS).
- The NATA recommends EHS victims be treated with cold water immersion (CWI) using water between 1.7°C and 15°C so patients' rectal temperature (T_{REC}) cooling rates exceed 0.16°C/min.
- Stationary tubs (TUB) are highly effective for treating EHS, but they may be impractical in certain situations (e.g., wilderness marathons) or when clinicians lack access to large volumes of ice and/or water.
- Portable CWI techniques (e.g., tarps) are becoming increasingly popular for EHS treatment. One commercial product, the Polar Life Pod® (PLP), may be an effective tool for treating severe hyperthermia.
- Little data exist comparing the PLP to TUB or examining subject perceptions following PLP usage.

Research Questions

1. Does the PLP or TUB reduce T_{REC} at "ideal" rates (i.e., >0.16°C/min)?
2. Do T_{REC} cooling rates differ by CWI method?
3. What are subjects environmental symptom questionnaire (ESQ) and thermal sensation perceptions before, during, and after each CWI tool?

Methods

- Randomized, crossover, laboratory study

Procedures

- 13 individuals (Table 1) exercised in the heat until T_{REC} was 39.5°C.
- They immersed themselves in TUB (567.8 ± 7.6 L) or PLP (202.7 ± 23.8 L) until T_{REC} was 38°C (Figures 1-3).
- We used similar volumes of ice (16-24 gallons) in each condition because clinicians need ice for other reasons in their practice.
- Thermal sensation and ESQ responses were recorded before, during, and after exercise and cooling.

Statistical Analysis

- Means and SD for all dependent variables except for nadir T_{REC} which is reported as median and interquartile range.
- Dependent t-tests and repeated measures ANOVAs with Tukey-Kramer post-hoc tests were used as appropriate and data were normally distributed. Wilcoxon signed rank test was used for T_{REC} nadir since normality was violated.
- NCSS v.2007 (α=0.05).

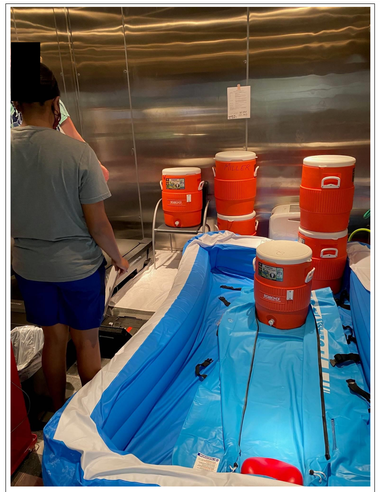

Figure 1. Pre-immersion experimental set-up on PLP days. Six, 10-gallon coolers were prepared with 4 gallons of crushed ice and 6 gallons of water in each cooler.

Figure 2. Subjects lay supine while 40-60 gallons of ice/water were poured into the PLP. The water volume utilized depended on subjects size. PLP length was also adjusted based on subjects' height. The unit was shaken continuously during cooling until T_{REC} was 38°C.

Figure 3. On TUB days, subjects were immersed up to the neck in 150 gallons of water. The water was stirred continuously until T_{REC} was 38°C.

Results

Table 1. Participant demographics and hydration information.

	Polar Life Pod®	TUB
Demographics		
Age (y)	21 ± 2	
Men and women (n)	8 and 5	
Height (cm)	176.2 ± 11.1	
Body mass index	24 ± 2	
Body fat (%)	14 ± 9	
Body surface area (m^2)	1.90 ± 0.20	
Hydration Indices		
Pre-exercise urine specific gravity	1.005 ± 0.002	1.007 ± 0.006
Body Mass pre-exercise (kg)	73.99 ± 11.24	73.96 ± 11.08
Body Mass post-exercise (kg)	73.12 ± 11.12	73.03 ± 11.0
Sweat rate (L/h)	1.03 ± 0.33	1.06 ± 0.34
Post-testing hypohydration (%)	1.2 ± 0.4	1.3 ± 0.5

Data are means ± SD, n=13.

Table 2. Environmental Symptoms Questionnaire (ESQ) Responses with the Polar Life Pod® and TUB

	Polar Life Pod ®	TUB
Pre-exercise	2 ± 2 [a]	2 ± 2 [a]
Post-exercise	25 ± 13	29 ± 14
Post-cooling	25 ± 14 [b]	12 ± 9 [c]

Data are means ± SD (n=13). PLP = Polar Life Pod®. The 16-item ESQ is rated on a 5-point Likert scale with scores ranging from 0 (not at all) to 5 (extreme). ESQ scores at each time point were summed to create a total symptom score for each time which was then statistically analyzed. [a] = Pre-exercise in both conditions < all other times within each condition. [b] = PLP post-cooling > TUB post-cooling. [c] = TUB Post-cooling < TUB Post-exercise. All suprascripts indicate P<0.05.

Table 3. Exercise and cooling data

	Polar Life Pod®	TUB
Exercise Conditions		
Exercise duration (min)	41.6 ± 6.9	42.2 ± 9.3
Environment temperature (°C) [a]	38.6 ± 0.2	38.1 ± 0.2
Environment relative humidity (%) [a]	45 ± 1	47 ± 1
Cooling Descriptives		
Pre-immersion water temperature (°C) [b, e]	3.2 ± 0.6	15.0 ± 0.1
Post-immersion water temperature (°C) [c, e]	4.5 ± 2.3	15.7 ± 0.2
Water volume utilized for cooling (L) [d, e]	202.7 ± 23.8	567.8 ± 7.6
T_{REC} cooling rate (°C/min) [a]	0.28 ± 0.09	0.20 ± 0.09
Nadir T_{REC} (°C) [a]	36.6 (0.9)	37.5 (1.2)
Subjects who self-reported shivering [e] during or after CWI (n)	10	8
Time to shivering onset (min) [e]	3.8 ± 1.8	6.2 ± 3.2

All data are means ± SD except for Nadir T_{REC} which is reported as median and interquartile range (n=13). PLP = Polar Life Pod®, T_{REC} = rectal temperature. [a] = Significantly different between conditions (P<0.05). [b] = For PLP, this is the average water temperature in the coolers. For TUB, this is the temperature at 20 cm from the bottom of the TUB. [c] = For PLP, this is the temperature of the water located near the subjects neck when T_{REC} was 38°C. [d] = These are approximate starting volumes of water used within each condition. Because the PLP was not watertight, some water was lost while attempting to fill the PLP and during cooling. [e] = Data reported descriptively and not statistically analyzed.

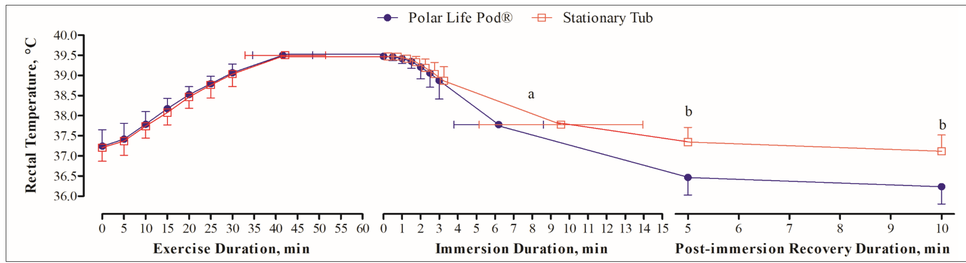

Figure 4. Rectal temperatures during exercise, cooling, and recovery. Time 0 indicates the start of exercise or cooling. X-axis error bars in exercise duration and immersion duration indicate the SD of the final exercise and CWI durations. [a] = PLP cooling duration < TUB cooling duration (t_{12}=2.5, P=0.01). [b] = PLP < TUB (P<0.05).

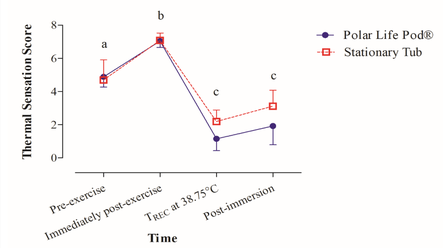

Figure 5. Thermal sensation scores between the PLP and TUB. [a] = TUB and PLP pre-exercise differed from all other times within their respected conditions. [b] = TUB and PLP post-exercise > T_{REC} at 38.75°C and Post-immersion. [c] = PLP < TUB. All suprascripts indicate significance at P<0.05.

Conclusions & Clinical Implications

1. Both the PLP and TUB exceeded expert recommendations for "ideal" cooling rates (i.e., >0.16°C/min) and are excellent options to treat hyperthermia and, potentially, EHS.
2. The PLP cooled hyperthermic subjects faster than TUB and with fewer resources. This was because much colder water temperatures (~3°C vs. 15°C) were possible, with the ice volumes constraints, in the PLP.
3. Subjects felt considerably colder, had lower T_{REC} nadir, and experienced more symptoms of heat illness after treatment with the PLP due to the much colder water utilized. These side effects likely would have also occurred in TUB if similarly cold water temperatures had been used in TUB. Regardless, if CWI is utilized to treat EHS, clinicians should have rewarming strategies (e.g., heated blankets) available to help patients feel better and reduce hypothermic afterdrop post-immersion, if necessary.

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