

*Original Research***Reflective Blankets Do Not Effect Cooling Rates after Running in Hot, Humid Conditions**

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ABSTRACT

International Journal of Exercise Science 8(1) : 97-103, 2015. Reflective blankets (RB) are often provided at the conclusion of endurance events, even in extreme environments. The implications could be dangerous if increased core body temperature (CBT) is exacerbated by RB. To evaluate the effect of RB on cooling rate for individuals walking or sitting after intense running. Pilot, randomized control trial experimental design. Environmental chamber. Recreational runners (age=25±5y; mass=76.8±16.7kg; height=177±9cm) completed an 8km (actual mean distance=7.5±1.1km). We randomly assigned participants into one of four groups: walking with blanket (WB=5), walking without blanket (WNB=5), sitting with blanket (SB=5), or sitting without blanket (SNB=4). Participants ran on a treadmill at their own pace until volitional exhaustion, achieving the 8km distance, or experiencing CBT=40°C. Every three minutes during the running (time determined by pace) and cooling protocol (62 min in chamber), we measured CBT, HR, and Borg scale, and environmental conditions. We evaluated cooling rate, peak physiological variables, pace, and environment by condition using a Kruskal-Wallis non-parametric one-way ANOVAs. We identified similar exercise sessions (df=3; CBT $\chi^2=0.921$, p=0.82; HR $\chi^2=7.446$, p=0.06; Borg $\chi^2=5.732$, p=0.13; pace $\chi^2=0.747$, p=0.86) and similar environmental characteristics between conditions (df=3; Wet Bulb Globe Temperature=26.18±2.78°C, $\chi^2=1.552$, p=0.67). No significant differences between conditions on cooling rate (df=3, $\chi^2=2.301$, p=0.512) were found, suggesting RBs neither cool nor heat the body, whether seated (SB=0.021±0.011deg/min; SNB=0.029±0.002deg/min) or walking (WB=0.015±0.025deg/min; WNB=0.021±0.011deg/min) in a hot, humid environment. CBT in distance runners is not altered by the use of a RB during a seated or walking cool down after a strenuous run.

KEY WORDS: Exertional heat stroke, running, endurance

INTRODUCTION

Marathon runners and other endurance athletes often compete in hot, humid environments throughout the spring, summer, and fall months. At the end of most endurance events each finisher is provided with food, water or other recovery fluids (carbohydrate-electrolyte solution, chocolate milk, etc.), and a

reflective blanket (RB). Although some of these items are scientifically sound choices, several recovery trends are not steeped in scientific evidence, one of which includes RBs. The intended use of the blankets is to retain the metabolic heat produced during running, but often they are used regardless of environmental temperature. The manufacturers of the MCR Medical Thermal Blankets state the main benefit of

the 87" x 59" blankets is to retain up to 90% of the body's heat (1), and in cold-environments may be incredibly effective. However, these RBs are being used post-race despite the ambient temperatures reaching 100°F throughout the racing season. When running, the core body temperature (CBT) naturally increases due to metabolic heat (3). Upon completion, we anticipate CBT decreases, simply due to a change in intensity (3), but some external factors (clothing, RBs, etc.) can inhibit cooling. RBs seem to be counterintuitive to the need to return to baseline CBT, especially when used in hot, humid environments. If body heat is retained by a RB or additional clothing, the human body will have difficulty dissipating heat and returning to normal, resting CBT. When CBT remains elevated despite ending exercise, undesired stress is placed on the cardiovascular system as the body continues to use its cooling mechanisms, against resistance. The purpose of this study was to evaluate the effect of RBs on cooling rate. We hypothesized participants using the blankets would have a slower CBT cooling rate than the participants who did not use the blankets.

METHODS

Participants

After receiving IRB approval, we recruited 19 healthy, endurance-trained individuals. Participants included 14 males and 5 females (age=25±5y; mass=76.8±16.7kg; height=177±9cm) who ran a minimum 10 mi/wk for at least the last three months. Exclusion criteria included history of stroke, cardiovascular disease, recent incident of exertional heat stroke (within 6 months), diabetes, recent history of lower extremity injury/surgery (within 6

months), smoking, or taking medications that alter heart rate.

Protocol

We used a pilot, randomized control experimental design to observe the effect of RBs on CBT cooling rate. We used four conditions: no blanket, blanket, recovery walking with blanket, and recovery walking with no blanket. Because some participants rarely sit, unless unable to ambulate, immediately following a race, we attempted to replicate the activities post-race. The seated individuals simply sat wearing or not wearing the RB. Those walking on the treadmill were instructed to casually walk during the recovery period (at no elevation).

Participants completed a health history questionnaire during the pre-screening session on the study prior to participation in the protocol. The participants completed the questionnaire to exclude anyone who may not have met the inclusion criteria and to gather demographic data.

During the pre-screening session, we measured height in centimeters using a standard wall mounted tape measure (Novel Products; Rockton, IL), body mass using a standard physician scale (Transcell TI 500E; Koenig Scale, Terre Haute, IN), resting heart rate and blood pressure using an automatic sphygmomanometer (HEM-780, Omron; Bannockburn, IL).

During the pre-screening session, we scheduled the participant for the exercise session. Within 24 hours of the exercise session, we met with the participant to ensure they were in good health and provided them with the ingestible thermistor (Jonah capsule, MiniMitter

Company, Inc; Bend, OR). We randomly assigned participants into one of four groups for the cool down protocol: walk with blanket (WB) (n=5), sit with blanket (SB) (n=5), walk without blanket (WNB) (n=5), sit without blanket (SNB) (n=5). On the day of the exercise session, participants reported to the environmental heat chamber in shorts, t-shirt, and athletic shoes. A self-selected warm-up was allowed for as long as desired prior to the official start of data collection.

To monitor and maintain consistency between exercise sessions, we measured fluid consumed, environmental conditions, distance, heart rate, and rating of perceived exertion. Participants rehydrated freely with lukewarm water during the exercise and cooling period. After the entire protocol was complete, we measured the volume of the fluid (mL) consumed by using a metered water bottle (mean=850±270mL; no significant differences between groups $F_{3,15}=1.497$, $p=0.256$; range=700-1040mL).

We measured wet bulb, dry bulb, and wet bulb globe temperature as well as relative humidity in the environmental heat chamber (which includes radiant heat lamps to replicate sunshine). We measured environmental variables using an Area Heat Stress Monitor (hs-32 Metrosonics, Quest Technology; Oconomowoc, WI). We maintained a stable hot, humid environment between conditions (Wet Bulb=22.84±1.28°C; Dry Bulb=29.85±1.35°C; Wet Bulb Globe Temperature=26.18±2.78°C; Relative Humidity=43.57±11.15%) comparable to similar studies in-vivo and in-vitro (4, 5).

To monitor CBT, participants swallowed a small capsule, the Jonah Ingestible Core Temperature Capsule, 5-8 hours before activity. The capsule measures CBT and transmits a signal to the VitalSense® Monitor (MiniMitter Company, Inc; Bend, OR). We used the capsule and monitor to gather data in real-time and we measured CBT throughout the data collection session.

While on the treadmill, we monitored distance with the intention that all participants complete an 8km run (actual distance mean=7.5±1.1km). Due to some IRB limitations, we asked that participants control their own intensity and for as long as they could without experiencing signs and symptoms of exertional heat stroke. Because of the environmental conditions, some individuals were unable to complete the 8km run, but achieved an elevated CBT. We used a heart rate (HR) monitor (Polar FTI; Lake Success, NY) to measure the participants HR and we used the Borg Scale (6-20) to rate the perceived exertion (RPE) to monitor perceived intensity.

As participants were running, we monitored CBT to ensure it reached the desired temperature of 103.5-104°F (39.22°-40°C) and to avoid risk of exertional heat illness (>104°F). The cooling protocol began once the participants reached the target temperature, completed the 8km run, or until they expressed a desire to stop running. We measured the athletes CBT, RPE, and HR every three minutes during the exercise protocol until the CBT reached 39°C., at which time we measured these three factors every minute for the remaining duration of the exercise protocol.

REFLECTIVE BLANKETS AND CORE BODY TEMPERATURE

Table 1. Accessory physiological and environmental variables establishing that conditions were not significantly different.

Accessory Variable	Walking with Blanket	Seated with Blanket	Walking with No Blanket	Seated with No Blanket	Grand Mean±SD	Kruskal-Wallis Statistic (df=3)	Statistical Significance
Peak Core Body Temperature (°C)	39.2±0.2	39.3±0.3	39.1±0.2	39.5±0.1	39.3±0.5	0.921	p=0.82
Peak Heart Rate (bpm)	181.4±2.4	183.0±4.5	188.6±1.9	195.0±2.9	186.6±8.1	7.446	p=0.06
Rating of Perceived Exertion (rpe)	16.2±0.6	15.4±0.5	17.4±0.7	17.8±0.9	16.6±1.7	5.732	p=0.13
Pace (meters/minute)	194.0±16.4	191.5±11.2	202.1±14.4	184.7±11.5	193.5±28.2	0.747	p=0.86
Dry Bulb Temperature (°C)	30.5±0.9	30.2±0.6	29.5±0.3	29.0±0.2	29.9±1.4	4.131	p=0.25
Wet Bulb Temperature (°C)	23.6±0.5	22.5±0.6	22.8±0.5	22.3±0.8	22.8±1.3	2.173	p=0.54
Wet Bulb Globe Temperature (°C)	26.9±1.2	27.1±2.1	25.5±0.3	25.0±0.5	26.2±2.8	1.552	p=0.67
Relative Humidity (%)	44.3±3.8	39.0±5.1	45.2±5.7	46.4±7.2	43.6±11.2	1.985	p=0.58

If a participant was in the WB or SB groups, we immediately placed a RB over their shoulders when they finished running. The cooling data was recorded for a total of 62 minutes following the completion of the running protocol. CBT and HR measurements were taken every minute for the first 20 minutes of the protocol to ensure participant safety, and were then measured every three minutes for the remainder of the cooling protocol. At the conclusion, we calculated the rate of cooling (62 minutes used due to the 3 min intervals).

Statistical Analysis

We used separate Kruskal-Wallis non-parametric one-way ANOVAs (which is reported as a χ^2) to evaluate peak CBT, HR, RPE, running pace, and environmental variables for each of the four conditions. Because of the small sample size, we used the Kruskal-Wallis to compare the cooling rates in each condition. Significance was achieved at $p < 0.05$ and analysis was performed using SPSS for Windows (version 20).

RESULTS

Participants completed the exercise sessions with similar intensity and under similar conditions, as none of the conditions

demonstrated significant differences for CBT, HR, RPE, or environmental measures (Table 1).

We did not identify any significant differences between conditions on cooling rate ($df=3$, $\chi^2=2.301$, $p=0.512$, $1-\beta=0.512$, $ES=0.005$) or at the end of the cooling period ($df=3$, $\chi^2=0.658$, $p=0.883$, $1-\beta=0.90$, $ES=0.117$), suggesting RBs neither cool nor heat the body, whether seated ($SB=0.021\pm0.011\text{deg/min}$, $37.9\pm0.3^\circ\text{C}$; $SNB=0.029\pm0.002\text{deg/min}$, $37.6\pm0.1^\circ\text{C}$) or walking ($WB=0.015\pm0.025\text{deg/min}$, $37.9\pm0.5^\circ\text{C}$; $WNB=0.021\pm0.011\text{deg/min}$, $37.8\pm0.1^\circ\text{C}$) in a hot, humid environment (Figure 1).

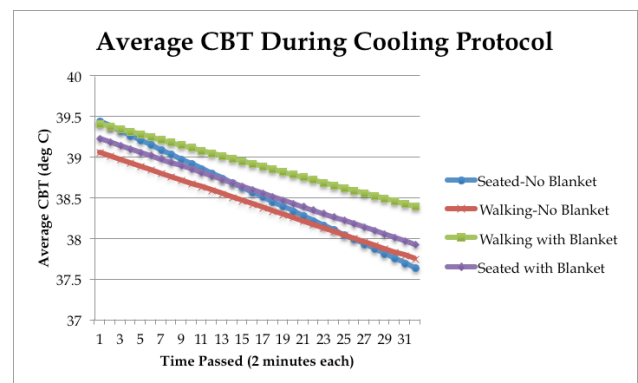


Figure 1. Graph indicating the rate of change in CBT during the cooling protocol in comparison with each of the research groups.

DISCUSSION

Our primary purpose was to determine the degree that RBs effect cooling rates when utilized by runners following an 8km run in a hot, humid environment. In the four groups, we observed cooling rates of athletes while seated and walking in a hot, humid environment. We hypothesized the use of RBs post-race by distance runners would decrease the cooling rate. However, our results indicate the RBs neither impede nor expedite CBT cooling an 8km run in a hot, humid environment.

Although not significant, the WB elicited the least amount of cooling while the SNB showed the greatest amount of cooling. This observation may indicate a trend towards inhibited cooling when an athlete completes an active cool down with the use of a RB, due to maintained metabolic heat production, compared to WNB. We observed the largest amount of cooling when an athlete cooled passively without the use of a RB, yet not statistically different between groups. Our power analysis indicated moderate to strong power, yet little effect. As compared to other methods of cooling, these methods would not be recommended for rapid cooling in the case of exertional heat stroke (7).

The amount of metabolic heat produced is unique to the individual and the environmental circumstances. Adenosine triphosphate is produced and metabolized in the body, and used for mechanical energy accounting for no more than 25% of the energy utilized. The remainder is released from the body as heat. When the hypothalamus is stimulated by thermoreceptors, indicating an increase in CBT, the sympathetic nervous system

causes increased blood flow to the skin and increased sweat production to cool the body (9). The four mechanisms of CBT cooling are evaporation, radiation, convection, and conduction (9). During prolonged exercise, evaporation, radiation, and convection are the primary methods utilized. Conduction only occurs when coming into contact with other materials (9). During our investigation, conduction may have contributed to the cooling rate in the conditions with RBs, while evaporation would have been inhibited. On the contrary, in the SNB and WNB conditions, evaporative cooling would have played the primary role in decreasing CBT.

Other intrinsic factors playing a major role in metabolic heat production are the body size and metabolic rate of each athlete (8-10). Extrinsic factors that inhibit the amount of CBT cooling are the environmental temperature, humidity, air flow, intensity, clothing, and equipment (10). Each of these plays their own role in inhibiting natural methods of cooling by influencing the ability for radiation, evaporation, convection, and conduction to occur in the body. Radiation occurs most when at rest and is caused by the body releasing infrared rays to all surrounding objects as long as the body has a higher temperature than these objects. Evaporation is the primary means of cooling while exercising where it can account for up to 80% of cooling (9). When sweat is produced, it is converted to vapor which releases excess heat. In our study, radiation, evaporation, convection, and conduction should have occurred similarly because the environmental conditions were consistent between conditions. Differences in cooling rates, although not significant, could be attributed to the athletes' clothing and/or

the RBs that impede natural cooling mechanisms of the human body.

Sweat production plays a major factor in CBT regulation. Casa, et al. states changes occur in HR and CBT up to an increase of 0.12°C to 0.25°C and 3-5 beats/min for every 1% decrease of an individual's body mass, which is primarily body water loss (4). Maintaining hydration levels greatly assist in maintaining lower CBT and HR levels during endurance activities (2, 4, 6). While completing aerobic activity for long periods of time, cardiovascular drift naturally rises placing increased demands on the heart to continue to produce the same cardiac output (CO). This cardiovascular drift is caused by an increased amount of blood needed at the skin, but not returning to the heart. Therefore, the HR increases to maintain CO. When hypohydrated the viscosity of blood increases because of reduced plasma volume. Blood flow is then hindered and cardiovascular drift continues to rise. Eventually, the body cannot manage both the needed increase in HR to manage CO (4, 6, 9). When RBs are placed over the body's surface, the natural mechanism of evaporative cooling to dissipate sweat and the conduction of another surface on the skin may inhibit cooling. Although not different between groups, the loss of natural mechanisms to cool and the continuation of metabolic heat production during active recovery may have equally contributed to slower cooling rates, as did the environmental conditions.

Our initial hypothesis was based on potential factors impeding cooling in association with RBs. Due to the amount of metabolic heat likely to be retained when using the RBs, it seemed the temperature

surrounding the body would remain elevated. As a result, the primary means of cooling would be evaporation, which would be limited by the blanket covering the athlete. With the increase in sweat produced during the cooling process, it seemed likely HR and temperatures would maintain their levels or even increase (2, 4, 6). During the cooling protocols, the blanket conditions also limited convection from becoming a major cooling influence by limiting air flow. Based upon Casa, et al. we expected intensity during the cooling protocol to play a major factor and cause the participants required to walk to have slower cooling rates throughout the data collection due to the metabolic heat being produced (4). Although our results were not shown to be significant, the cooling rates in this study were drastically slower than any other means discussed in the literature.

To standardize our protocol, we could have evaluated VO_2max values of the participants to fix both exercise and cooling intensity. Also, we did not measure hypohydration including sweat rate, percent body mass loss, urine osmolality, and other clinical measures, which could have played a role in limiting cooling (as the RB may have prohibited evaporative and convection cooling, while increasing conduction). Anecdotally, participants disliked wearing the RB and felt hot and became irritable. Providing a mechanism to collect qualitative data regarding how the RBs felt would have enhanced this investigation.

This study represents the first to evaluate the effect of RBs on CBT cooling rates. We did not see any significant differences in CBT cooling rates that would have been

caused specifically by the RBs retaining metabolic heat produced by the athletes whether they were walking or seated with or without a RB. This is contrary to our initial hypothesis that the retention of this metabolic heat would cause temperatures to stay elevated for increased durations following exercise. Overall, RBs neither elongated nor expedited cooling after an 8km run in a hot, humid environment. RBs are neither essential, nor necessary after the conclusion of a race in a hot, humid environment, similar to the one replicated in our study.

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