The Impact of Wrist Cooling with the Novel Dhama Technology on 10km Running Time Trial Performance in the Heat

Stephen J. Ives, Ph.D., EP-C, CSCS

INTRODUCTION

The profound impact of environmental heat stress on exercise performance is both well-documented scientifically, and appreciated by the athletic community. Specifically, marathon run performance is known to be significantly impaired with increasing temperature, and lab-based studies also demonstrate notable reductions in performance (2).

Environmental heat stress is known to increase strain on the cardiovascular system in particular (1). Similarly, exercise also induces stress on the cardiovascular system, and thus the combination of heat stress with exercise is a potent challenge, because of the need to supply large amounts of blood, and oxygen, to working muscles while also needing to send blood to the skin to dissipate heat. These high demands for blood flow begin to challenge the maximal output of the heart, contributing to fatigue, exhaustion, and/or a decline in exercise performance (1, 3, 6).

Accordingly, researchers have been developing strategies to prevent heat stress associated declines in exercise performance. One such approach has been the use of pre-cooling prior to exercise in the heat (3, 7). A review suggested that pre-cooling via cold water immersion likely benefits performance (3), where ingestion of crushed ice/water ice slurry may benefit performance but the effect can be short lived (3, 7), and wearing cooling garments prior to exercise demonstrate modest benefits (3). Though the benefits of pre-cooling are not to be ignored, the issue of practicality raises serious concern over implementation, in fact one author went as far to say "with respect to cooling method, practicality for training and competition should be the main focus beneath efficiency", and thus practical methods need further exploration (7).

Recently, Dhama innovations has developed a wearable, active cooling device that is light weight and can be worn on the wrist during activity (similar to wrist worn Activity/HR/GPS units) while posing minimal disruption to the athlete. However, it has yet to be determined whether such a cooling band is capable of improving endurance performance in the heat and additionally what impact this may have on post-exercise recovery.

Therefore, we sought to investigate whether the *dhamaSPORT*™ wrist cooling bands improve exercise performance in the heat, lessen the physiological strain, or improve recovery. We hypothesized that: use of the Dhama wrist cooling band would reduce perceptions of effort and thermal stress, reduce heart rate, and improve performance on a 10km running time trial, and these effects would be greater with the use of 2 cooling units. Second, use of the cooling bands would improve: recovery of heart rate, blood pressure, heart rate variability, core temperature, and would reduce fatigue and thermal sensations, all of which would also be greater with the use of 2 bands.

METHODS

Athletes

Thirteen exercise-trained healthy male volunteers between the ages of 18 and 54 years were recruited for this study. To participate in this study, all athletes must have been regularly exercise training for more than one hour at least three times a week for the past four months, and have a relatively high aerobic fitness (VO_2max of >45 ml/kg/min). All athletes provided written informed consent prior to any testing. The protocol was approved by the local ethics committee.

The athletes we recruited were all experienced runners (5km, 10km, half and/or full marathon experience) and/or triathletes (sprint, Olympic, half and full ironman experience). They were on average: 33 years old, 15% body fat, and had a VO_2max of 59 ml/kg/min. To put this in context, all athletes tested within the top 5% for their age, that is they were fitter than 95% of their age group.

Study overview

The current study was conducted in a blinded counterbalanced crossover design to investigate the potential impact of wrist cooling on performance in, and recovery from, exercise in the heat (See Figure 1 below for overview).

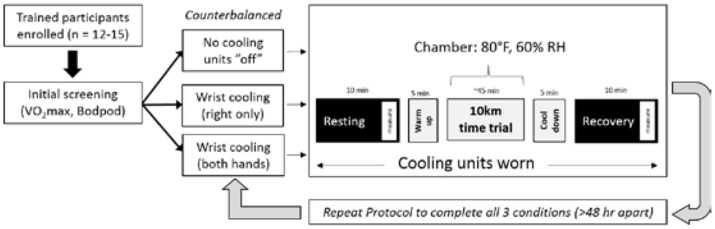


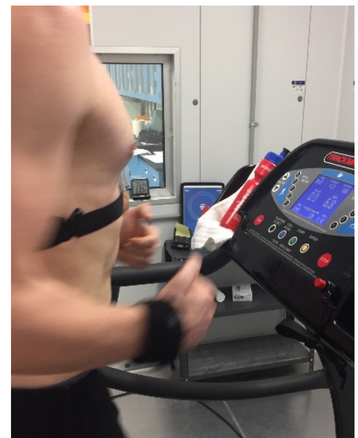
Figure 1. Overview of the study design

Which means the athletes were not told which condition they were in, the order in which they completed the trials was accounted for, the athletes completed all conditions, and they wore the devices on all visits. For each visit, athletes were asked to prepare for each session as if it were a race, arrive rested, hydrated, and fueled. Athletes were instructed to maintain a similar diet, hydration, and sleep regimen throughout the duration of the study. All athletes were asked to report to the laboratory on four separate occasions: a screening day and 3 experimental trials. The first visit was to assess participant characteristics including: body composition (% body fat via BodPod) and aerobic fitness via graded exercise testing on a treadmill to determine maximal oxygen consumption (VO_2max) a gold standard indicator of aerobic fitness. The modified McConnell protocol (4) was used to determine VO_2max and is an appropriate test for runners.

Procedures

Upon arrival for each study visit athletes provided a urine sample to ensure adequate hydration. Athletes were then equipped with a heart rate monitor (H7, Polar USA, Lake Success, NY), and 2 Dhama wrist cooling units (*dhamaSPORT™*, Gen II). In one condition, both units were "off" (off/off); in the second condition, one was turned "on" (highest setting, 44°F) and the other "off" (off/on); and in the third condition, both units were turned "on" (again highest setting) (on/on). Once set up, athletes were escorted to a chair and allowed to rest for 10 minutes, after which a battery of baseline assessments were performed, specifically: core temperature, heart rate and heart rate variability (an indicator of athlete stress/recovery) via heart rate monitor, thermal sensation via thermal sensation scale, fatigue via a visual analog scale (5), and blood pressure via the mobilograph (GmbH, Germany).

After attaining baseline measures, athletes were then allowed to warm up for ~5 minutes outside of the environmental chamber in normal room temperature. After warm up, they were then escorted into an environmental chamber at ~80 °F and 60% relative humidity. Once in the chamber, athletes were instructed to complete the 10km time trial (~6.2 miles) as fast as possible. Thus, athletes were in direct control of the treadmill speed. Athletes were provided encouragement throughout the trials. Athletes were allowed to drink water freely during all trials. During exercise, athletes were asked to report their thermal sensation ("how hot they felt"), rating of perceived exertion ("how tired they felt") using standardized visual scales every 5 minutes, while heart rate and core temperature were monitored continuously and recorded every minute. If core temperature rose from normal 37°C (98.6 F) to 39.1°C (102.4 F) or higher, we had to end the trial due to safety concerns of the participant.



Athlete Running with Dhama band

Once the 10km time trial was completed athletes were removed from the chamber and performed a cool down outside of the chamber. HR and core temperature continued to be monitored for safety reasons. Fifteen minutes after the cessation of the exercise, we obtained a post-exercise assessment of the same baseline measures, namely: fatigue, thermal sensation, core temperature, HR, HRV, and BP. Once post-exercise measures were obtained, the Dhama wrist cooling units were turned off and removed. Athletes then reported back to the lab to complete the other two trials in a random order as described above. Visits were completed with a minimum of 48 hours in between, but were typically 96 hours apart.

RESULTS

Impact of dhamaSPORT™ at Rest

The bands had no positive or negative effect on core body temperature, heart rate variability (athlete stress/recovery), blood pressure, thermal sensations (how hot or cold they felt), or fatigue at rest (Table 1). When the bands were turned on, resting heart rate did tend to increase 3-5 beats/min, while statistically significant this was not a large change in practical terms.

Table 1. Baseline measurements comparisons.

Variable	OFF/OFF	OFF/ON	ON/ON
Core Temperature (°C)	37.0 ± 0.5	37.2 ± 0.6	37.1 ± 0.7
Heart Rate (bpm)	56.0 ± 7.0	61.0 ± 8.0 *	59.0 ± 6.5
RMSSD	109.0 ± 48.0	97.6 ± 41.8	106.4 ± 49.5
Mean Arterial Pressure (mmHg)	106.0 ± 11.0	108.6 ± 11.4	105.5± 10.4
TSS	3.4± 0.6	3.2± 0.4	3.5± 0.6
RPE	2.0± 1.0	1.5±0.7	2.0±0.6
VAS (Fatigue)	1.4± 1.3	1.7±1.1	1.2± 1.0

*** main effect of condition**
Means ± Standard deviations. Significance set at p<0.05

RMSSD is an indicator or heart rate variability; TSS is thermal sensations (0-8 scale); RPE is Rating of Perceived Exertion or "tiredness" (0-10 scale); VAS is visual analog scale (0-10 scale).

Impact of dhamaSPORT™ on Performance

Use of the Dhama cooling bands resulted in a statistically meaningful increase in running speed over time (Figure below).

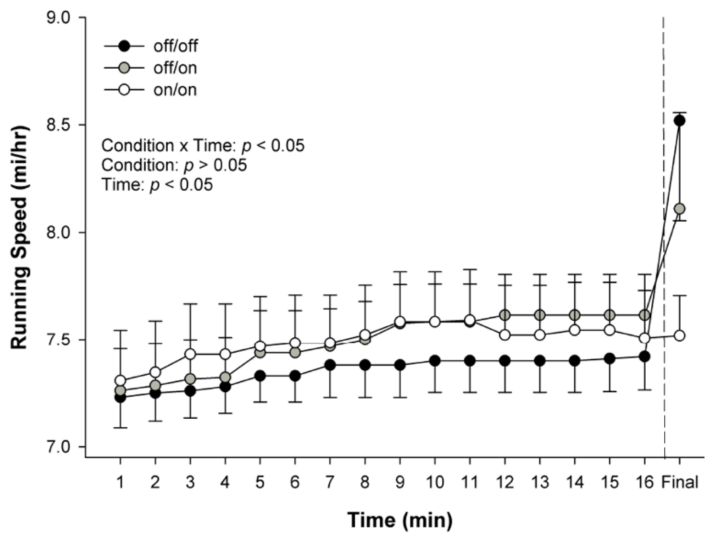


Figure 2. Effect of dhamaSPORT™ cooling bands on self-selected running speed during the 10 km TT. Averages ± SE.

However, due to safety constraints and concern for participant safety, we had to pull several athletes which prevented them from completing the 10km time trial. This occurred in all conditions (both bands off (off/off), one on (off/on), and both units on (on/on)). Though, in the interest of understanding the impact of the Dhama cooling bands on performance, we took the self-selected treadmill speed/pace for each participant, up to the point where we had to end the trial, and predicted their 10km time. What we found was that athletes ran ~10-30 seconds faster with the use of the bands (Figure 3 below). Importantly, this may underestimate the potential performance benefit of the Dhama bands as the athletes didn't have the chance to fully execute their race plan (e.g. negative split and/or sprint). Based upon the study design, a placebo effect was not possible.

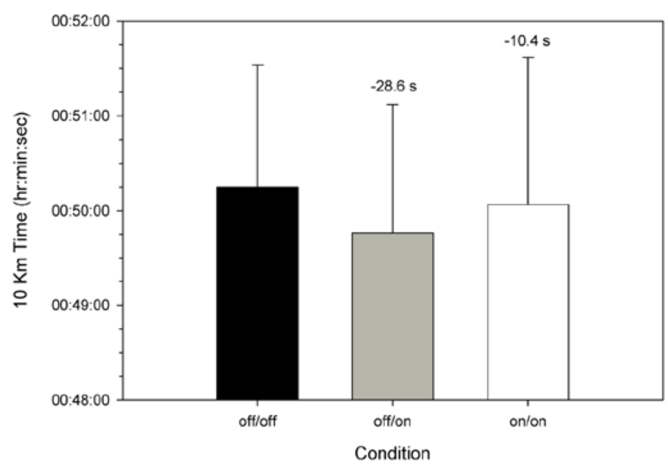


Figure 3. Impact of the dhamaSPORT™ cooling bands on predicted 10km time trial performance. Averages± SE.

Impact of dhamaSPORT™ on Physiology

Use of the Dhama cooling bands did not affect core temperature, and initial review of data suggests use of the bands might result in an increase in temperature. However, when we take into account the increased running speed, any such effect disappears. Thus, while the bands might not be capable of mitigating rise in body temperature during a maximal effort 10km-running time trial, they do increase running speed which in of itself, naturally increases body heat. Interestingly, despite a faster running speed, and possibly greater heat load, athletes did not rate their fatigue or thermal sensations higher.

Impact of dhamaSPORT™ on Recovery

The cooling bands did not enhance or impede recovery, as indicated by blood pressure, heart rate, and heart rate variability. The athletes also rated their post-exercise fatigue and thermal sensations similarly between trials. Which again, given they were running faster, it would be expected that they would have reported higher thermal sensation (how hot they felt) and/or fatigue, but this was not the case.

CONCLUSION

We found that when athletes used the *dhamaSPORT™* cooling wrist bands, they ran faster, resulting in faster projected 10km times, on average 20 seconds faster with the use of the bands. To put this into perspective, when looking at the pro men's results of the 2016 AJC Peachtree road race, one of the nation's largest 10km events, run in Atlanta, GA during July (similar environmental conditions at race start to those in our study) a 20 second boost in performance could mean being on the podium or not. For the Bolder Boulder 10km race 1st place through 6th in the pro division was separated by 20 seconds.

The athletes in the current study tolerated use of the band during the 10km time trial quite well and they enjoyed the cooling action during the recovery period. If you are an athlete and are looking to improve your performance during exercise in the heat, the *dhamaSPORT™* is likely to improve your performance without increased sensation of fatigue or thermal strain.

About the author: Stephen J. Ives, Ph.D., CSCS, EP-C, is an Assistant Professor of Health and Exercise Sciences at Skidmore College. Dr. Ives is an American College of Sports Medicine Certified Exercise Physiologist, and National Strength and Conditioning Association, Certified Strength and Conditioning Specialist. He has authored 52 scientific publications, including work on interventions in sports performance. Dr. Ives was a competitive rower, and is now a recreational cyclist.

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