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Ice vests extend physiological work time while wearing explosive ordnance disposal protective clothing in hot and humid conditions

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ABSTRACT

Background: Explosive ordnance disposal (EOD) technicians may be required to work in hot, humid environments while wearing heavy protective clothing. We investigated the ability of an ice vest to attenuate physiological strain and subsequently extend work tolerance.

Methods: Eight male participants (24.3 ± 4.1 yr, 51.9 ± 4.6 mL kg^{-1} min^{-1}) walked (4.5 km h^{-1}) in simulated hot and humid conditions (35 °C; 50% relative humidity). Participants wore either an EOD suit (CON) or EOD and ice vest (IV). Heart rate, core and skin temperature were recorded continuously.

Results: Participants walked longer in IV compared to CON (8.1 ± 7.4 min, $p < .05$). Over 90% of trials were terminated based on participants reaching 90% of their maximum heart rate. IV resulted in cooled skin ($p < .001$) and a physiologically negligible change in core temperature ($p < .001$). A condition by time interaction was identified for heart rate ($p < .001$), with a lower rate of rise in the IV condition.

Conclusions: The cardiovascular inefficiency that limited performance was attenuated in the IV condition. The ice vest facilitated heat loss from the periphery; thus, the observed reduction in heart rate may reflect the preservation of central blood volume. The results identify the efficiency of a simple, inexpensive ice vest to assist EOD technicians working in the heat.

1. Background

Due to the hazardous nature of their work, those in the Explosive Ordinance Disposal (EOD) division don personal protective garments before entering the field. Tasked with searching for, disarmament and clearing of explosive devices, these ensembles are designed to protect individuals from injury or death in the event of a detonation. As expected, such ensembles consist of thick impermeable material and multiple shielding panels, which contributes considerably to the garment's mass (~35 kg). Unavoidably, the ensemble layers insulate the wearer and compromise heat dissipation into the environment (Potter et al., 2021), and its cumbersome and rigid design increases the metabolic heat produced (Bach et al., 2016) as movement is restricted. With impaired heat loss and increased heat gain, internal heat storage accumulates, and a condition of uncompensable heat stress is formed. If unable to regulate thermal load, technicians become at risk of heat illnesses. Missions conducted in hot and humid geographic locations exacerbate the thermal burden experienced by operators (Stewart and Townshend, 2013), increasing their risk of heat strain. Under such conditions, safe work duration can be limited by thermoregulatory and cardiovascular strain, reducing physiological tolerance and thus the time available for personnel to complete missions safely (Stewart et al., 2014; Costello et al., 2015; Potter et al., 2021). Personal cooling devices have been sought as potential solutions to alleviate physiological heat stress responses and extend work time (Chan et al., 2015).

Personal cooling systems have been developed and tested in recent years for application in the emergency services (Li et al., 2021), occupational (Gao et al., 2010), athletic (Tyler et al., 2015) and at-risk cohorts (Johnston et al., 2006; Meyer-Heim et al., 2007). Designs have included liquid, air, and phase change systems, in partial or whole-body covering, portable and tethered systems. Due to the situational needs and constraints associated with EOD work, only portable systems are

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feasible. Active cooling configurations have been trialled with the EOD ensemble however only in earlier works. The liquid and air-cooled systems in these studies attenuated physiological strain during laboratory simulated work tasks, however they were noted to be complex to operate, restrictive, challenging to remove, heavy and overall, not compatible with EOD work (Masadi et al., 1991; Frim and Morris 1992). While smaller, lighter and more efficient active cooling garments have since been developed (Bach et al., 2020; McEntire et al., 2013), they have not been investigated with the EOD suit. In ensembles with similar characteristics (firefighting and chemical protective suits), these modern iterations have been shown to beneficially reduce physiological strain (McEntire et al., 2013; Chan et al., 2015). However, the additional weight of the device (power, pump and coolant supply) and the tendency for movement to occlude flow within the reticulated tubing, still limits the practicality of these garments (Kim et al., 2011; Chan et al., 2015).

More suited to field settings, phase change garments act as a heat sink, absorbing internal heat from the skin and shifting from a solid to a liquid form during the process. A recent investigation assessed the physiological effect of a phase change vest (melting point 25 °C) beneath the EOD ensemble while working in uncompensable conditions with promising (reductions to physiological and perceptual strain) results when the cooling vest was replaced during an exercise battery, albeit in a small cohort, $n = 5$ (Davey et al., 2020). Ice is the most common form of phase change material and has been shown to reduce thermal strain while wearing personal protective clothing (House et al., 2013; Bach et al., 2019; Maley et al., 2020). However, to the authors' knowledge, the application of an ice vest under the EOD ensemble in hot conditions has not yet been examined. Establishing this may highlight the potential benefits of phase change cooling devices to assist EOD technicians in extending safe work limits or performing current activities under reduced heat strain in environmental extremes.

This study aimed to investigate the effect of an ice vest on physiological responses and work capacity while in an EOD ensemble in simulated conditions. It was hypothesised that the ice vest would alleviate the physiological strain and extend work time while wearing the EOD ensemble in hot, humid conditions.

2. Methods

2.1. Participants

Eight healthy recreationally trained males participated in the study. Individuals were screened against eligibility criteria and provided written informed consent before participating. Ethical approval was attained from the Queensland University of Technology's Human Research Ethics Committee. Table 1 contains the sample's demographic details, anthropometrics, and aerobic capacity.

2.2. Experimental design

Participants attended the laboratory on three occasions. Sessions were separated by at least seven days, the trial order was randomized (v4 Research Randomizer Form), and participant testing time for both sessions was maintained to control any variances in circadian rhythm and subsequently thermoregulation (Mills, 1966).

Table 1
Participant characteristics presented as Mean (SD).

Age (yr)	Height (m)	BM (kg)	FM (%)	BSA (m^2)[a]	VO_{2PEAK} [mL $kg^{-1}min^{-1}$]
24.3 (4.1)	1.8 (0.5)	84.9 (14.2)	20.6 (7.8)	1.95 (0.12)	51.9 (4.6)

BM = body mass; FM = fat mass; BSA = body surface area; VO_{2PEAK} = peak oxygen consumption.

[a] Derived from Du Bois and Du Bois (1916).

In session one, participants were familiarised with the laboratory equipment, personal protective clothing and experimental procedures. Participants' height, nude body mass and body fat were measured before performing a progressive incremental running test to exhaustion on a motorised treadmill to ascertain their maximal aerobic power. Body composition was measured using dual-energy X-ray absorptiometry (Lunar Prodigy, GE Healthcare Lunar, USA) and analysed using dedicated software (enCORE, version 9, GE Healthcare Lunar, USA). Maximal aerobic power was assessed via indirect calorimetry (TrueOne 2400, Parvo Medics, USA) following a standardised protocol (Bach et al., 2019). To calculate a 90% heart rate maximum, participants wore a chest strap mounted heart rate monitor (Team2, Polar, Finland) during the aerobic power test. The remaining two sessions involved the participant continuously walking on a treadmill (4.5 km h^{-1}) in an environment chamber (35 °C, 50 % relative humidity (RH)) for up to 60-min while wearing one of two protective ensembles; either solely the EOD protective suit (CON) or the EOD suit and an ice vest cooling garment (IV). The two sessions were identical except for the clothing ensemble worn and the load carried was slightly (1.2 kg) greater in the IV condition. The ambient conditions were monitored to within 34.9 ± 0.2 °C and 49.5 ± 0.5 % of the set point temperature by a Wet Bulb Globe Temperature (WBGT) weather station (3M Quest TEMP 36, 3M, USA).

Termination criteria employed complied with the American Society for Testing and Material guidelines: (1) core temperature reaching 39 °C; (2) 60-min of walking duration; (3) heart rate reaching 90% of the maximum; or (4) imminent heat illness (ASTM International, 2016). Meeting any of the aforementioned criteria resulted in the research staff removing the participant from the environmental chamber, extricating them from the personal protective clothing, and monitoring their recovery within an air-conditioned room (21 °C). The period from the commencement of exercise up to this terminating point denotes work time.

2.3. EOD protective clothing and ice vest

Participants wore the Med-Eng EOD suit and helmet during each trial (Allen Vanguard, Ogdensburg, New York, USA). The ensemble consisted of a jacket, trousers, groin protection and helmet (33.4 kg); and additional base clothing (balaclava, t-shirt, shorts, sports socks, underwear and athletic shoes). An ice-based cooling vest (ICEEPAK Australia, Australia; 1.2 kg) was donned over the base clothing and under the EOD jacket during the IV conditions. The ice vest covered the participant's torso and was adjusted to fit tightly. Four ice packs (each 14.5 by 32 cm) were stored in a −20 °C freezer before placing them into the ice vest for trials.

2.4. Physiological measures

Following standard procedure (Andersen et al., 1971), participants were instructed to abstain from exercise, alcohol, tobacco, vitamin and mineral supplements and caffeinated drinks in the 24-h before testing. Participants were asked to consume at least 40 mL kg^{-1} of water the day before trials (Agostoni et al., 2010) and 500 mL 2 h before the session. Self-collected mid-stream urine samples were tested for sufficient specific gravity (USG) before commencing trials (USG – PAL-10S, Atago, Japan). USG results <1.020 were considered euhydrated (Armstrong et al., 1994) and those >1.020 required participants to consume 500 mL of water before repeating the test.

To measure core temperature, participants self-inserted a single-use disposable rectal thermistor (YSI 400, DeRoyal, USA – [±0.1 °C]) 12 cm past the anal sphincter (International Organisation for Standardisation, 2004). Thermistors were connected to a wireless logger during the trials (T-TEC7, Temperature Technology, Australia – [±0.2]), with the device sampling data at a frequency of 1 Hz. Thermocron loggers fastened to four sites on the participants via adhesive tape (width 3.8 cm – Premium Sportstape, Leuko, Germany) in accordance with the International Organisation for Standardisation (2004) were used to collect skin temperature at a rate of 0.2 Hz (DS1971-F5 iButton®, Maxim Integrated, USA – [±0.5 °C: resolution: 0.0625 °C]). Weighted skin temperature (Tsk) was calculated using the following equation (International Organisation for Standardisation, 2004):

$$T_{sk} = (T_{neck}{*}0.28)+(T_{right\ scapula}{*}0.28)+(T_{left\ hand}{*}0.16)+(T_{right\ shin}{*}0.28).$$

A chest strap mounted heart rate monitor (Team2, Polar, Finland) was worn and sampled at 0.5 Hz.

The physiological strain index (PSI; Moran et al., 1998) was also calculated using the equation:

$$PSI = 5{*}\left(\frac{Trec - 36.5}{39.6 - 36.5}\right) + 5{*}\left(\frac{HR - 60}{180 - 60}\right)$$

2.5. Perceptual measures

A recording of thermal comfort and sensation was collected every 15 min during the trials. Thermal sensation was assessed using a modified 13-point scale (Gagge et al., 1969) with the following numerical-verbal anchors: 1 "unbearably cold," 2 "extremely cold," 3 "very cold," 4 "cold, " 5 "cool," 6 "slightly cool," 7 "neutral," 8 "slightly warm," 9 "warm," 10 "hot," 11 "very hot," 12 "extremely hot," and 13 "unbearably hot." Thermal comfort was measured using Gagge's 9-point scale (Gagge et al., 1969) with the following numerical-verbal anchors: 1 "comfortable," 1.5, 2 "slightly comfortable," 2.5, 3 "uncomfortable," 3.5, 4 "very uncomfortable," 4.5 and 5 "extremely uncomfortable."

2.6. Data analysis

All data analysis was undertaken in R (version 4.0.3). Participants' baseline characteristics (USG and nude body mass) and work time were assessed using linear regression with a random intercept for each participant. Hedges' g_{av} was calculated using the averaged standard deviation as the denominator (Lakens, 2013). Physiological (heart rate, PSI, core and mean skin temperature) responses were analysed using linear mixed-effect models. The physiological models included condition (ice vest, no ice vest), time and their interaction as fixed effects, and a random intercept for each participant. Non-linear time effects (i.e., second- and third-order polynomials) were considered and examined for best fit (Akaike information criterion and Bayesian information criterion), and variance explained (R^2). Linear mixed effect models were fit using the 'lme4' package (Bates et al., 2015). Visual inspection of residual plots did not reveal any apparent deviations from homoscedasticity or normality for all models. Perceptual (thermal sensation and comfort) responses were modelled with a beta response distribution using the 'betareg' package (Cribari-Neto and Zeileis, 2010). This distribution is appropriate for bounded data as it can accommodate a variety of distributional shapes and skewed errors. Before analysis data were transformed to the (0,1) beta interval. Beta regression models included condition as a fixed factor.

3. Results

3.1. Baseline data

All experimental trials were completed, thus totaling 16 trials. There was no evidence of a difference between conditions in baseline body mass (mean difference (MD) [95% CI], 0.02 kg [−0.36, 0.83], t = 0.831, p = .433) nor USG (−0.002 [−0.006, 0.003], t = −0.792, p = .454).

3.2. Work time and tolerance criteria

All CON conditions were terminated due to participants reaching 90% of their maximum predicted heart rate. Of the eight IV trials, 60-min of walking was completed in one, with the remaining seven terminating upon attaining 90% of maximum heart rate. Work time improved in the IV condition (mean (M) standard deviation (SD), 38.1 min (12.7)) compared to CON (30.0 min (7.2), t = 3.107, p = .017, MD [95% CI], 8.1 min [2.7, 13.6], Hedges' g_{av} [95% CI], 0.70 [0.11, 1.25], Fig. 1).

3.3. Physiological data

Core temperature displayed a time effect and though a condition effect was identified, the magnitude was physiologically negligible (MD [95% CI] = −0.05 °C [−0.08, −0.02], p < .001, Fig. 2C). There was no condition by time interaction effect (p = .931). At termination, core temperature was similar in both conditions, 38.2 ± 0.3 °C in the CON and 38.4 ± 0.3 °C in the IV condition. Skin temperature differed over time (p < .001) and between conditions (p < .001; Fig. 2B). During the IV condition, skin temperature was lower (MD [95% CI] = −3.11 °C [−2.96, −3.27], p < .001). There was no condition by time interaction effect (p = .671). Heart rate differed over time (p < .001) and between conditions, with IV being lower (MD [95% CI] = −9 b min^{-1} [−11.0, −7.7], p < .001, Fig. 2A). There was also an interaction effect with the rate of rise in heart rate being lower in the IV condition (p < .001). PSI differed over time (p < .001) and between conditions, with IV being lower (MD [95% CI] = −0.5 [−0.6, −0.4], p < .001. There was also an interaction effect with the rate of rise in PSI being lower in the IV condition (p < .001).

3.4. Perceptual data

Thermal sensation was higher in CON (M (SD) 9.4 (1.4)) compared to IV (7.9 (1.3); MD [95% CI], 1.5 [0.2, 2.8], p = .024). There was no difference in thermal comfort between CON (M (SD) 2.7 (0.7)) and IV (2.4 (0.6); MD [95% CI] 0.3 [−0.4, 0.9], p = .422).

4. Discussion

This study investigated the ability of an ice vest to attenuate physiological strain and subsequently extend work time while wearing an explosive ordnance disposal ensemble. The main findings of this study were that 1) work time was extended in the IV compared to the CON trials, 2) cardiovascular, rather than thermoregulatory, strain was the limiting factor to work time while wearing the EOD ensemble and, 3) rate of rise in heart rate and skin temperature was lower while wearing the ice vest, potentially reflecting greater peripheral heat loss and subsequently contributing to the reduced physiological strain. These results

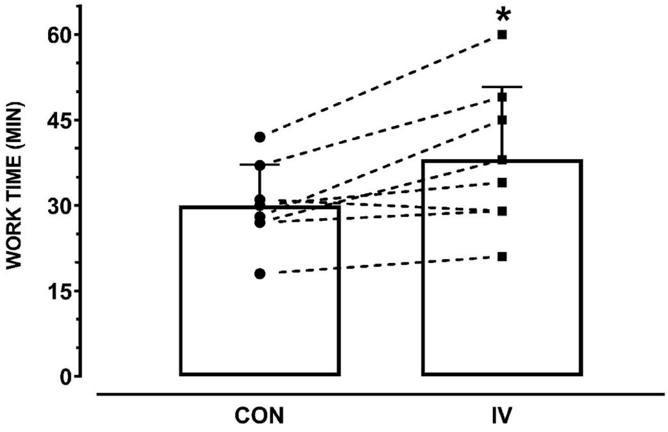

Fig. 1. Work time (Mean ± SD) for EOD with no cooling (CON) and EOD and ice vest (IV), conditions. Individual results are denoted by filled markers and connected with dashed lines. *different (p < .05) from CON.

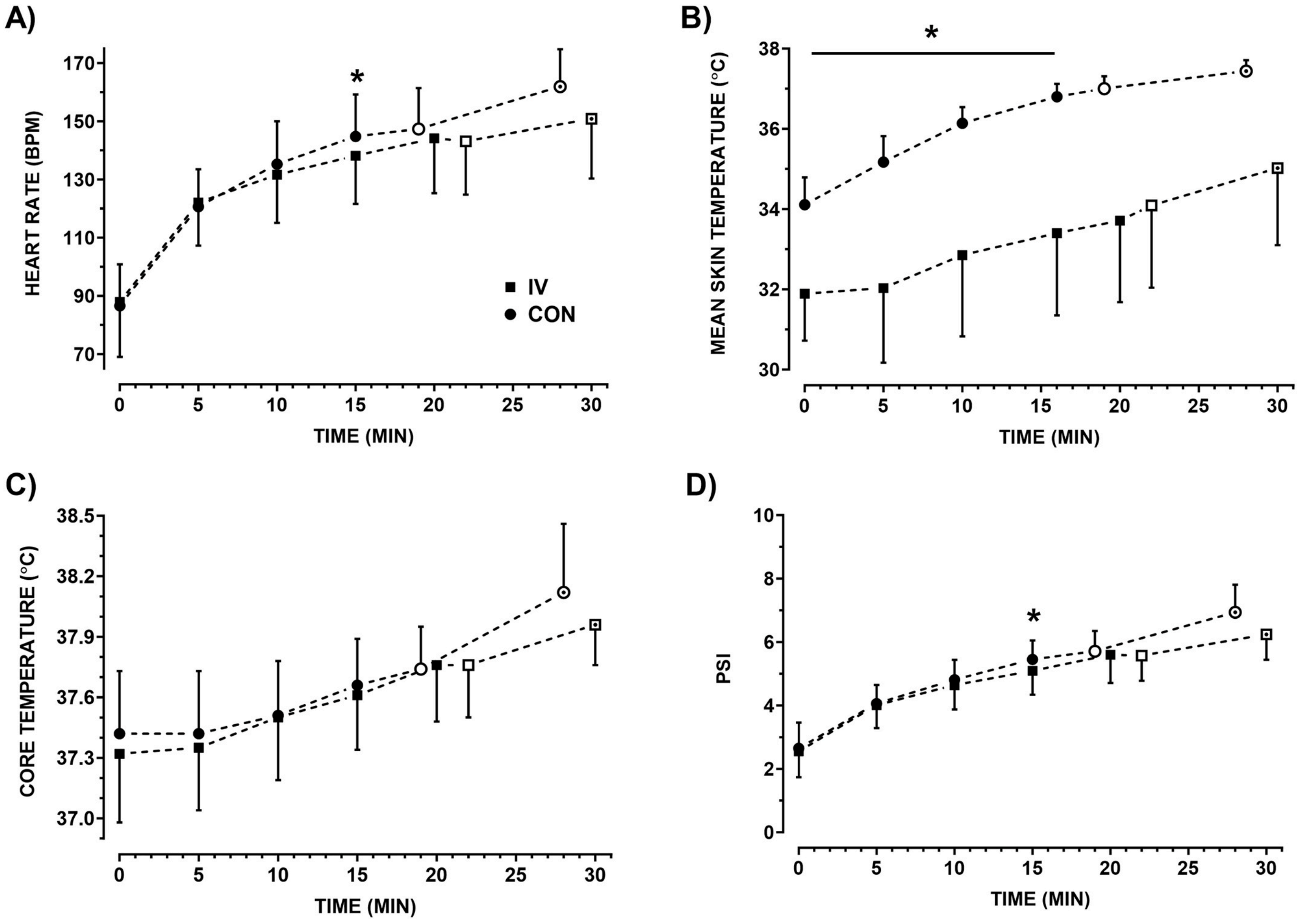

Fig. 2. Physiological variables across conditions (Mean ± SD). Comparisons between EOD with no cooling (CON, circle marker) and EOD and ice vest (IV, square marker) for (A) heart rate, (B) mean skin temperature, (C) core temperature and (D) PSI during work. Filled marker represents (n = 8) participants plotted at 5 min intervals, thereafter, an open or dotted marker represents n = 7 and n = 5 participants remaining, respectively. After 30-min both conditions had only 5 participants remaining and is subsequently not displayed. * denotes statistically different between conditions; please note that statistical comparisons between conditions only occurred for complete data sets and therefore ceased at the 15 min timepoint.

support the hypothesis that the ice vest would attenuate physiological strain and, in doing so, extend the work time during the simulated trials.

Work time was, on average, 8.1 min longer when wearing the ice vest (Fig. 1). Although this duration may appear minimal, it equates to a 21% improvement in exercise tolerance which may be of practical importance for operational success in the field. EOD scenarios may involve extended searching activities before disabling and clearing an explosive device; while all scenarios will involve repeatedly walking into and from exclusion zone locations. Assuming the conditions produced in this study (4.5 km h^{-1}; 35 °C, 50% RH) were replicated in a field operation, a technician would be able to travel an additional ~600 m based on the average work time improvement observed.

Previous research by the authors' (laboratory and field-based) has produced similar near maximal heart rate responses to those in the present study during simulated tasks in the same EOD9 ensemble (Stewart et al., 2011, 2014). These investigations were conducted in WBGT's ranging from 21 to 34 °C. Almost all trials in the current study (94%) were terminated due to a heart rate exceeding 90% of the maximum. While core temperature rose steadily throughout the current trials, the final core temperature did not exceed 38.4 °C in either condition. These results exemplify the conclusion drawn in former work that cardiovascular strain governs physiological work times in EOD operations in the heat (Stewart et al., 2014; Costello et al., 2015).

Given that cardiovascular strain limited exercise time, it is logical to assume that the extended work time in the IV trials resulted from attenuation of cardiovascular strain. When the ice vest was worn, the rate of rise in heart rate was lower (Fig. 2A). Consequently, participants were able to tolerate an extended work period before termination. How the ice vest reduced heart rate and thus physiological strain is explained by the circulatory and thermoregulatory systems' interrelated response to exercise in the heat.

Applying an ice vest beneath the EOD suit significantly reduced skin temperature (Fig. 2B), widening the core to skin temperature gradient and facilitating heat loss from the blood perfusing the skin (Gao et al., 2010). Cardiovascular strain was likely attenuated by the maintenance of blood within the central circulation as the requirement for cutaneous blood flow was reduced when the ice vest was worn (Crandall and Gonzalez-Alonso, 2010).

Humans are usually capable of dissipating heat through increased skin blood flow and sweating. However, personal protective clothing often possesses features that restrict heat loss (McLellan et al., 2013). Multiple layers, complete encapsulation, and high-water vapour-resistant materials create a microenvironment around the skin, insulate the wearer and limit their evaporative capacity (McLellan et al., 2013; Chan et al., 2015). Heavy and restrictive ensembles also impose considerable stress on the body due to the additional load (McLellan et al., 2013). The EOD ensemble is unique in that it possesses all these properties, optimising the protective functioning of the garment while inhibiting heat loss and exacerbating heat gain [Bach et al., 2016; Potter et al., 2021]. This stress is compounded when working in high ambient temperature and humidity, further compromising heat exchange (Stewart et al., 2014). Unsurprisingly, uncompensable heat stress often forms under such conditions.

Interestingly, the reduction in skin temperature caused by the ice vest could not translate to a significantly lower or slower rate of rise in core temperature compared to a non-cooling control. Similar investigations support this notion that phase change cooling garments tend to have a substantially smaller effect (if any) on deep body temperature than skin temperature (Barwood et al., 2009; Maley et al., 2020; Seeley and Sherman, 2021). The limited evaporative capacity afforded by the vest, which would have contributed considerably to restoring a negative heat balance, is one possible explanation (McLellan et al., 2013). As highlighted by the results, using an ice vest can enable work at a higher metabolic load in hot conditions for the same duration compared to no cooling or allow work in the environment to be maintained for a longer period (Bach et al., 2020).

Per the principle of latent heat storage, the ice vest warms as it stores energy (heat) during phase change. Thus, the cooling benefit of the system is limited by the phase change material's heat storage capacity. In their meta-analysis, Chan et al. (2015) identified that though phase change material garments can attenuate physiological strain, their cooling capacity diminishes over time, lasting between 45 and 120 min, depending on the amount of heat produced or the heat transfer afforded by the external environment.

Alternative personal cooling like active air and liquid systems with longer cooling durations have been investigated with protective ensembles, including the EOD suit (Masadi et al., 1991; Frim and Morris, 1992). Portable active liquid-cooling systems mitigated physiological strain in EOD technicians during simulated work (Masadi et al., 1991; Frim and Morris, 1992), while air-based systems were ineffective (Frim and Morris, 1992). However, due to the complexity, added weight, restrictive design, and cost to procure and maintain active systems, they are less viable in field settings than a phase change material vest (McLellan et al., 2013; Chan et al., 2015; Bach et al., 2018).

Notably, the availability of ice and capability of storing or re-freezing ice in the field is a clear limitation of an ice vest. Other phase change materials with a greater melting temperature can be 're-charged' in temperate water or air and thus are potentially a practical substitute to ice-based vests. Davey et al. (2020), however, recently showed that compared to a no-cooling condition, a phase change material vest (melting point 25 °C) provided no physiological relief during an intermittent cycle of 10 min EOD representative work followed by 3 min rest periods, repeated in total six times while wearing an EOD ensemble (40 °C; 16% RH). The rise in physiological strain was reduced when the cooling vest was replaced between the 3rd and 4th cycle. This is likely as the cooling rate of the material is directly proportional to the cooling gradient between the phase change material and the skin, i.e., phase change materials with a colder melting temperature have a greater cooling effect (Gao et al., 2010). In support of this, only phase change material vests with the lowest melting points (<20 °C) were found to attenuate heat strain while performing in a firefighting uniform (House et al., 2013).

A simple and potentially effective solution to the limited cooling capacity of a phase change material is replacing the cooling pack once melted. In the field, the EOD technicians often return to their command point to analyse x-rays, discuss tactics, and collect additional equipment, providing an opportunity to remove components of the ensemble (helmet and jacket routinely). This may be the most practical and logical time for the phase change material packs to be replaced. Previous studies have assessed the effectiveness of replacing phase change material cooling systems during activity in different forms of protective clothing (fire-resistant coveralls, chemical protective suit and EOD suits), however not all compared these results to a control condition where the pack was not replaced (Muir et al., 1999; Butts et al., 2017; Davey et al., 2020). Recent work that did make this comparison concluded that while working in an EOD suit, replacing a phase change material vest after full phase change is complete can better attenuate heat strain (Davey et al., 2020). Unfortunately, as the vest had a high melting point (>20 °C), its cooling potential was far less than if a material with a cooler melting point had been assessed.

The findings of this study are limited by the protocol and sample investigated. Trials were completed in ambient conditions (35 °C, 50% RH) outlined by the ASTM F2300-10 for evaluating cooling systems (ASTM International, 2016). However, assessment in a range of environments is more suitable to identify the efficiency and compatibility of a cooling system, given that the composition of hot conditions that may be encountered in the field can vary (Bach et al., 2020). The functionality of an ice vest in different operational tasks like those performed in previous field work (Stewart et al., 2011) is also warranted. Further, the reader is reminded that the results from the current work are specific to the homogenous cohort of young, fit, healthy, unacclimated males sampled. While participants of this description often frequent heat stress mitigation studies, they do not reflect the changing diversity among the working population. As such, assessing personal cooling strategies in more representative ambient conditions, different tasks and cohorts in future investigations would be of considerable benefit.

5. Conclusions

In conclusion, the present study identified that physiological work time while wearing an EOD ensemble in the heat is improved with an ice vest. The cardiovascular inefficiency that limited work time in the CON condition was attenuated in the IV condition, exemplified by the lower heart rate rise. The ice vest facilitated heat dissipation through the skin, as evidenced by the lower mean skin temperature throughout the exercise trials. The reduced cardiovascular strain may reflect the preservation of central blood volume and subsequently prolonged work time. The results highlight the benefit of an inexpensive cooling device in assisting EOD technicians working in a hot environment. Extrapolation of the current work to different environmental conditions, operational tasks and representative cohorts in future investigations would be beneficial.

Ethics approval and consent to participate

All participants gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the Queensland University of Technology's Human Research Ethics Committee. Approval number 1600000857.

Availability of data

The datasets generated during and/or analysed during the current study are available in the Dryad repository, https://doi.org/10.5061/dryad.s1rn8pk94.

Competing interests

The authors declare that they have no competing interests.

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CRediT authorship contribution statement

Kate P. Hutchins: Writing – review & editing, Writing – original draft, Data curation. **Matthew J. Maley:** Writing – review & editing, Formal analysis. **Aaron J.E. Bach:** Writing – review & editing, Formal analysis, Data curation. **Kelly L. Stewart:** Writing – review & editing, Funding acquisition. **Geoffrey M. Minett:** Writing – review & editing, Funding acquisition. **Ian B. Stewart:** Writing – review & editing, Supervision, Resources, Methodology, Funding acquisition, Formal analysis, Conceptualization.

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