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BRIEF REPORT

Portable Prehospital Methods to Treat Near-Hypothermic Shivering Cold Casualties

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Objective.—To compare the effectiveness of a single-layered polyethylene survival bag (P), a single-layered polyethylene survival bag with a hot drink (P+HD), a multi-layered metalized plastic sheeting survival bag (MPS: Blizzard Survival), and a multi-layered MPS survival bag with 4 large chemical heat pads (MPS+HP: Blizzard Heat) to treat cold casualties.

Methods.—Portable cold casualty treatment methods were compared by examining core and skin temperature, metabolic heat production, and thermal comfort during a 3-hour, 0°C cold air exposure in 7 shivering, near-hypothermic men (35.4°C). The hot drink (70°C, ~400ml, ~28kJ) was consumed at 0, 1, and 2 hours during the cold air exposure.

Results.—During the cold air exposure, core rewarming and thermal comfort were similar on all trials ($P = .45$ and $P = .36$, respectively). However, skin temperature was higher (10%–13%; $P < .001$; large effect sizes $d > 2.7$) and metabolic heat production lower (15%–39%; $P < .05$; large effect sizes $d > .9$) on MPS and MPS+HP than P and P+HD. The addition of heat pads further lowered metabolic heat production by 15% (MPS+HP vs MPS; $P = .05$; large effect size $d = .9$). The addition of the hot drink to polyethylene survival bag did not increase skin temperature or lower metabolic heat production.

Conclusions.—Near-hypothermic cold casualties are rewarmed with less peripheral cold stress and shivering thermogenesis using a multi-layered MPS survival bag compared with a polyethylene survival bag. Prehospital rewarming is further aided by large chemical heat pads but not by hot drinks.

Key words: rewarming, hypothermia, thermogenesis, multiple trauma, frostbite, wilderness medicine

Introduction

To prevent hypothermia-related mortality, it is vital to develop portable methods to attenuate heat loss that casualties and first responders can use as part of prehospital care while they await more sophisticated medical facilities.[1,2] Multiple layering that includes a vapor-proof barrier and insulation has recently been highlighted as important for cold protection.[3,4] Unfortunately, being cumbersome and heavy (2.5 kg), the methods used in these studies have limited portability. A more portable cold protection method option is a survival bag constructed of multiple layers of metalized plastic sheeting (MPS: Blizzard Survival weight 0.4 kg). The effectiveness of this survival bag to protect shivering human cold casualties compared with other vapor-proof barriers remains unknown. Portable heat sources that may benefit cold casualties are limited to chemical heat pads and the ingestion of hot drinks, as body-to-body contact is ineffective in rewarming shivering cold casualties.[5] Although a recommended practice to support shivering,[1] no study has investigated whether hot drink ingestion has thermally beneficial effects for cold casualties. As cold drinks reduce core temperature and subjective thermal discomfort during exercise-induced hyperthermia, it might be hypothesized that hot drinks may increase core temperature and thermal comfort in shivering cold casualties.[6] Large chemical heat pads are more effective than spontaneous

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The opinions and assertions herein are the private views of the authors and do not construe official views of Bangor University or Blizzard Protection Systems Ltd.

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thermogenesis to rewarm persons with inhibited shivering[7]; however, it remains unclear if they are effective in rewarming shivering cold casualties. This study's objective was therefore to compare the effectiveness to treat cold casualties of a single-layered polyethylene survival bag, a single-layered polyethylene survival bag with a hot drink, a multi-layered metalized plastic sheeting survival bag, and a multi-layered MPS survival bag with 4 large chemical heat pads.

Methods

STUDY DESIGN

A crossover study was performed where participants completed all trials in a random order. Randomization was completed by SJO (www.randomizer.org). The study received University Ethics Committee approval.

Participants

Seven healthy men (mean ± SD: age 21 ± 3 years; height 178 ± 5 cm; nude body mass 70.5 ± 5.2 kg; body fat 10 ± 3%) volunteered for the study after giving written informed consent. Participants reported no infection and did not take medication or nutritional supplements 6 weeks before or during the study. To standardize nutritional status and physical activity, participants completed a food and activity diary for the 24 hours before the first trial, which they then repeated before each subsequent trial. In the 24 hours before each trial, participants also consumed water equal to 35 ml per kilogram body mass and refrained from alcohol and exhaustive exercise.

EXPERIMENTAL PROCEDURES

In 4 trials, participants were made near-hypothermic by cold water immersion, after which they completed a 3-hour 0°C cold air exposure in an environmental chamber using 1 of 4 cold casualty treatments: a single-layered polyethylene survival bag (P: 3-mil [~0.08 mm thick] polyethylene, weight 0.25 kg, packed size 24 × 15 × 1 cm; Figure 1A), a single-layered polyethylene survival bag with a hot drink (P+HD), a multi-layered MPS survival bag (MPS: Blizzard Survival bag, weight 0.39 kg, packed size 21 × 11 × 4 cm; Figure 1B), and a multi-layered MPS survival bag with 4 large chemical heat pads (MPS+HP: Blizzard Survival Heat bag, weight 1.90 kg, packed size 30 × 25 × 7 cm; surface area of each large chemical heat pad 24 × 30 cm). The fifth trial was a control (CON) where participants remained seated in an ambient temperature 20°C (relative humidity [RH] 41%).

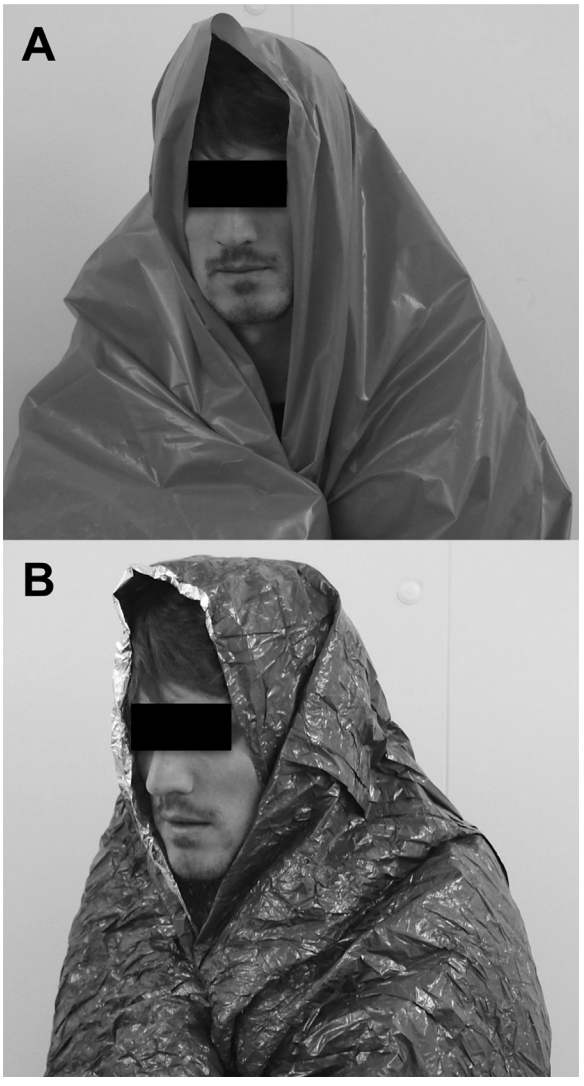

Figure 1. Polyethylene survival bag (A) and a multi-layered metallized plastic sheeting survival bag (B: Blizzard Survival bag).

After an overnight fast, participants arrived at 0800 hours. After voiding, anthropometric and body composition measures of height, body mass, and body fat were obtained (InBody230; Biospace, Seoul, South Korea). Urine was analyzed for specific gravity (Atago, Tokyo, Japan). Participants then fitted a rectal thermistor 12 cm beyond the anal sphincter (2020 Series; Grant Instruments, Cambridgeshire, UK) and began a 30-minute seated rest dressed in a tracksuit, swim shorts, t-shirt, socks, and shoes. On the cold stress trials, participants were then immersed up to the axilla in 13.0 ± 0.1°C stirred water wearing swim shorts until core temperature reached 36°C. After, participants were carefully dried, dressed in dry shorts, socks, and gloves, and fitted with skin thermistors. Participants then entered an environmental chamber and after 5 minutes seated were given,