EVALUATION OF TWO COLD WEATHER GLOVES DURING ACTIVE NON-CONTACT AND PASSIVE CONTACT ACTIVITIES.

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INTRODUCTION

Handwear testing with human subjects is conducted primarily because measured dry insulation values (I_T) from models may not reliably predict actual thermal protection experienced in the field. Total clothing insulation, sweating, individual activity level or thermal contact with external objects also affect hand temperatures. In this study, the physiological responses of eight volunteer subjects wearing the Combat Vehicle Crewman cold weather (CVC) and Light Duty (LD) gloves were tested in an environmental chamber. The CVC glove is an insulated one piece glove of knit fire-retardant fabric with a leather reinforced palm. The LD glove is a two piece glove consisting of an uninsulated leather shell and a separate liner knit of wool and nylon. Glove total dry insulation (I_T) values were measured on two biophysical hand models (1). I_T for the knit fabric CVC glove was measured as 0.16 $m^2 \cdot K \cdot W^{-1}$ (1.00 clo) and for the LD glove, I_T was 0.12-0.14 $m^2 \cdot K \cdot W^{-1}$ (0.80-0.92 clo).

METHOD

Subjects were tested while performing two activities at chamber temperatures of -7°C (20°F) and -15°C (5°F) in a wind speed of 2.2 $m \cdot s^{-1}$ (5 mph). The activity mode was walking on a level treadmill at 1.3 $m \cdot s^{-1}$ (3 mph) for 120 min. The second passive activity utilized a "contact simulation device" (2) designed to simulate contact with a cold-soaked surface. This device required subjects to push against an polyethylene envelope containing propylene glycol which was maintained at chamber temperature. This was the first study which utilized the device. During testing, subjects repeated a scenario of 5 min of pushing or "contact" followed by 1 min of rest for a total of 60 min. Electronic timers recorded cumulative pushing or contact time (CT) and total elapsed or endurance (ET) time. All testing activities were preceded by a 10 min baseline period. The eight subjects were divided into two groups and alternated days of walking (morning) and contact (afternoon) testing activities. The primary physiological limit for subject exposure was a finger temperature of 5°C (41°F). Parameters monitored included four finger temperatures, rectal temperature and heart rate. Subjects wore the CVC uniform (overalls, jacket, cotton/wool long underwear, leather combat boots, balaclava and face mask with goggles and CVC helmet).

RESULTS

Mean parameters (s.d.) for the eight subjects were height 178 (7) cm, mass 74.6 (7.8) kg, and A_D 1.92 (0.12)m^2. Table 1 summarizes the results for ET and CT. Repeated measures MANOVA analysis was applied to the combined data for both environments by activity. In all cases, mean ET and CT (activity 2 only) times were greater when the subjects wore the CVC glove. Figure 1 illustrates patterns of finger temperatures during the walking activity. Results were significant ($p<0.001$) only for ET and CT during the contact activity. Post hoc comparisons of paired data using Tukey's t-test ($p=0.05$) found no significant differences between glove types affecting the responses when results were analyzed by individual environment. A variety of relationships involving finger temperatures, including a comparison of slopes for each glove for the temperature drop from 15 and 10°C, were analyzed. Only significant differences between digits (middle>little) and hands [right>left (walk) or non-push>push (contact)] were found. Figure 2 illustrates a time lag in the onset of cold induced vasodilation (CIVD) between the middle and little fingers. The offsets were often less pronounced or even absent in some cases, but differences in finger temperatures were observed in all cases.

Table 1. Mean endurance (ET) and contact (CT) times in minutes (s.d.), n=8

Activity	ET-CVC glove	ET-LD glove	CT-CVC	CT-LD
walk at -6.7°C	108 (39)	61 (13)	......	......
walk at -15°C	88 (41)	46 (18)	......	......
contact at -6.7°C	57 (48)	30 (15)	40(11)	16(12)
contact at -15°C	33 (40)	19 (8)	30(14)	7 (6)

FIGURE 1
MEAN FINGER TEMPERATURE AT -7°C (WALK)

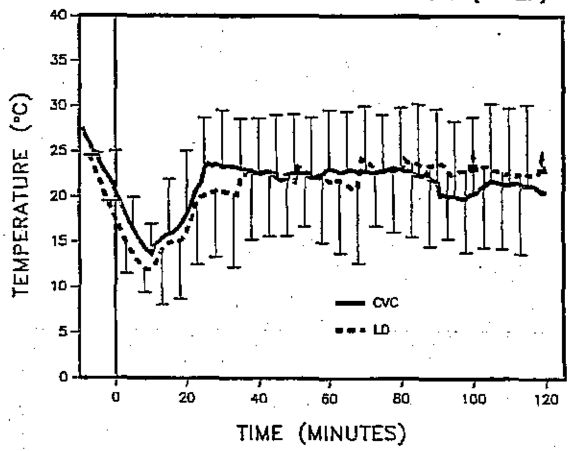
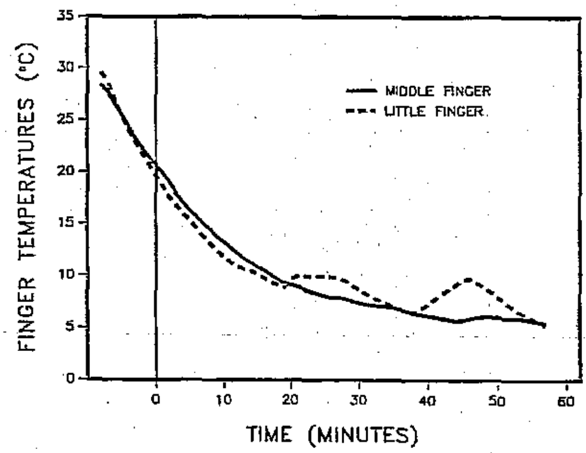


FIGURE 2
RIGHT HAND TEMPERATURES AT -7°C (CONTACT)



CONCLUSIONS

Although a small difference in I_T occurred between gloves and a lack of a significant difference in digital temperature between gloves, subject endurance and contact simulation times indicate ($p<0.001$) that the CVC glove provides better cold protection than the LD glove. The simple relationship between measured handwear insulation and subject performance and hand warmth is confounded by the ratio of relative mass of hands to total body mass and variations in peripheral blood circulation. The effects of clothing and activity were controlled in this study, but individual variability is also a confounding factor, which cannot be entirely resolved by results derived from a small and relatively homogeneous subject population. Humans subjects are used to test handwear because activity levels, sweating, and total clothing insulation have confounded simple efforts to translate measured dry insulation values into predictions of human performance. Observations of differences in finger temperatures on the same hand, particularly cases where the onset of CIVD was asynchronous between fingers, suggests that the onset of CIVD was in response to local temperatures rather than a centrally mediated response. Adequate thermal protection for a military user is defined primarily in terms of function and prevention of injury, not thermal comfort. Emphasis is therefore on temperatures at the most vulnerable locations (finger tips), rather than at the palm or dorsal surface. It is particularly interesting that although the tendency of the smaller extremities to cool faster is well known (3), other studies used either the middle finger (4) or other less vulnerable region to estimate thermal protection.

DISCLAIMER

The views, opinions and/or findings in this report are those of the authors, and should not be construed as official Department of the Army position, policy or decision, unless so designated by other official documentation. Human subjects participated in these experiments after giving their free and informed voluntary consent. Investigators adhered to AR-25 and USAMRDC Regulation 70-25 on Use of Volunteers in Research.

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