THE EFFECTS OF CLOTHING INSULATION AND LEVELS OF TORSO HEATING ON FINGER DEXTERITY

D. Brajkovic, J. Frim and M.B. Ducharme

Defence and Civil Institute of Environmental Medicine
Toronto, Ontario, Canada

INTRODUCTION

Recently it has been found that active torso heating using an electrically heated vest (EHV) can keep bare extremities of well-insulated subjects comfortable (at about 25°C) for up to 3 hours during exposure to -15°C air (1). The purpose of the present study was to examine the effects of clothing insulation and levels of torso heating on finger dexterity during torso heating.

MATERIALS AND METHODS

Eight subjects were exposed randomly to 6 conditions (1 week apart) in addition to 1 familiarization test. Rectal temperature (T_{re}) and finger dexterity were measured during a 3-hour exposure to -15°C air. The EHV consisted of 10 printed-circuit heaters that covered the torso. The heaters were powered by 5 Hewlett-Packard, counter-top, DC power supplies. The heaters were not in direct contact with the skin but inside a pocket made of Nomex® fabric. In addition, a 1-cm layer of Thinsulate® insulation was placed inside the pocket on the outer surface of the heater. Subjects wore either light Arctic clothing insulation (LI; 2.6 clo) or heavy Arctic clothing insulation (HI; 3.6 clo), and they were exposed to 3 levels of torso heating (no heating, NH; moderate heating, MH; high heating, HH). During the NH conditions, no torso heating was provided, but thin, knitted gloves and Arctic mitts were worn. The hands were bare during MH and HH. During the MH and HH conditions, the skin temperature under the EHV was maintained at 40°C and 42°C, respectively. Finger dexterity was measured every 30 min by using a Purdue Pegboard (PP) test or a C-7 Canadian Forces rifle disassembly and assembly test. The PP test is a timed assembly task in which the subject attempts to put together as many 4-piece unit assemblies (pin, washer, collar, washer) as possible in 1 minute. The washers and collars are less than 1-cm wide. Each unit assembled counts as 4 points. The PP test was done at time 30, 90 and 150 minutes. Three tests were done at each of these times. The C-7 rifle task is a timed task in which the subject takes apart a C-7 rifle into 12 pieces and puts it back together again. The rifle task was done at time 0, 60, 120 and 180 minutes. During the NH conditions, the knitted gloves and Arctic mitts were removed every 30 min so that the tasks could be performed barehanded.

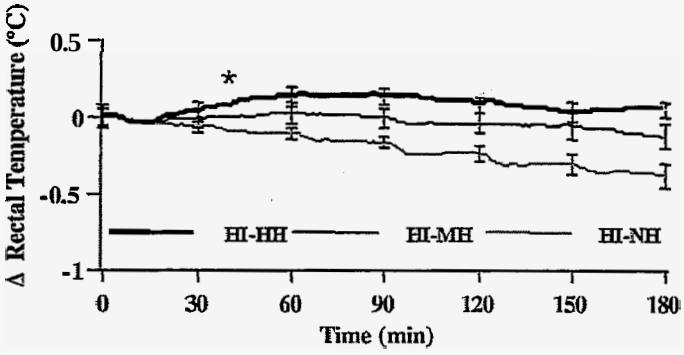

Figure 1. Change in Tre during a 180 min exposure to -15°C air for conditions HI-HH, HI-MH and HI-NH. (Mean ± S.E.) * specifies the first significant difference between HI-HH, HI-MH and HI-NH.

RESULTS

The following results are for $n = 8$. The level of significance is $P < 0.05$.

Rectal Temperature. The mean ± SE initial T_{re} at time 0 for the 6 conditions was 37.24 ± 0.03°C. T_{re} was significantly greater during HI-HH as compared to HI-MH and HI-NH starting at time 37 min. See Figure 1. There was no significant difference in T_{re} response between LI-MH and LI-HH. See Figure 2. T_{re} was significantly lower during LI-NH starting at time 37 min when compared to LI-HH and LI-MH.

Finger Dexterity. There were no significant differences between Purdue Pegboard Performance (PPP) at time 30, 90 and 150 min during HI-HH and HI-MH. See Figure 3. PPP during M-NH was significantly decreased at time 90 and 150 when compared to PPP at time 30. PPP during LI-MH and LI-NH was sig-

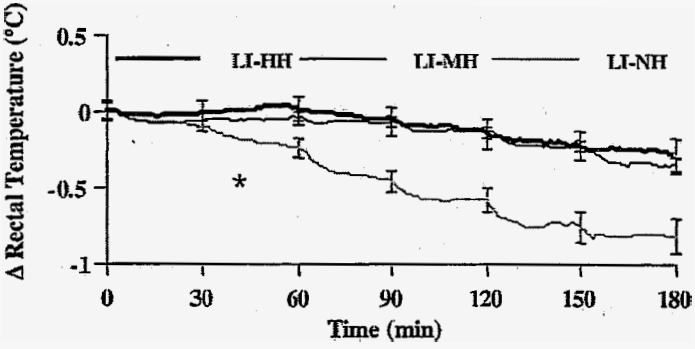

Figure 2. Change in Tre during a 180 min exposure to -15°C air for conditions LI-HH, LI-MH and LI-NH. (Mean ± S.E.). * specifies the first significant difference between LI-HH, LI-MH and LI-NH

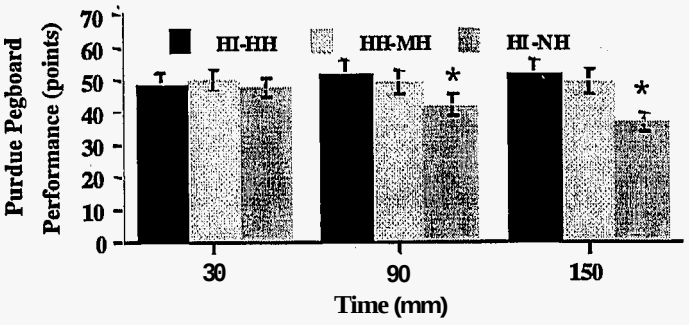

Figure 3. Purdue Pegboard Performance at time 30, 90 and **150** rnin during exposure to **-15°C** air for conditions HI-HH, **HI-MH** and HI-NH. (Mean ± **S.E.)** * specifies that there is a significant difference when compared to time 30 **rnin**

nificantly decreased at time 90 and **150** when compared to PPP at time 30. See Fig. **4.** In addition, PPP was significantly decreased at time 30 rnin for LI-NH when compared to LI-MH and LI-HH at time 30 min.

There were no significant differences between the **C-7** rifle task time (RTT) at time **0, 60,** 120 and **180** rnin during HI-HH and **HI-MH.** See Fig. **5.** RTT during HI-NH was significantly increased at time 120 and **180** when compared to **RTT** at time 0. RTT during LI-MH and LI-NH was significantly increased at time **120** and **180** when compared to RTT at time 0. See Fig. **6.** In addition, RTT was significantly increased at time **60** during LI-NH when compared to RTT at time **0.**

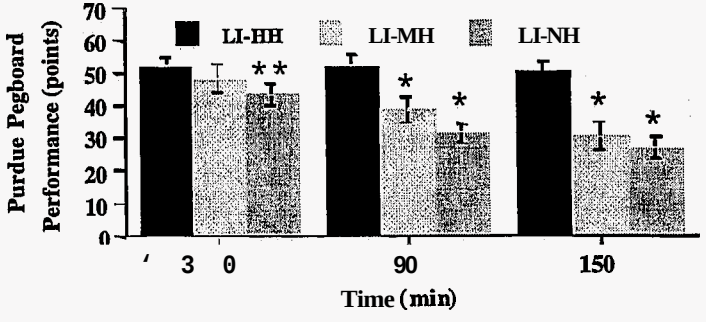

Figure 4. Purdue Pegboard Performance at time 30, 90 and **150** rnin during exposure to **-15°C** air for conditions LI-HH, LI-MH and LI-NH. (Mean ± S.E.) * specifies that there is a significant difference when compared to time 30 min. ** specifies that LI-NH is signicantly different than LI-HH and **LI-MH** at time **30.**

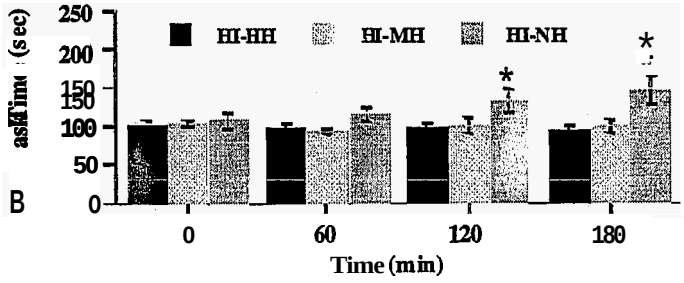

Figure 5. Rifle Task Time at time 0, 60, 120, and 180 min during exposure to -15°C air for conditions HI-HH, HI-MH and HI-NH. (Mean±S.E.).

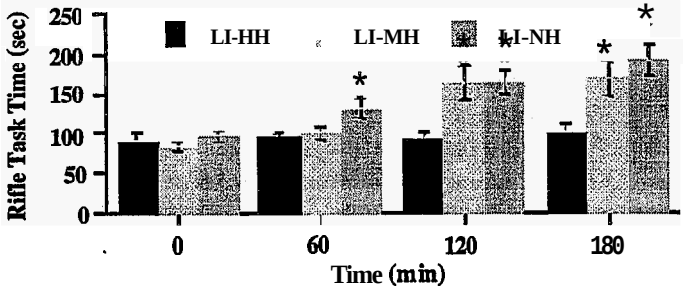

Figure 6. Rifle Task Time at time 0, 60, 120, and 180 min during exposure to -15°C air for conditions LI-HH, LI-MH and LI-NH. (Mean±S.E.)

DISCUSSION

During active torso heating, finger dexterity can be maintained for 3 hours as long as there is a sufficient amount of clothing insulation and/or heating. Passive insulation is not an effective solution in maintaining finger dexterity when resting in a cold ambient environment.

CONCLUSION

Finger dexterity is maintained during all active torso heating conditions except for the LI-MH condition during which the insulation and heating levels were both reduced.

REFERENCE

1. Brajkovic, D., Ducharme, M.B. and Frim, J. 1994, The influence of localised auxiliary heating on hand comfort during cold exposure, *Proceedings of the Sixth International Conference on Environmental Ergonomics,* (Montebello, Canada),