MANUAL PERFORMANCE WHILE WEARING NBC CLOTHING IN COLD

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INTRODUCTION

Manual performance is a combination of good tactile sensitivity, hand dexterity, muscle strength and motor co-ordination. Most of these variables are negatively affected by cooling (1,2). Also the use of gloves impairs manual performance **(3).**

When NBC (nuclear, biological and chemical) protective clothing is used hands are usually covered by coilon-rubber gloves. The gloves enable to handle various tools. In cold climate hand and finger skin temperatures are reported to decrease to very low levels when gloves are used with NBC clothing (4).

The purpose of this study was to examine the effects of whole body cold exposure (-10 "C) on manual performance while cotton-rubber gloves were used together with NBC protective clothing.

MATERIALS and METHODS

Six healthy men partisipated as subjects. Their age was 25 ± 1.0 years (mean ± SE), height 178 ± 2.0 cm, weight 73.4 ± 2.6 kg and body fat 14.4 ± 1.1%. The subjects were dressed in NBC protective clothing (activated charcoal) and underwear with long sleeves and legs, Socks, rubber boots with felt lining and a full-face mask were also used. Hands were covered by thin cotton gloves and rubber overgloves.

Each subject was exposed to three different conditions: 1) standing at 20 "C for 40 minutes, 2) standing in the cold (Ta: -10 "C) for 40 minutes and **3)** standing in the cold (Ta: -10 "C) for 10 minutes followed by 30 minutes walking on a treadmill (5 km/h). Manual tasks were performed after each condition at the exposure temperature.

Six different manual tasks were performed after each exposure while wearing gloves. The tests were a peg-board, magazine loading, bolt and nut, ball picking and a hand grip test. In the peg-board test 48 pegs were turned 180". In the magazine loading test 25 blank cartridges were loaded one by one into the magazine. In the bolt and nut test the subjects completed three sets of bolts and nuts

using only fingers without turning the wrist. In the ball picking test subjects picked up **20** lead balls (diameter 11 mm) one by one from one plate to another. After completing this they reversed the process until all **20** ball were again on the original plate. Ball picking test was performed both seeing and without seeing the balls. The time needed to complete the tasks was recorded in every test. The maximal isometric strength of the hand was determined by a hand grip dynamometer (Newtest, Finland). All tasks were also performed with bare hands at 20 °C without wearing NBC clothing and the full-face mask. All subjects performed the tasks by their dominant right hand.

Rectal (T_{re}) and skin (15 sites) temperatures **(YSI-400** series, Yellow Springs Instruments, **USA)** were measured continuously and stored in a data logger (Squirrel1 1200, Grant, UK) every minute during the experiments. The nine measuring sites of skin temperatures were: forehead, chest, lower back, forearm, hand, middle finger, thigh, shin, and foot. Mean skin temperature (T_{sk}) was calculated by weighting the local 8 sites by representative areas. Rectal and skin temperatures were not measured during the bare hand tests at **20** "C.

The results were analyzed by the paired t-test and by the Pearson correlation test.

RESULTS

T_{re} and T_{sk} were unchanged during rest at **20** "C **(37.3** ± 0.1 and **32.5** ± **0.2** "C, respectively). After rest at -10 "C T_{re} was unchanged **(37.3** ± 0.1 "C) but T_{sk} decreased to **27.1** ± **0.4** °C. After exercise at -10 °C, T_{re} and T_{sk} were **37.9** ± 0.1 and **28.2** ± 0.3 **"C,** respectively, being significantly higher than those after rest at -10 °C.

During rest at -10 "C finger skin temperature (T_f) decreased to (mean ± SE) 10.7 ± 1.0 "C. After exercise at -10 "C and rest at 20 °C T_f was **19.6** ± **4.0** and **34.3** ± 0.2 "C, respectively. Hand skin temperatures were **20.1** ± **0.7,** 20.6 ± 2.8 and **34.5** ± 0.2 "C, after the rest at -10 "C, the exercise at -10 "C and the rest at 20 "C, respectively.

The results of the manual performance are presented in table **1.** Time spent to complete the bolt and nut test, the magazine loading and the peg-board test after rest at -10 "C increased by 50 % ($p<0.01$), **39 % ($p<0.05$)** and **30 % ($p<0,05$),** respectively as compated to the rest at **20** "C. Ball picking tests and hand grip strength were not affected by cold. After exercise at -10 °C the cold-induced deterioration is still seen, but only the bolt and nut test showed significant difference in comparison to **20** "C. Without gloves the performance was significantly better in all tests except in peg-board and magazine loading than with

gloves at 20 "C. The time to complete the ball picking test without seeing was significantly longer than when seeing was allowed.

Manual performance was directly related with finger skin temperature in bolt and nut test (fig. 1), peg-board and magazine loading tests ($r = -0.90$, $r = -0.77$ and $r = -0.72$, respectively, $p < 0.01$).

Table 1. Manual performance in different tests. Gloves were used in all tests except at 20 "C Bare hands. Mean ± SE, n = 6.

	-10 °C Rest	-10 °C Exercise	20 °C Rest	20 °C Bare hands
Peg-board (s)	79.8 ± 5.0*	74.1 ± 5.2	61.4 ± 2.7	58.4 ± 1.3
Bolt and nut (s)	57.5 ± 3.0*	55.1 ± 3.5*	38.3 ± 2.5	33.3 ± 1.9"
Magazine loading (s)	89.7 ± 10.6*	80.4 ± 8.7	64.6 ± 4.1	54.9 ± 2.9
Ball picking, seeing (s)	39.7 ± 0.9	39.6 ± 2.2	37.2 ± 1.3	32.4 ± 1.0"
Ball picking, not seeing	64.6 ± 1.3	66.6 ± 4.3	58.9 ± 3.3	48.6 ± 1.1"
Hand grip strength (kg)	47.5 ± 1.8	46.9 ± 1.8	47.3 ± 1.8	57.4 ± 2.1"

*differs significantly from 20 "C Rest

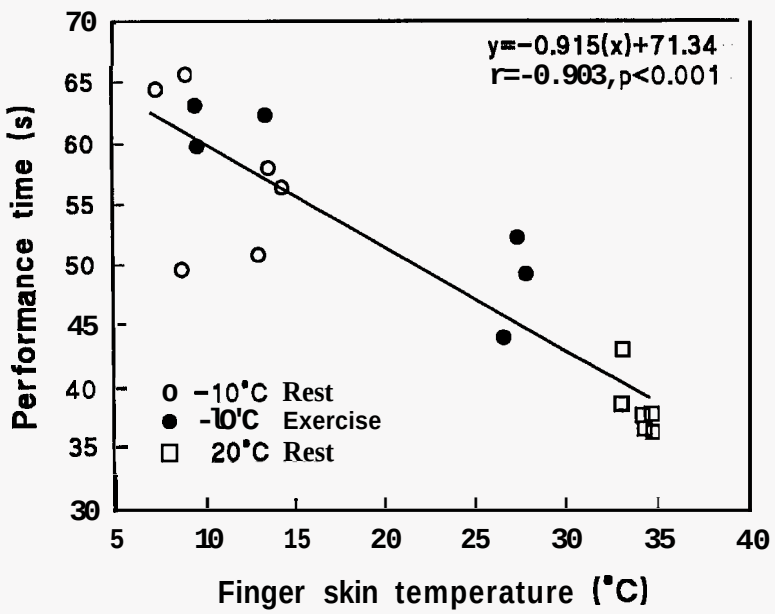

Fig. 1. Relationship between finger skin temperature and manual performance in the bolt and nut test.

CONCLUSIONS

Results show that the cold exposure in NBC protective clothing decreased finger skin temperature to the level where manual performance is generally considered to decrease. Individual variation in finger and hand skin temperature was, however, rather wide. The measurements in this study showed that cooling impaired significantly only those tasks, which required fine motor skills or finger dexterity. Gloves themselves decreased performance especially in tasks which were related to tactile sensitivity and finger dexterity. Although exercise in cold increased deep body and mean skin temperatures, hands and fingers were still rather cold. Nevertheless, only bolt and nut test, which required finger dexterity, showed significant deterioration after exercise in the cold in comparison to rest at 20 °C. In the present study cooling was not enough to decrease hand grip strength.

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