

# THE THERMAL RESPONSE FROM REPEATED EXPOSURES TO SEVERE COLD WITH INTERMITTENT WARMER TEMPERATURES

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## INTRODUCTION

Many workers in artificially cold environments, e.g. cold storage, are often exposed to very cold environments. Work in such very cold environments has resulted in some medical problems: (1) It is important that the workers should keep warm in warm resting places after exposure to a very cold environment. The workers tend to remove their cold-protective clothing (especially jackets) in warm resting places due to the discomfort of such heavy clothing, but not much research has been conducted on the effect of repeated cold exposure, and the effect of cold-protective clothing in warm places of rest after severe cold exposures (2,3). Hence this study was conducted to evaluate the physiological reaction and manual performance during exposures in warm and cool environments after exposure to very low temperatures. Furthermore, this experiment was conducted to study whether it is desirable to remove cold-protective jackets in a warm environment after severe cold exposures.

## METHODS

Eight healthy male students volunteered as the subjects. Their mean (S.D.) age, height and weight were 21.0 (1.7) years, 169.0 (6.2) cm and 61.1 (5.6) s, respectively. They wore trunks, long underpants, a long-sleeved sweat shirt, socks, cold-protective trousers, a cold-protective jacket, a pair of gloves and a hood. Total clothing weight was 3.26s, and the total insulation value estimated from this weight was 2.3 clo. The experimental schedule is shown in Figure 1.

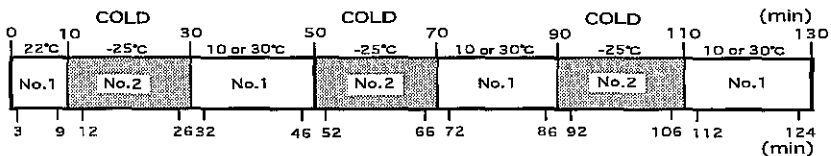


Fig. 1 Experimental Schedule

The subjects remained in a very cold room (-25°C) for 20min, after which they were transferred into either a warm room (30°C) or a cool room (10°C) for 20min. In the warm and cool rooms, the subjects either removed their cold-protective jackets (condition A), or wore them continuously (condition B). Rectal temperature, skin temperatures at twelve sites, and heart rate were measured continuously. Blood pressure was measured, and thermal comfort and pain sensation were ascertained from the subjects before and after transfer from each room. The manual performance consisted of a counting task and was conducted as quickly as possible for 15s with a manual counter. Differences between the conditions were compared by paired t-test, and in a statistical test a value of  $P < 0.05$  was accepted as indicating significance.

## RESULTS

Figure 2 shows the time course of average fall in rectal temperature under both conditions. The left side indicates repeated exposures to severe cold and cool rooms, alternately. The right side indicates repeated exposures to severe cold and warm rooms, alternately. Rectal temperatures fell due to repeated exposure to the severe cold under both conditions. The decreases in rectal temperature under the cooler conditions were greater than those under the warm condition after 130min of the experiment. The decreases in rectal temperature under Condition B were significantly greater than those under Condition A after 20min of the experiment in the warm condition but, there were no significant differences between Condition A and Condition B in the cool condition.

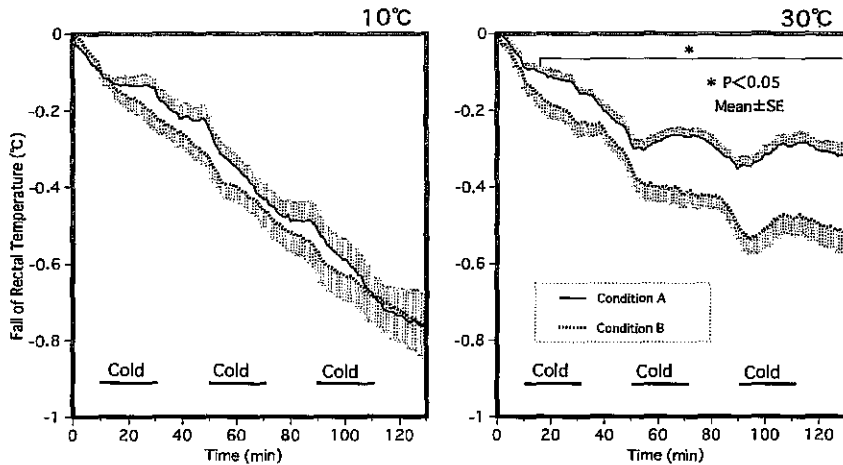


Fig.2 Change in rectal temperature with and without cold-protective jackets in a warm room (left : 10°C, right : 30°C) .

Tochihara et al. (3) have reported that the decreases in rectal temperature under condition A were greater than those under condition B in the warm room after severe cold exposures. This inconsistency may be due to the fact that there were differences in clothing insulation on the lower parts of the body and differences in the warm room temperature.

Mean skin temperature decreased in the very cold room and increased in the warm room. The increases in mean skin temperatures in the cool room were significantly smaller than those in the warm room after repeated exposures to the severe cold.

Systolic and diastolic blood pressure increased in the cold room and decreased in the warm room, and increased gradually with time from repeated cold exposures, as shown in Figure 3. At the end of the cold exposure, the average systolic blood pressure under Condition A was higher than that under Condition B in the cool condition, but there were no significant differences between the two conditions in the warm condition except for the warm room after 72 minutes.

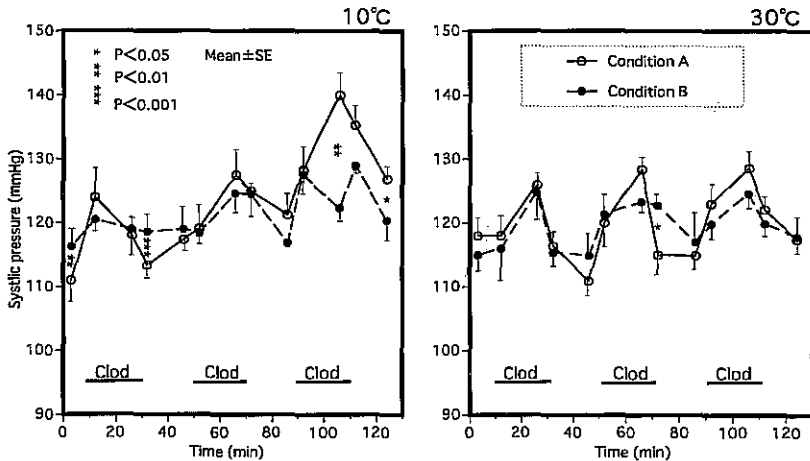


Fig. 3 Change in systolic blood pressure with and without cold-protective jackets in a warm room (left : 10°C, right : 30°C) .

Figure 4 shows the results of the counting performance, presented as the percentage of the pre-exposure control values. Counting performances decreased with repeated cold exposures under both conditions in the warm and the cool conditions, respectively. The average falls in these values in the cool condition were higher than in the warm condition. In the cool condition, the decreases in these values under Condition A were significantly lower than those under Condition B.

Comfort, thermal and pain sensations under Condition A were more severe than those under Condition B in the cool room after repeated severe cold exposures, but there were no distinct differences between both conditions in the warm room after repeated severe cold exposures.

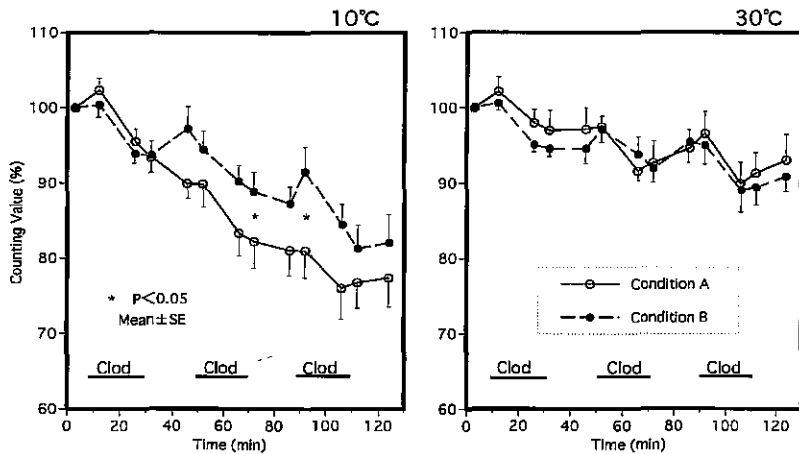


Fig. 4 Change in manual performance with and without cold-protective jackets in a warm room (left : 10°C, right : 30°C) .

## CONCLUSIONS

Rectal temperatures fell gradually due to repeated cold exposures with or without severe cold-protective clothing in the cool (10°C) environment, suggesting that workers should continue to wear cold-protective clothing in the cool (10°C) environment to prevent decreases in manual performance and increases in blood pressure and discomfort. By continually wearing cold-protective clothing, they were able to sustain their performance in the cool environment to the same level as in the warm (30°C) environment. It was recognized that the psychological responses and manual performance were not influenced by the presence or absence of cold-protective clothing in the warm (30°C) environment after repeated severe cold exposures. These results suggest that it is necessary for the workers to make sure to rewarm in the warm room outside of the cold storage and continue to wear cold-protective clothing in the cool room.

## REFERENCES

1. Nielsen R., 1986, Clothing and thermal environments, *Applied Ergonomics*, 17(1), 45-57.
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3. Tochiyama Y., Ohnaka T., Tsuzuki K. and Nagai Y., 1993, Comparison of thermal responses with and without cold protective clothing in a warm environment after severe cold exposures. *J. therm. Biol.*, 18(5/6), 639-642.