THERMAL RESPONSES FROM REPEATED EXPOSURES TO SEVERE COLD AT NIGHT

. H. Ozaki[1], Y. Nagai[2] and Y. Tochihara[3]

[1]Aeromedical Laboratory, JASDF, Tokyo, Japan
[2]Osaka Kyoiku University, Osaka, Japan
[3]Kyushu Institute of Design, Fukuoka, Japan

INTRODUCTION

There are over 3,800 cold storage facilities in Japan, and 80% of them are kept at temperatures between -20°C and -30°C. The artificial severe cold environment may have adverse effects on manual performance, and medical problems have been reported in workers in these facilities (1). Since work in cold environments may have adverse effects on health and performance, simulated experiments of cold storage operations have been conducted in several laboratories (2). In addition, there have been several surveys under field conditions (3). In Japan, workers in frozen-fish cold storage facilities must perform night work in order to deliver the products to markets that open early in the morning. However, limited research has been conducted on the effects of repeated severe cold exposures at night. The purpose of this study was to evaluate physiological reactions and manual task performance during exposure to severe cold (-25°C) at night (3:00 to 5:00 AM) and in the afternoon (3:00 to 5:00 PM), respectively.

METHODS

The subjects were 13 healthy male student volunteers. Their mean age, height and body weight were 20.3 years, 170.4 cm and 64.6 kg, respectively. They wore trunks, long underpants, a long-sleeved sweatshirt, socks, cold-protective trousers, a cold-protective jacket, a pair of gloves and a hood. The total clothing weight was 3.26 kg, and the total insulation value estimated from this weight was about 2.3 clo. In addition, they wore cold-protective boots (1.5 "C). The subjects remained in a severely cold room (-25°C) for 20 min, then moved into a cool room (10°C) for 20 min. This pattern was repeated 3 times. This pattern was designed the same as in our previous experiment (4). The subjects remained seated during the experiments except when changing rooms. The experiments were started at 3:00 PM or 3:00 AM, and each experiment was performed under either the repeated cold exposure or no cold exposure (Control). Rectal and skin temperatures at 12 points (forehead, cheek, chest, abdomen, back, forearm, hand, thigh, leg, foot, second finger and second toe) on the subjects were measured continuously during the experiments. Blood pressure was measured, and thermal, pain and comfort sensations were ascertained from the subjects before and after transfer fiom each room. The counting task was conducted as fast as possible for 15 s with a manual counter *(5)*. The data were analyzed using analysis of variance (ANOVA). When appropriate, comparisons of means were performed using the Student's paired t-test. A probability of less than **0.05** was considered significant.

RESULTS

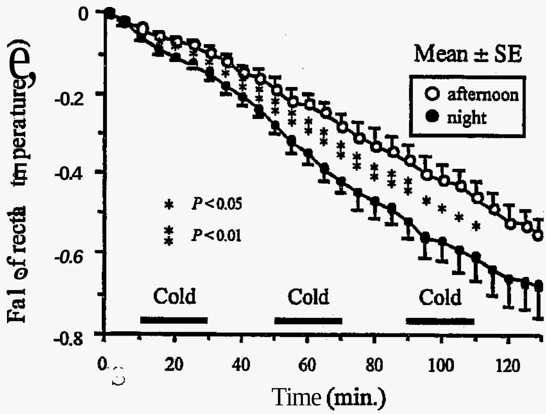

Figure 1. Changes in rectal temperature with repeated cold exposure.

Figure 1 shows the time course of the average fall in rectal temperature (T_{re}) in the afternoon and at night. T_{re} fell due to repeated exposure **to** severe cold and cool environments. The decreases in T_{re} at night were significantly greater than those in the afternoon, except after 110 **min** of the experiment. At the end of the experiment, T_{re} had decreased by 0.68°C on average at night and 0.55°C in the afternoon. The mean **skin** temperature decreased in the severe-cold room and increased in the cool room, but there were no significant differences between the afternoon and night.

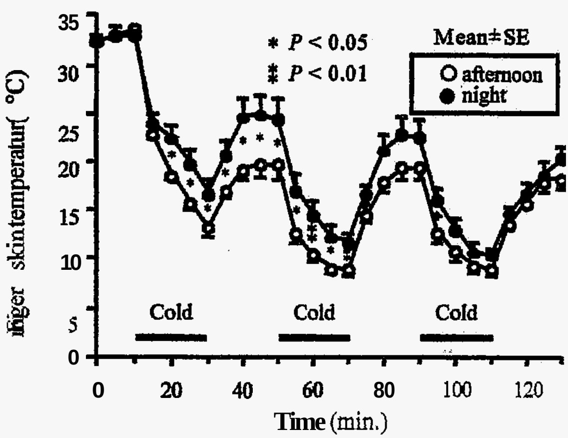

Figure 2. Changes in finger skin temperature with repeated cold exposure.

Figure 2 shows the time course of average changes in finger skin temperature (T_f) in the afternoon and at night. T_f markedly decreased due to cold exposures **and** rewarmed rapidly in the cool environment. Although T_f **in**creased slightly in the cool environments, it decreased gradually following repeated cold exposures. The decreases **in** T_f **in the afternoon** were significantly greater than those at night. At the end of the first cold period, average T_f in the afternoon and at night was 13.19°C and **16.74°C,** respectively.

The variation in the toe skin temperature (Tt) was considerably smaller than that in T_f. T_t decreased gradually following repeated cold exposures in the afternoon and at night. From the beginning to the end of the experiment, T_t at night was significantly higher than in the afternoon. The maximal average difference in T_t between the afternoon and night was 5.51°C during the second cold period.

Systolic and diastolic blood pressure increased in the cold room, decreased in the cool room and increased gradually with time following repeated cold exposures. After the second cold exposure, the average diastolic blood pressure at night was higher than that in the afternoon, but there were no significant differences between the afternoon and night regarding the average systolic blood pressure.

Counting performances decreased with repeated cold exposures in the afternoon and at night, respectively. From the beginning to the end of the first cold exposure, the average falls in these values in the afternoon were significantly higher than those at night.

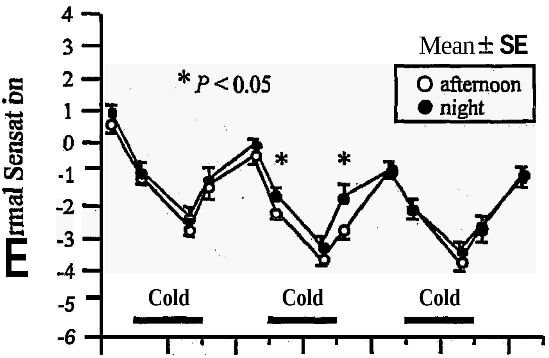

Figure 3. Changes in thermal sensation with repeated cold exposure.

Means of the thermal hand sensation in the afternoon and at night are presented in Figure 3. Thermal hand sensation in the afternoon was significantly more severe than that at night after 52 min and 72 min of the experiment. Pain sensation of the finger in the afternoon also was more severe than that at night, but there were no significant differences between the afternoon and the night in comfort sensation.

DISCUSSION

At the beginning of the experiment, rectal temperatures in the afternoon were significantly higher than at night due to the subject's circadian rhythm. Additionally, the fall in T_{re} during cold exposures at night was significantly greater than that in the afternoon (Figure 1). It was shown that a severe decrease in T_{re} occurred when the human body was exposed to cold at night. Although there were no significant differences in mean skin temperature between the afternoon and night, and T_f and T_t at night were significantly higher (Figure 2). These higher skin temperatures on the peripheral parts of the body suggest increased rates of heat loss in these areas. This finding may explain why the subjects tended not to feel thermal and pain sensations of the peripheral portions to as great a degree at night (Figure **3).** These phenomena may lead to an increase in the risk of hypothermia. In addition to decreased core body temperature, a decline in manual performance affects the safety and efficiency of working at night

CONCLUSIONS

The subjects' peripheral skin temperatures were higher at night than in the afternoon. Subjects felt diminished thermal and pain sensations in the peripheral portions **of** the body. However, rectal temperature and manual dexterity decreased remarkably at night. These findings suggest that there is an increased **risk** both of hypothermia and of accident for those working at night.

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