EFFECTS OF FACIAL COOLING ON THERMAL RESPONSES OF HUMANS

Y. Tochihara*, G. Ohlsson, E. Karlsson, D. Gavhed and I. Holmér

*Department of Physiological Hygiene, National Institute of Public Health
4-6-1 Shirokanedai, Minato-ku, Tokyo 108, Japan
Division of Ergonomics, National Institute for Working Life
S-171 84 Solna, Sweden

INTRODUCTION

Recently, several threshold limiting values (TLV) for works in cold environments have been reported (ACGIH, 1984, ISO/TR-11079, 1993, Japan Association of Industrial Health, 1994). In these TLV, windchill index (WCI) has been used extensively to estimate the cooling effect of temperature and wind. However, there is few physiological data from the moderate speed of wind. Therefore, the following experiment was conducted to investigate the effects of facial cooling on thermal responses of humans.

METHODS

The subject's face was exposed to cold air at wind speeds of 0.2, 2, 4 and 6 m/s at 0, -5 and -10°C. Each subject was exposed to 12 conditions in total, and was tested only once in a day. WCI of the severest condition (-10°C and 6 m/s) was 1490 W/m^2. Four healthy adults volunteered as subjects. They were dressed with a cold-protective clothing which adequately protected the whole body except the face in a pre-room kept at 21°C. They wore goggles for eye protection. Upon entering the cold chamber, the subject sat and immediately the wind was blown on his/her face for 10 minutes. The wind was blown through a square tunnel with a 50 cm width. After the cold exposure, the subjects were moved to the pre-room and rested for four minutes. This experiment was carried out in autumn.

Skin temperatures at mid-point of forehead, top of cheek, top of nose and anterior surface of earlobe were measured with copper-constantan thermocouples every four seconds. They were fixed to the skin by small air permeable tape. Blood pressure and heart rate were obtained on the left upper arm by an automatic tonometer. The subjects were asked to rate on a five point scale with their experience of thermal sensation of face and pain sensations at forehead, cheek, nose, and ear. They were subsequently asked whether the environment was an acceptable work place.

The experiment was terminated when the conditions were intolerable to the subjects. Moreover, the experiment was terminated when skin temperatures fell below -1°C, or if systolic blood pressure increased over 225 mmHg.

RESULTS

Since the ear skin temperature of Subject C decreased below **-1°C**, the experiment was terminated after 5-min of exposure at **-10°C** and ***6*** **m/s**. The lowest values in **skin** temperature was recorded at ear level, followed by nose, cheek and forehead. This order remained constant in the **12** conditions. From a two-way analysis of variance, it was found that effects of air temperature and air velocity on skin temperatures at three sites were highly significant ($P<0.01$). With the ear skin temperature, only the effect of air velocity was significant. Although, differences among the air temperatures and air velocities were always significant at forehead; there were no significant differences in cheek, nose and ear skin temperatures between 4m/s and ***6*** m/s.

Figure 1 showed changes in systolic blood pressure for four subjects at -10°C with winds at 6 m/s. Although systolic blood pressure of the four subjects increased during the facial cooling, there were large individual differences in the degree of increase. There was only a 10 mmHg increase during the 10 min exposure for Subject **A,** on the other hand, there was more than a 60 mmHg increase for Subject D. The highest value for Subject D was **221** mmHg, this value was very close to the critical value. The highest values for the three subjects were obtained at the three-minutes exposure point, the value for Subject D was at the 7-minutes exposure point.

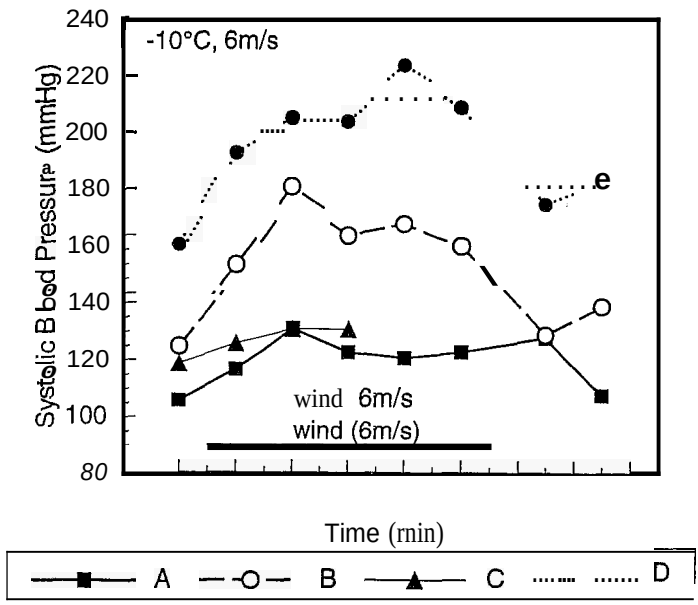

Fig.1 Changes in systolic blood pressure at -10°C **with** wind at 6 m/s

The highest values of the both systolic and diastolic blood pressure were obtained at the condition of -10°C with winds at 6m/s. Effects of air temperature and air velocity on diastolic blood pressures were significant. Although, there were similar tendency with systolic blood pressure, these effects were not significant. On the other hand, .the lowest heart rate was obtained at the condition at **-5°C** with winds at 2m/s, there were no signifcant differences in heart rate among the temperatures and wind velocities.

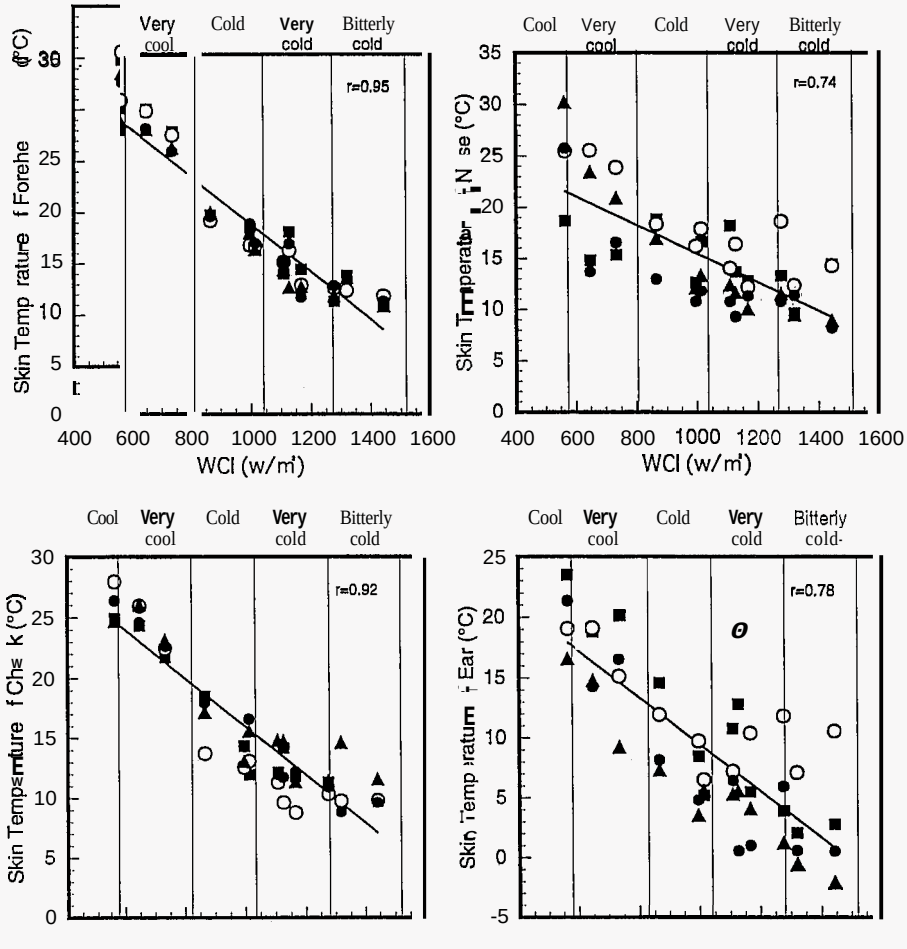

Fig.2 Relationships between WCI and the lowest skin temperatures during the wind exposures.

Pain sensation of the ear became severe more rapidly with wind exposure. Half of the subjects reached the 4th grade (very very painful) after three minutes of exposure at 10°C and 6 m/s, and the others reached maximum after five minutes of exposure. Thereafter, there were small changes in pain sensation during the exposures. There were large variances in pain sensation among the subjects, for example, when Subject A voted 'very painful', Subject D had no pain.

Figure 2 illustrated the relationships between WCI and the lowest forehead, cheek, nose and ear skin temperatures during 10 minutes facial cooling. The highest correlation coefficient was obtained at the forehead level (r=0.95), followed by the cheek (r=0.92), the ear(r=0.78) and the nose(r=0.74). Individual differences in forehead, cheek, nose and ear under the condition of WCI=1490 were 1.1°C, 2.0°C, 6.2°C and 12.7°C, respectively.

The relationships between WCI and the severest subjective responses during facial cooling were highly significant (P<0.01) were shown in Figure 3. Even under conditions nearing WCI=1200, the severest subjective responses (4th Grade) were recorded.

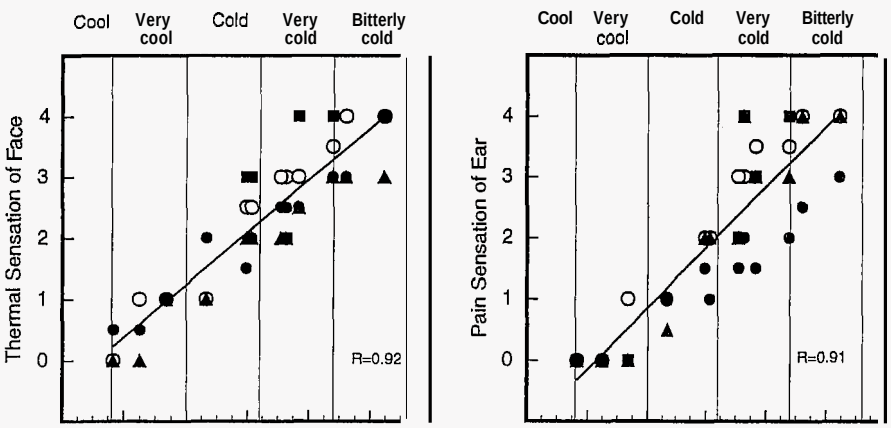

Fig.3 Relationship between WCI and the severest subjective responses during the wind exposures.

■ A ○ B ▲ C ● D

CONCLUSION

Although significant relationships between WCI and blood pressure, skin temperatures and subjective responses were confirmed; even in a safety range, evaluated from WCI, there were dangerous drops of skin temperatures and increases in blood pressures. Therefore, it is necessary to reconsider WCI in this range of thermal conditions.