

## EFFECTS OF COOLING THE UPPER TORSO ON THERMOPHYSIOLOGICAL RESPONSES AND CLOTHING MICROCLIMATE IN SUBJECTS WEARING PROTECTIVE CLOTHING FOR PESTICIDE

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### INTRODUCTION

Farmers need protective clothing while spraying pesticide in order to protect themselves against agricultural chemicals. However, wearing the protective clothing often causes hyperthermia, because heat loss, especially wet heat loss through the protective clothing does not occur effectively from the human body to the environment. Although various cooling systems which can prevent the core temperature and the sweat rate from rising have been studied (1, 2), these are not necessarily practical or appropriate for field use. With these in mind, we tried to study the thermophysiological effects of cooling the upper torso with a portable frozen gel strip in exercising and resting subjects.

### MATERIALS AND METHODS

Five healthy female adults, aged 19-20 yrs, volunteered as subjects. Subjects wore only a cotton pesticide protective clothing with water repellent finish in the control (without cooling) conditions. In the with cooling condition, a cooling system consisting of cotton undershirts with two pockets (one on the front, the other on the back) and a neck belt holding a frozen gel strip was also worn. The total weight of the frozen gel strips was 510 g. Subjects wore the protective clothing and were studied at an ambient temperature of  $30 \pm 0.3^\circ\text{C}$  and a relative humidity  $\pm 5\%$ . After the subjects rested for 15 min in a chair they repeated three work/rest cycles of 15 min exercise on a cycle ergometer (50W) followed by 5 min rest. Frozen gel strips were inserted into pockets and neck belts just before the first exercise bout. Core and skin temperatures (8 sites), heart rate, local sweat rate from forearms by the usage of capacitance hygrometry, and clothing microclimates (temperature, humidity) between undershirts and protective clothing at level of below circa 20 cm from frozen gel strip were continuously measured during the experiment. The amounts of sweat remaining on the clothes were calculated by the weight difference of the clothing. The subjects rated their sensation of temperature, humidity and comfort.

### RESULTS

Cooling the upper torso inhibited an increase of forearm sweat rate during exercise (Fig. 1). The amounts of sweat remaining on the undershirts and protective clothing were significantly lower in the 'cooling' than in the 'without cooling' conditions (Fig. 2). The mean skin temperature exhibited a smaller increase in the 'cooling' trials. The chest skin temperature decreased abruptly when frozen gel strips were inserted (Fig.3). The increase in core (tympanic and rectal) temperature during exercise was significantly delayed in the 'cooling' trials. The clothing microclimate temperature and humidity at trunk level were clearly lower in the 'cooling' than in the 'without cooling trials'. Thermal sensation was improved from 'very hot' to 'warm' in the cooling trials (Fig.4).

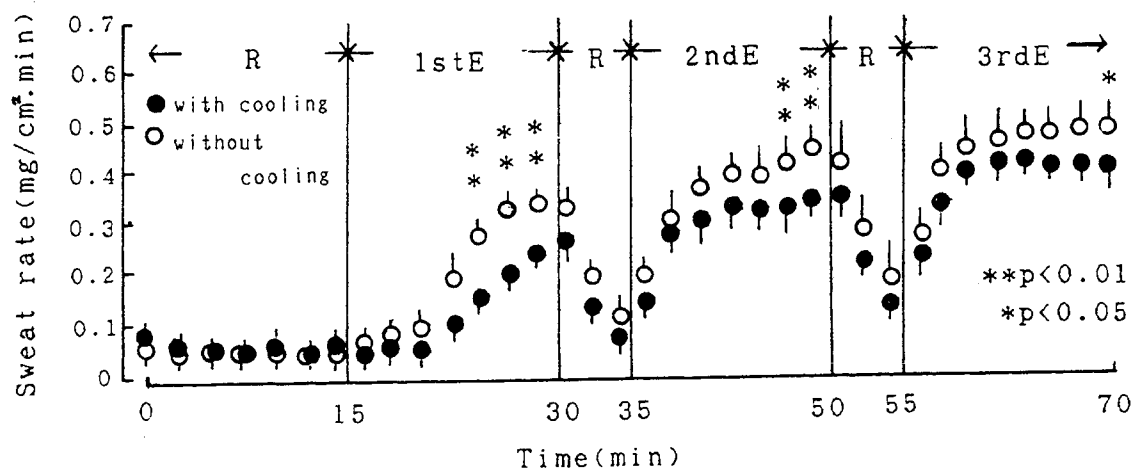


Fig.1. Forearm sweat rates during rest and exercise under the influences of two kinds of protective clothing. The values are means  $\pm$  S.E. Closed circles: 'with cooling', and open circles: 'without cooling' conditions.

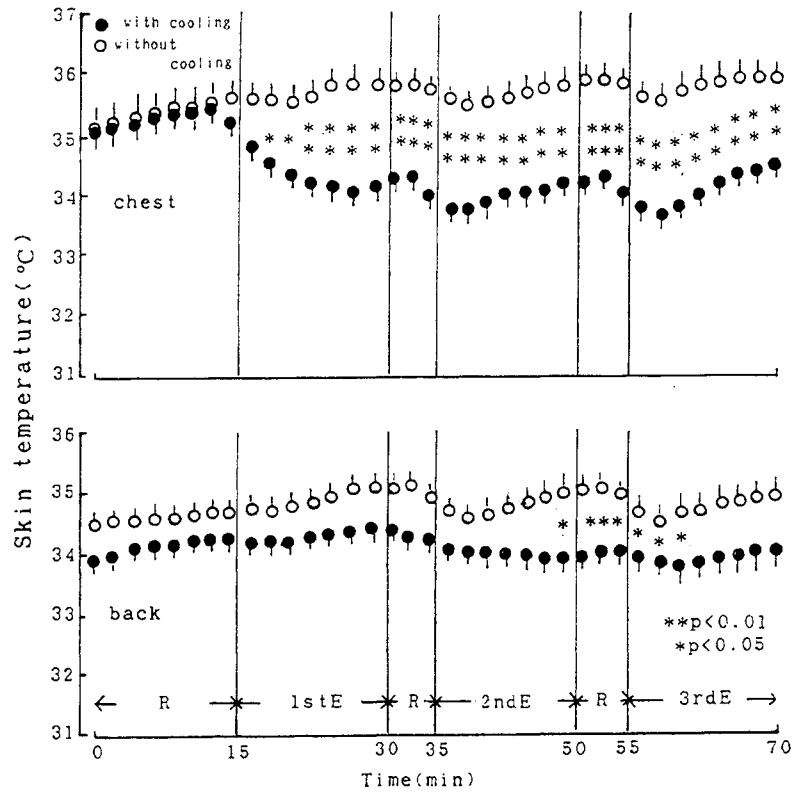


Fig. 3. Skin temperatures of chest (top) and back (bottom) during rest and exercise under the influences of two kinds of protective clothing. The values are mean±S.E. of 5 subjects. Closed circles: 'with cooling', and open circles: 'without cooling' conditions.

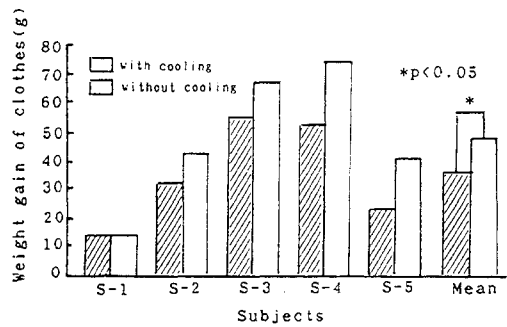


Fig. 2. The amount of sweat remaining on undershirts and protective clothing of each 5 subjects.

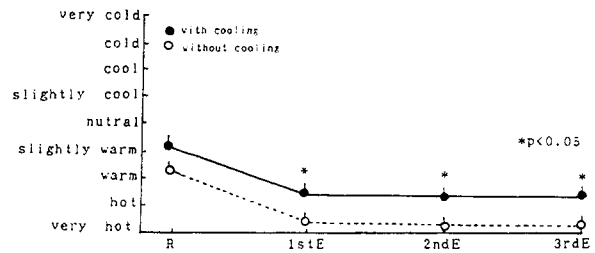


Fig. 4. Subjective vote of thermal sensation. The values are mean±S.E. of 5 subjects.

CONCLUSION

It was concluded that cooling the upper torso with the aid of frozen gel strips reduces the thermophysiological load in exercising subjects wearing protective clothing for pesticide at an ambient temperature of 30°C. Furthermore, the clothing microclimate (temperature, humidity) at trunk level and subjective sensations were improved by cooling

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