THERMAL AND PHYSIOLOGICAL ASSESSMENT OF A LIQUID COOLING GARMENT

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INTRODUCTION

In this study thermal experiments and physiological experiments were carried out to assess the characteristics of a liquid cooling garment(LCG).

METHOD

Thermal characteristics of LCG were measured using an electrically heated manikin in an environmental temperature 40 °C (air velocity < 0.2m/s). The manikin skin temperature was controlled at about 30 °C by changing the heating power. Two clothing ensembles,LCG only, LCG and thermal insulation clothing(TIC), were used in the experiment to compare the effects of a hot environment on the LCG's efficiency. The heat flux from the manikin skin(HFms) (13sites), the heat flux from the clothing surface(HFcs) (6sites), the temperature of the clothing surface and the heating power were measured. The heat fluxes were used to analyse heat transfer in man/LCG/environment system.

In the physiological experiments subjects were 10 healthy young men, who were dressed in work suit,helmet,shoes and LCG, and were sedentary in a hot environment for 70 minutes. The environmental temperature was set to dry bulb temperature (Tdb) of 35 °C and wet bulb temperature (Twb) of 28 °C, Tdb 40 °C and Twb 29 °C, Tdb 45 °C and Twb 31 °C. Flow rate (FL) of the circulating water in LCG was about 1 l/min and water inlet temperature (Twi) was changed from 16 °C to 25 °C. The skin temperatures (13 sites), auditory canal temperature, heart rate and sweat rate were measured. The comprehensive index of heat stress (CIHS) was calculated to evaluate the effectivness of LCG. The CIHS difference between cooling and no cooling conditions was considered as the amount of heat strain to be reduced by LCG.

RESULTS

Table 1. heat flux of manikin test with constant FL 1.2 l/min

Clothing	LCG	LCG	LCG+TIC	LCG
Twi °C	15	20	20	25
HFms W/m²	52.2	49.4	48.4	26.7
HFcs W/m²	-109.4	-94.8	-30.9	-66.9

Table 2. heat flux of manikin test with constant Twi 20 °C

Clothing	LCG	LCG	LCG
FL l/min	1.2	0.92	0.73
HFms W/m²	49.4	45.0	40.6
HFcs W/m²	- 94.8	-89.5	-89.5

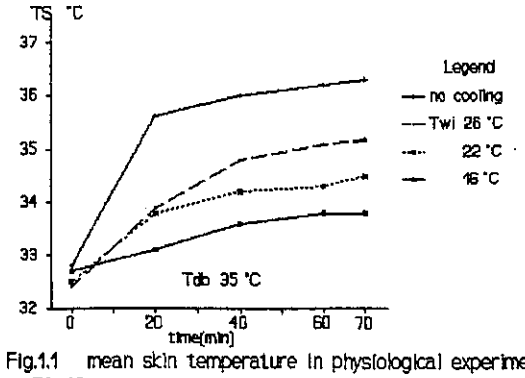

Fig.1.1 mean skin temperature in physiological experiments

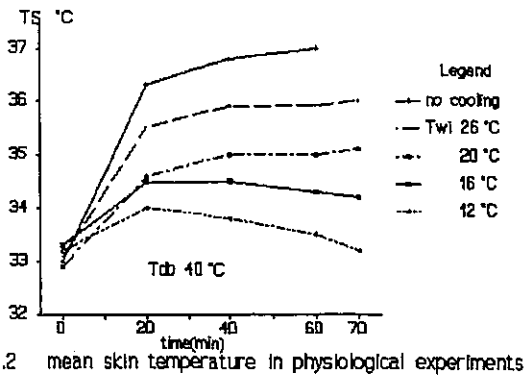

Fig.1.2 mean skin temperature in physiological experiments

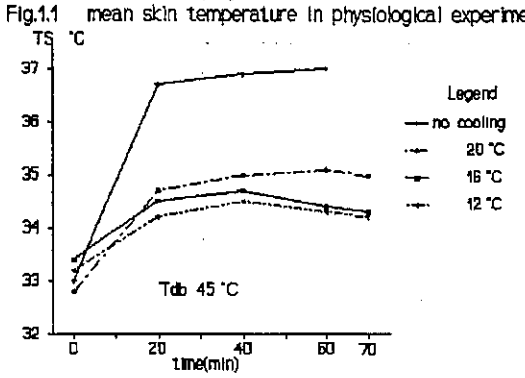

Fig.1.3 mean skin temperature in physiological experiments

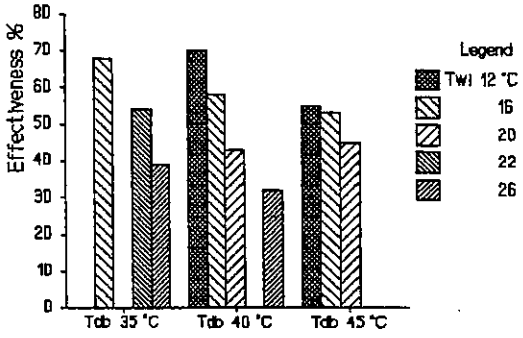

Fig.2 Effectiveness of LCG in reducing heat strain

DISCUSSION AND CONCLUSIONS

The heat flux in Tables 1 and 2 show clearly the heat exchange relations among man/LCG/thermal environment system. HFms is less than HFcs, i.e., LCG absorbs more heat from environment than it removes from body. HFms with TIC is the same as that without TIC while HFcs with TIC is greatly less than that without TIC. Therefore TIC is necessary to improve the LCG efficiency and the heat flux from the skin may be an useful variable for controlling LCG.

The physiological experiments show that LCG is effective in reducing heat strain. The heat strain can be alleviated by 40%-70% according to CIHS. The results from skin temperatures, heart rate, sweat rate and CIHS indicate that the effectivness of LCG is desirable with Twi 16-26°C at Tdb35°C and Twi 12-20°C at Tdb40-45°C.

REFERENCES

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