LOCAL MODERATE VENTILATION AND THERMOREGULATORY RESPONSES IN MAN EXERCISING IN AN IMPERMEABLE GARMENT

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INTRODUCTION

When an impermeable garment is worn by humans working in the heat, sweat evaporation is limited or even suppressed, leading to a risk of hyperthermia. Microclimate cooling systems consisting of either an ice-jacket, water perfused-garment, or an air-ventilation system (1) are used to limit this risk. Previous studies have shown that with the same ventilatory flow rate, a local cooling was as efficient as a total body cooling (2, 3, 4). The present work was carried out to study the influence of ventilating the trunk or leg regions of an impermeable suit on thermal responses in man working in a warm environment. A dry air-ventilation system was used because it favored the sweat evaporation, which represents the natural heat-dissipation mechanism of the body.

METHODS

Ten healthy young males volunteered for these experiments, knowing their content and potential risks. After having signed an informed consent, each subject participated in three tests at the same time-period of the same week day, every week. After a period of rest in thermoneutral conditions, each test consisted of a 60-minute exercise on a cycle ergometer (work load: 60 Watts) in a warm environment (30°C wall and air temperatures, 10°C dew-point temperature and 0.3 $m.s^{-1}$ air velocity).

Oesophageal (T_{es}), rectal (T_{re}), 10 local skin temperatures and 4 local sweat rates from 4 highly ventilated sweat capsules (on left and right chest, and on right and left thigh) were measured every minute throughout the experiments. Mean skin temperatures of the trunk and the legs were calculated by averaging values of 4 sensors (chest, abdomen, shoulder, and lumbar area) for the trunk and by averaging values of 3 sensors (foot, calf, and thigh) for the legs.

On three separate days, subjects wore shorts, sport-shoes, and an impermeable garment (decontamination ensemble) with the head kept out of the ensemble. During ventilated trials a system consisting of perforated tubes in which dry nitrogen was equally dispatched at a flow rate of 40 $l \cdot min^{-1}$ over the ventilated surface area of the trunk or legs. Subjects were tested in three randomly ordered trials: 1) no ventilation (NV); 2) ventilation of the trunk region (TV); and 3) ventilation of the leg region (LV).

RESULTS

In this short paper, results are expressed as differences between final exercise and final rest values.

- Oesophageal and mean skin temperatures increased less when the body was partially ventilated compared to the no ventilation condition. Although the core temperature showed the same rise in the two exposures with local ventilation, mean skin temperature in TV was lower than in LV due to the fact that local skin trunk temperature was lower in TV compared to LV.
- Under each of the three conditions, the trunk skin temperature increases were smaller than those of the legs. Moreover, the leg skin ventilation influenced the skin trunk temperature, while the trunk ventilation did not modify the leg skin temperature.
- Although the skin temperatures were influenced by local ventilations, only the leg sweat rate was modified by local ventilation. In addition, sweat rate was always greater on the trunk than on the legs.
- Ventilation of the trunk caused lower increases in oesophageal, mean skin, and local trunk temperatures, but did not modify leg skin temperature or local sweat rates. On the other hand, ventilating the legs caused lower increases in oesophageal, mean skin, and local trunk temperatures and leg sweat rates, but did not influence leg skin temperature or trunk sweat rate.

	Increase in Tes (°C)	Increase in Tsk (°C)	Increase in local skin temperature (°C)		Local sweat rate ($mg.min^{-1}.cm^{-2}$)	
Test			Trunk	Legs	Trunk	Legs
NV	0.88 (0.09)**	3.02 (0.13)**	2.61 (0.17)	3.55 (0.27)	1.03 (0.09)	0.98 (0.08)
TV	0.74 (0.09)	2.54 (0.13)	1.27 (0.18)*	3.41 (0.19)	1.07 (0.10)	0.90 (0.10)
LV	0.69 (0.09)	2.69 (0.08)	2.27 (0.18)	3.28 (0.24)	0.98 (0.10)	0.82 (0.08)

Table: Body temperature increases and local sweating observed during the three tests (NV: no ventilation, TV: trunk ventilation, LV: leg ventilation) – Mean and S.E.M. for the 10 subjects. ** NV different from both TV and LV ($P<0.05$); * TV different from LV ($P<0.05$).

DISCUSSION

Despite smaller increases in body temperatures during local ventilation, the local trunk sweat rate, greater than the one of the legs, was the same in the three conditions, probably because it had reached its maximum level. On the other hand, the leg ventilation led to a lower local sweat rate on this area compared to the non ventilation condition.

Although trunk and legs represent approximately the same percentage of the total body area (= 38 %), and although the local ventilation limited the rise in internal and mean skin temperatures, it was concluded that only the trunk ventilation had a real impact on mean skin temperature even though it was not sufficient to reduce efficiently the heat strain because of relatively moderate air renewal rate. Nevertheless, the trunk appeared as an area adequate for selective local ventilation.

CONCLUSION

In conditions of restricted evaporation in impermeable ensembles, it seems better to ventilate locally the trunk for at least two reasons: the lesser increase in skin temperature and the higher local trunk possible sweating which can occur and which could then be evaporated thanks to local ventilation.

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