TEMPERATURE AND SWEATING ADJUSTMENTS UNDER EVAPORATIVE RESTRICTION IN EXERCISING MAN

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INTRODUCTION

When an impermeable ensemble is worn by humans working in the heat, the efficiency of sweat evaporation is limited and heat is continuously stored, leading to a risk of hyperthermia. Generally, it is possible to provide some cooling by using a microclimate refrigerating system consisting of either an ice–jacket or a water perfused–garment or an air–ventilation system.

In order to assess which part of the body is the most effective in cooling the body when evaporation is restricted, we examined the physiological reactions (1) – i.e. the thermal and sweat evaporative adjustments – in conditions where some cutaneous areas were –or were not – covered with an impermeable plastic foil.

METHODS

Ten young males volunteered for these experiments, knowing their content and potential risks. After having signed an informed consent, each subject participated in the tests at the same time–period of the same week day, every two weeks. After a thermoneutral exposure at rest, each test consisted of a 60 min work period on a cycle ergometer (work load : 70 Watts) at a 30°C wall and air temperature, constant dew–pein! (2.0 kPa) and low air velocity (0.3 meter per second).

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

Four tests were randomly carried out on each subject :

- **control : wearing only** shorts **and sport–shoes**
- **totally** wrapped in stretchable polyurethane foil, except for head and neck.
- **partially** wrapped in the impermeable foil covering :
  either arms and trunk or arms and legs.

When partially wrapped, the subjects could benefit from some cooling provided by the remaining body–parts which were uncovered, mainly trunk or legs (2).

RESULTS

In this short paper, results are expressed as difference between control and each of the three experimental conditions. Effects of conditions on body temperature and local sweating variations were analyzed by means of analysis of variance with repeated measures : comparisons were performed with orthogonal and paired t–tests. The 0.05 level of confidence was considered significant. The table presented gives the variations associated with total or partial restriction in possible evaporation, from which it can be concluded that :

- Although the core temperature increased less than expected (3), it increased more when the body was totally covered and showed the same rise in the two exposures with partial evaporative restriction ($p<.05$).
- When total body was covered, trunk exhibited larger skin temperature increase ($p<.05$) and tended to sweat more ($p<.09$) than what was observed on the legs.
- Trunk and leg temperature increases were respectively larger when covered compared to uncovered ($p<.01$).
- Covering the legs induced increases of trunk sweating ($p<.01$) whereas covering the trunk had no consequence on either temperature or sweating of the legs.

Table 2 : Additional rises in body temperatures and local sweating in the three experimental conditions (covered subjects) compared to the control data (mean and sem for the 10 subjects).

Physiological variables	**Oesophageal temperature (°C)**	**Local skin temperatures (°C)**		**Local sweat rates (mg/min.cm2)**	
Covered zones :		**Trunk**	**Legs**	**Trunk**	**Legs**
Total	**0.6** *(0.1)*	***20*** **(0.4)**	**1.2 (0.3)**	**0.5** *(0.1)*	**0.3** *(0.1)*
Trunk	**0.3 (0.1)**	**1.7 (0.3)**	**0.0 (0.2)**	**0.3 (0.1)**	**0.0 (0.1)**
Legs	**03 (0.1)**	**0.4 (0.4)**	***0.9*** **(0.3)**	**0.5 (0.1)**	**0.2 (0.1)**

DISCUSSION

Although trunk and legs each represent approximately the same percentage of the total body area (≈38 %), overall restriction of evaporation induced higher thermal and sweating adjustments on the trunk in the situation of cycling. This indicates that the rotation of the legs during leg–exercise probably still provided some local convective cooling, since environmental temperature was **30°C.**

Local evaporative restriction of the trunk had no consequence on the legs responses, meaning that warmer blood did not irrigate the leg skin and *so* the central command for sweating was not significantly increased. These observations may indicate that the somewhat higher core and skin temperature did not generate thermal inputs powerful enough to override the already existing high command for sweating associated with the thermal and non thermal central command originating from the working muscles.

Leg evaporative restriction does not increase the leg temperature as much as the trunk in the trunk condition. A large leg skin temperature increase is only observed here in the case of overall restriction of a possible evaporation. Nevertheless, an important finding is that not cooling the legs increased the local trunk sweat rate, probably due to higher muscle temperature which in this case, increased the central command for sweating.

CONCLUSION

To avoid excessive heat accumulation when evaporation is restricted, it seems better to use local ventilation (4) of the trunk for at least two reasons :

- it induces a smaller elevation in leg skin temperature
- it facilitates greater sweat production of the trunk (because of absence of leg cooling) and thus evaporative cooling from the trunk.

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