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THE EFFECTS OF HEAT ACCLIMATION ON THE HEAT STRAIN OF WORKING IN PROTECTIVE CLOTHING

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INTRODUCTION

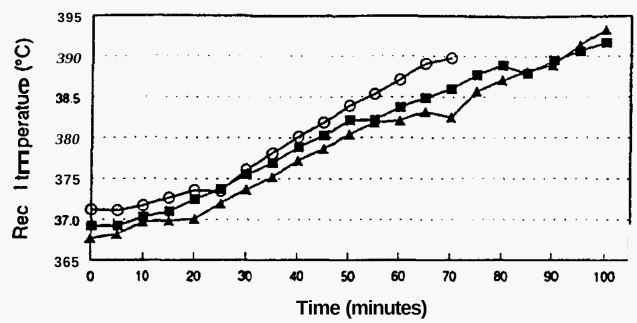
Protective clothing impairs the evaporation of sweat. The resulting loss of cooling frequently limits the endurance of work in hot enviroments (see for example Reference 1). Heat acclimation increases sweating (2) and therefore the potential for evaporative cooling. The aim of this experiment was to quantify any reduced heat strain in acclimated subjects working in the heat whilst wearing protective clothing.

METHODS

Heat strain was measured in 7 male subjects, dressed in British Army chemical protective clothing, during an 'exercise-in-heat' before and again after 5 and 10 successive days of heat acclimation. Clothing: multi-layered garments covering the torso, head, arms and legs; rubber gloves and boots; respirator. Total weight = 8.8 (0.3) kg; ratio of Woodcock Moisture Permeability Index (i_m) to total clothing insulation (IT) = 0.9 at an airspeed of 0.4 m/s. Exercise-in-heat test: treadmill walk at 4.8 km/h, 0% incline, for a maximum of 100 minutes (measured oxygen consumption was about 1 litre/minute); ambient air dry-bulb temperature = 35 °C; relative humidity = 50%; globe temperature = dry-bulb temperature; airspeed = 1.1 m/s; wet-bulb globe temperature (WBGT) index = 29 °C. Acclimation: Wearing light clothing treadmill walk (4.8 km/h, 0% incline) in a hot environment (WBGT index 38-40 °C) until rectal temperature (Tre) reached 38.8 °C when subjects sat. Tre was maintained at this level for about 1 hour, by continued rest or by intermittent walking, as required. Heat strain was measured during the test exposures by recording Tre, mean skin temperature (3), heart rate and total water loss. The ratio water evaporated : total water loss (E/P %) was calculated. Endurance times (time to self withdrawal or ethics withdrawal limits reached) were also recorded. Data are expressed as mean (1SD). Statistical significance was accepted at $P<0.05$. The experiment was approved by the local Ethics Committee.

RESULTS

Physical characteristics of the subjects: age = 25.1 (3.1) y; height = 1.73 (0.13) m; weight = 75.6 (7.8) kg; body fat (4) = 13.6 (4.5)% .



Acclimation state	Rectal temperature Initial °C	At withdrawal °C	Rate of rise °C/hour
Before	37.1 (0.2)	38.9 (0.3)	1.63 (0.40)
5 days	36.9 (0.5)	38.7 (0.5)	1.57 (0.32)
10 days	36.8 (0.4)	38.7 (0.4)	1.57 (0.10)

Figure 1: Throughout the test exposure rectal temperature was lower after after 5 days' acclimation (square) and after 10 days' acclimation (triangle) than before acclimation (circle). Acclimation reduced initial Tre, Tre at withdrawal and rate of rise of Tre.

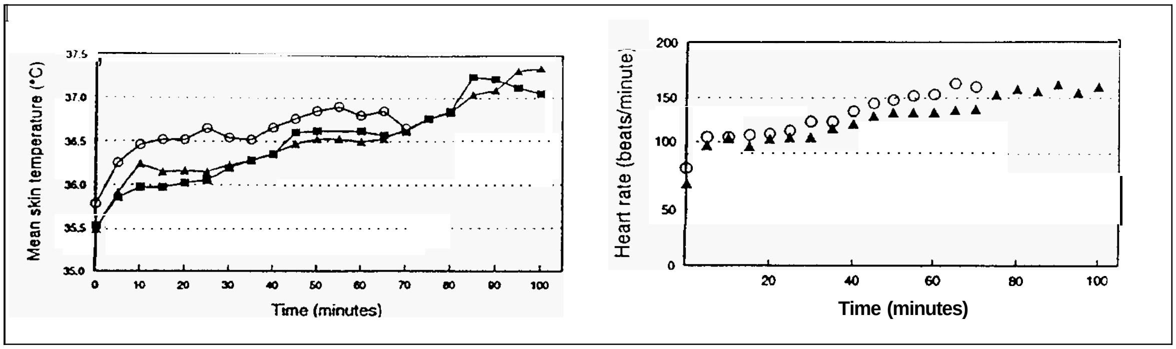


Figure 2: After 10 days' acclimation initial mean skin temperature was lower, 35.5 (0.5) °C, than before acclimation, **35.8** (0.3) °C; the rise in mean skin temperature over the test exposure time **was** unchanged, 1.1 (0.5) °C before, 1.1 (0.4) "C after; heart rate was about 5 beats per minute lower throughout the test exposure.

Acclimation increased total water **loss:** before = 1.57 (0.28) kg/hour; at 5 days = 1.88 (0.38) kg/hour; at 10 days = 1.98 (0.19) kg/hour and endurance time: before = 65 (7.6) minutes; at 10 days = 74 (15.7) minutes. E/P was 28.6 (14.8) % before acclimation; 23.0 (7.1) % at 5 days and 20.4 (2.7) % at 10 days.

CONCLUSIONS

These results show that heat acclimation does reduce thermal strain in an individual wearing protective clothing whilst working in a hot environment, **as** there is a reduction in both the initial rectal temperature and the rate of rise of **rectal** temperature thereby increasing endurance times. However, the benefits are small. Furthermore, the increased water loss may lead to dehydration which may have significant penalties, especially if water intake is restricted, which is often the case when wearing protective clothing. The benefits of acclimation are greater in this study than those previously reported (5). This difference may be because of the different exercise regimes adopted (Aoyagi *et al* used intermittent exercise) or to the different i_m/I_T characteristics of the personal protective clothing. We believe that the benefits of heat acclimation may be greater in clothing with a higher moisture vapour permeability that that used in this study.

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