SWEATING EFFICIENCY OF UNACCLIMATIZED WOMEN AND MEN WORKING IN HOT, HUMID ENVIRONMENTS

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INTRODUCTION

The ability to sweat is of paramount importance for successful adjustment to exercising in hot environments. However, of decisive importance is also the sweating efficiency, i.e.; the ratio between evaporation rate and total sweat rate. In a previous study it has been shown that a group of male subjects exhibited surprisingly low efficiency values for sweat evaporation, albeit tolerance to hot work was well maintained for short term exercise (1). Sufficient evaporative cooling was achieved at the expense of considerable dripping and water loss. This paper examines and compares these data with the sweating response of a group of female subjects exposed to the same absolute and relative submaximal work intensity in a hot, humid environment.

METHODS

The sweating response was compared in two groups of six healthy, unacclimatized women (W) and men (M). In independent experiments W and M, dressed in briefs only, exercised for 60 min at an air temperature of about 36 °C and 50 % relative humidity (rh). Both W and M exercised on a bicycle at the same absolute intensity of 100 W (ABS) (≈50 and 40 % of max aerobic power, VO_{2max}, respectively). In addition, W exercised at the same relative work load as M (REL) (≈50 % or 125 W). VO_{2max} was determined in seperate bicycle tests. Body weight change due to sweating and dripping was monitored every min by two independent weighing scales. Respiratory water loss, albeit negligible, was calculated according to formulas given in (7). Body temperature was measured every minute with a rectal probe inserted 10 cm beyond the anal sphincter.. Measurements on the male subjects comprised part of a previous study (1). Details on general experimental methodology and protocol are given in this study.

RESULTS

The time course of evaporative water loss and dripping is shown in Figure 1. The magnitude of sweating and dripping was on average significanlty larger ($p<0.01$) for M than for W compared at both relative and absolute work rates. Also illustrated in Figure 1 is 1 SD of the mean indicating the considerable individual variation, in particular for the men. Total sweat rates ranged between 14.4-28.0 g/min at 50 % REL. Corresponding values for the females were 8.5-11.9 g/min. Drip rates varied between 2.6-12.4 g/min for M at 50 % REL and between 1.1-3.7 g/min for W. Sweat dripping started later for W. Efficiency of sweat evaporation at 50% REL varied between 56-82% for M and 70-88% for W.

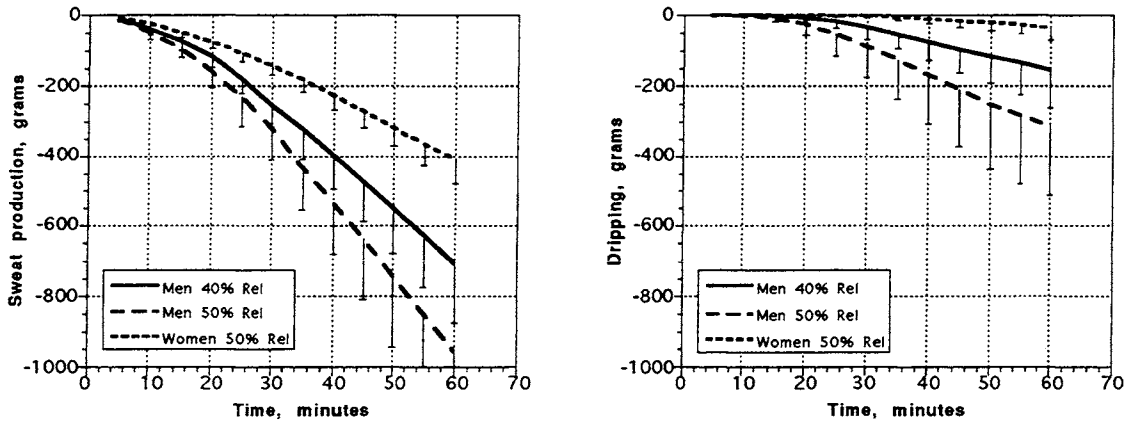

Figure 1. Mean values and 1 SD for total sweat production and dripping water loss.

Evaporative water loss (sweat production minus dripping) differed much less between M and W (Figure 2). Average value for W at 50 % REL was 7.8 g/min, for M at ABS 11.5 g/min and at 50 % REL 13.9 g/min. The difference reduces by about 16 % due to the smaller body surface area (Dubois) of W.

Apparently, W were not able to achieve the same evaporation rate as M at either ABS or REL work loads. The lesser evaporative cooling also resulted in a greater increase in rectal temperature (Figure 2). W attained a mean T_{re} of 38.9 °C (range 38.5-39.2) and M attained 38.5 °C (range 38.1-38.7) at 50 % REL ($p<0.01$).

Since environmental conditions were the same during all exposures evaporative cooling depended largely on the amount of skin wetting, that could be achieved by sweating. At the same absolute level of metabolic heat production (ABS) W suffer from the smaller body surface area for heat dissipation. Accordingly, higher core temperature results (Figure 2) (2). The same effect is caused by the higher relative work rate per se - core temperature rises as function of relative work load (3).

At the same relative work load our results indicate a persistent difference in physiological response - higher core temperature for W. Other investigators have indicated that such differences disappear when M and W are compared at the same relative work load (4, 5, 6).

Predicted values according to ISO 7933 (7) for sweat rate were overestimated and efficiency underestimated for women but agreed with measured values for men.

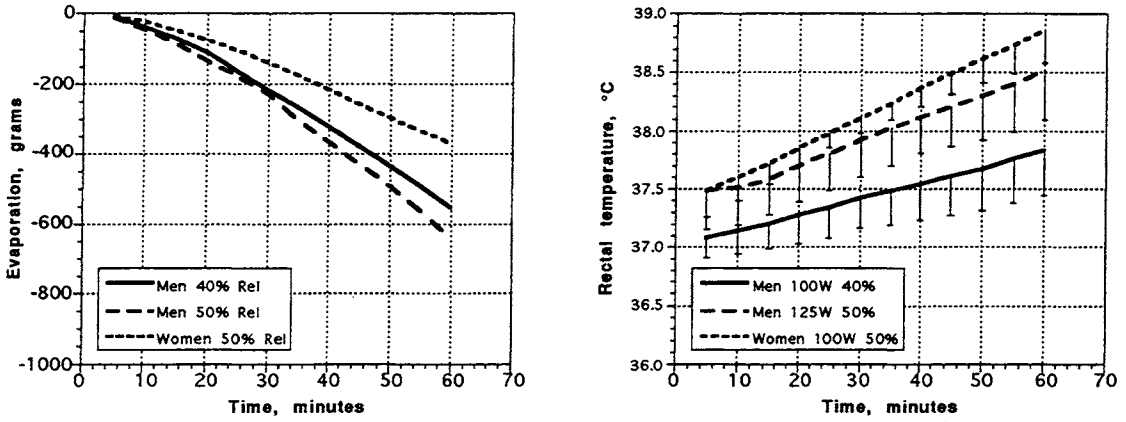

Figure 2. Means for evaporative water loss and rectal temperature during 60 min of work.. Bars indicate 1 SD.

CONCLUSIONS

Despite a significantly higher sweating efficiency (evaporated/produced sweat) maintained at high levels of skin wettedness, women appeared to be less tolerant to short exposures (≤1 hour) to humid heat. This was partly explained by the much lower total sweating capacity. It appears that ISO 7933 overestimates the thermal effect on unacclimatized women, at least for high stress levels. Comparisons of gender responses to heat, apparently, call for studies more carefully controlled in terms of individual factors such as fitness and level of acclimation.

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