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INDIVIDUAL RESPONSES TO EXERCISE IN THE HEAT AS RELATED TO SWEATING AND SKIN BLOOD FLOW

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It is well known that individuals may substantially differ in their physiological responses to heat stress. However, the mechanisms behind the individual variability are not clear. In order to study this question, we examined the heart rate and rectal temperature responses to dynamic exercise in a hot environment and their relationships to sweating and cutaneous circulation.

Eight, physically trained and unacclimated men were the study subjects. Their mean (±SD) age, body weight, and maximal oxygen consumption were 33±7 years, 82±5 kg, and 4.5±0.7 1 min^{-1}, respectively. The experiments consisted of 60 min bicycle ergometer tests at exercise intensities of 50 W and 100 W in a hot environment (36°C/30 %). The subjects were clad in shorts, socks, and sneakers. During the tests, oxygen consumption ($\dot{V}O_2$), heart rate (HR), rectal temperature (T_{re}), and skin temperatures were measured. The whole-body sweat rate (SW_t), evaporation rate (SW_e), and the rate of dripping sweat (SW_d) were measured by a continuous weighing technique. Skin blood flow was estimated from the changes in forearm blood flow (FBF) measured by venous occlusion plethysmography. For the analysis, the data from each test were averaged over the last 20 minutes.

In all, 13 tests were done at 50 W, and 10 tests at 100 W. At 50 W, in all tests a physiological steady state was attained, ie the rise in HR was less than 10 beats min^{-1}. At 100 W, in all experiments the HR increased continuously throughout the tests. At the end of exercise it varied from 98 to 150 beats . min^{-1}. At the exercise intensity of 50 W, the VO_2, T_{re}, SW_t, and FBF averaged (±SEM) 1.00±0.01 1 . min^{-1}, 37.20±0.04°C, 7.4±0.3 g . min^{-1}, and 5.6±0.4 ml . 100 ml^{-1} . min^{-1}, respectively. The rate of dripping sweat was negligible. The corresponding figures for 100 W were 1.50±0.03 l . min^{-1}, 37.60±0.06°C, 14.6±0.8 g . min^{-1}, and 12.65 1.1 ml . 100 ml^{-1} . min^{-1}, respectively. The rate of dripping was 6.1±0.7 g . min^{-1}. At 50 W, the HR and T_{re} did not significantly correlate with any of the thermoregulatory parameters. At 100 W, the HR and T_{re} correlated with the SW_t ($r=-0.66$ and -0.71, $p<0.05$), onset of dripping ($r=0.74$ and 0.66, $p<0.05$), and with the ratio of FBF/SWd ($r=0.83$ and 0.85, $p<0.01$).

The present results suggest that, during exercise in the heat when the demands for heat dissipation are increased, the level of thermal strain may be determined by the interaction of cutaneous blood flow and sweating, especially by the relationship between skin blood flow and the rate of dripping sweat.