EFFECT OF HEAT STRESS ON SKIN AND MUSCLE BLOOD FLOW DURING DYNAMIC HAND-GRIP EXERCISE

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INTRODUCTION

In a hot environment cutaneous circulation increases, and it is linearly related to the rise in internal body temperature. During exercise a significant diversion of blood flow to the skin may lower muscle perfusion and reduce physical performance. It has been shown that in sheeps exposed to heat stress blood flow in the active muscles reduced 26-56% when compared to the control situation (1). In humans, there is no direct evidence on reduced muscle blood flow under exercise-heat stress (2).

It can be hypothesized that in a hot environment muscle blood flow may decrease particularly during light muscle work while the amount of vasoactive substances entailing muscle vasodilation is small and the activity of sympathetic nervous system contributing vasoconstriction is high (3). Consequently, the aim of this study was to examine the effect of an acute heat stress in a sauna on blood flow changes in forearm skin and muscles during very light and light hand-grip exercise.

METHOD

The subjects were nine unacclimatized, physically active and healthy men. The study procedure followed the Helsinki declaration, and was accepted by the Ethical Committee of the Institute of Occupational Health.

The experiments were carried out in a dismountable sauna (2*2*2 m) which was set up in the laboratory. The subjects performed a test serie of hand-grip exercise both in a thermoneutral (25°C), and in a hot sauna environment (65-70°C). In the tests, the hand-grip exercise was performed with the right hand. The left hand served as a control, and was kept at the similar position as the exercising hand. The test serie was started by a rest period of 5 minutes, and followed by a period of 6 minutes of very light rhytmic dynamic hand-grip exercise (~13 % of the maximal voluntary contraction, MVC). After the very light exercise the subjects rested for 6 minutes and then repeated the hand-grip exercise at the light contraction level (~34 % MVC). The rate was 30 contractions/min. Hand-grip exercise was carried out, and hand-grip strength was measured with a dynamometer which comprised a water-filled rubber tube with a pressure probe connected to an indicator and a power supply.

In the experiments forearm blood flow was measured in the right and left forearm during pauses by venous occlusion plethysmography utilizing mercury-in-Rubber strain-gauges. By venous occlusion plethysmography, changes in skin blood flow can be estimated when the underlying muscles are at rest (control forearm). and changes in muscle blood flow (exercising forearm) can be estimated when cutaneous circulation is stable. Skin blood flow was also measured by a laser Doppler flow meter in the right and left forearm using two Periflux Pfld instruments (Perimed, Sweden). Internal body temperature was measured at heart level with an esophageal probe (YSI 511, Yellow Springs Instruments. USA). Skin temperature was measured in the right and left forearm by thermistors (YSI 427). Heart rate was continuously recorded every minute in the experiments using a Sport Tester PE 3000 Monitor (Polar Electro, Finland).

A two-way analysis of variance for repeated measures and the post hoc comparisons with the Newman-Keuls procedure were employed to determine the effects of environment and hand-grip exercise on blood flow. Differences were considered to be statistically significant when $p<0.05$.

RESULTS

In the end of the thermoneutral period esophageal temperature was ($\bar{x}\pm SD$) 36.92 ± 0.24°C, and in the end of heat stress it was 37.74 ± 0.22°C. The corresponding values for heart rate were 58 ± 7 beats/min and 99 ± 11 beats/min, respectively. In the thermoneutral environment skin temperature for both **forearms** was 32-33°C and in the heat ~40°C. There were no statistically significant differences in skin blood flow, measured by laser-Doppler flowmetry, between the exercising and control forearm.

The analysis of variance revealed a statistically significant ($p<0.01$) effect of both an environment and exercise on forearm blood flow. In thermoneutrality, hand-grip exercise increased blood flow in the working forearm, as compared to the control forearm, by 6.022.3 ml 100 ml^{-1} min^{-1} at 13 % MVC, and 17.9 ± 7.5 ml 100 ml^{-1} min^{-1} at 34 % MVC ($p<0.01$). In the heat, the increases were significantly ($p<0.01$) higher: 12.5 ± 6.6 ml 100 ml^{-1} min^{-1} at 13 % MVC, and 32.2 ± 17.8 ml 100 ml^{-1} min^{-1} at 34 % MVC, respectively.

CONCLUSIONS

These results suggest that heat stress of studied magnitude increases blood flow in active muscles during dynamic hand-grip exercise at 13 % and 34 % MVC.

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