EFFECT OF HEAD COOLING ON MAN DURING LIGHT EXERCISE IN A HOT ENVIRONMENT

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INTRODUCTION

The head is an excellent site for removing body heat (Nunneley *et al.*, 1971) and has been investigated as a region for artificial cooling. Several studies have shown that head cooling leads to an improvement in thermal comfort under the heat stress(Nunneley *et al.*, 1971; Brown and Williams, 1982; Nunneley *et al.*, 1982), but have investigated limited physiological responses, such as body temperature, heart rate, and weight loss.

We have previously studied the effects of head cooling on several physiological functions of man at rest under the condition of ambient temperature (Ta=40 °C) and relative humidity (RH=50 %) , and during moderate exercise (40 %$\dot{V}o_2$max) under the condition of 30°C/50 % (Katsuura *et al.*, 1989), and during moderate exercise (40 %$\dot{V}o_2$max) under the condition of 40°C/50 %. Results showed that head cooling may inhibit sweating and cutaneous blood flow of man at rest and during moderate exercise in hot environments.

In this study, the effects of head cooling on physiological responses were further investigated when subjects exercised lightly in a hot environment,

METHODS

Six male students, aged 22-24 yrs, volunteered for this study. They sat on a chair in a semi-reclining position for 120 min under three thermal conditions:

(1)Ta=40°C, RH=50% with water cooled cap (water inlet temperature Twi=10 °C) [HClO]
(2)Ta=40°C, RH=50% with water cooled cap (Twi=15°C) [HC15]
(3)Ta=40°C, RH=50% without head cooling [NC]

The water cooled cap was constructed as an open network of Tygon tubing(Fig. 1). The 10 tubes involved a total length of approximately 394 cm. The cool water flowed at a rate of 1000 ml/min.

Head cooling started 30 min after the subject wearing only shorts entered a climatic chamber. The subject exercised on a bicycle ergometer for 45 min after 45 min resting. A work level was kept at 20 %$\dot{V}o_2$max. Following exercise, the subject took a rest for 30 min.

Oxygen uptake ($\dot{V}o_2$), heart rate (HR), rectal temperature (Tre), forearm blood flow (FBF), skin temperature, sweat rate (SR) at chest region , weight loss were measured on each occasion. Thermal comfort and thermal sensation were also estimated.

RESULTS AND DISCUSSION

The heat removal ($\dot{H}$) from subject's head under the HC15 and HClO conditions were stabilized after 30 min of head cooling, and were approximately 1.8 kcal/min in HC15 and 3.0 kcal/min in HC10(Fig. 2).

Whereas $\dot{V}o_2$ did not change significantly due to head cooling, HR tended to decrease in HC10. An increase in Tre (ΔTre) with head coolmg was lower than that without head cooling. There was no difference in ΔTre between HClO and HC15 while the water inlet temperature were different under these conditions(Fig.3).

From the regression equation of FBF on Tre, the adjusted means of FBF under each condition were calculated. The adjusted means of FBF under head cooling conditions were significantly lower than that in NC(Fig.4). These results may be associated with lower hypothalamus temperature due to head cooling for a given Tre. Head cooling may inhibit sweating. The adjusted mean of SR calculated from the equation of SR on Tre was significantly lower in HClO than those in HC15 and NC(Fig. 5). Weight loss was significantly lower in HClO than that in NC. Both head and body thermal comfort improved with head

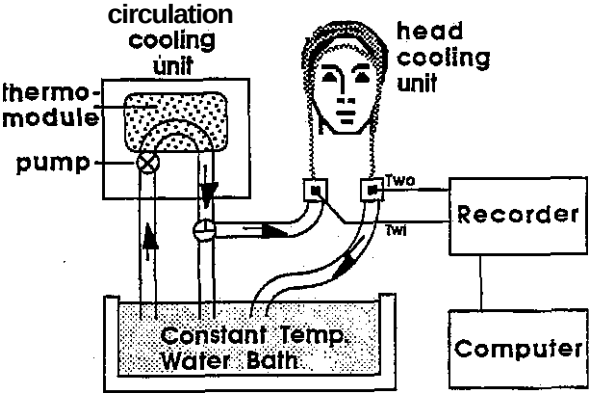

Fig. 1. Head cooling system

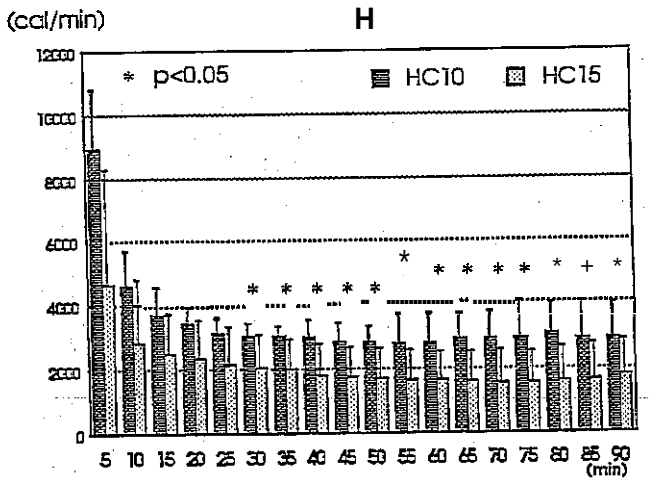

Fig. 2. Heat removal (H) from subject's head under the HClO and HC15 conditions. Values are means ± SD.

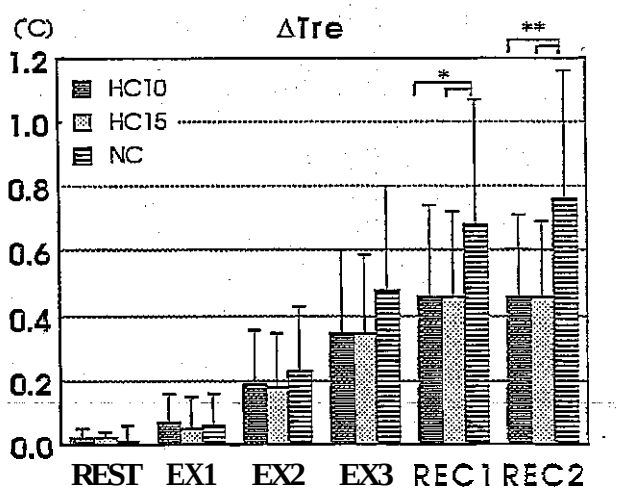

Fig. 3. Increase in Tre (ΔTre) under the HC10, HC15, and NC conditions. Values are means ± SD. *P<0.05; **P<0.01.

cooling.

In our previous study(Katsuura *et al.*, 1989), it was found that ATre rose prominently when subjects exercised moderately with head cooling in a 30°C environment. It was due partly to inhibition of effective sweat rate with head cooling. In the present study, however, such a negative effect of head cooling was not observed. Thus, head cooling is an effective means for man during light exercise to alleviate heat strain in a hot environment.

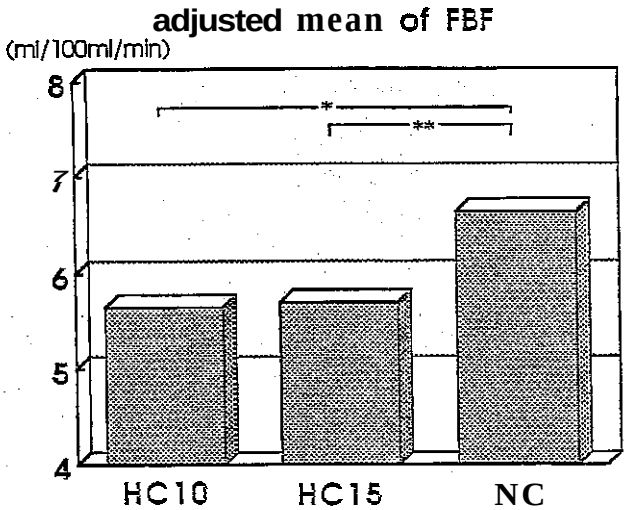

Fig. 4. Adjusted means of forearm blood flow (FBF) under the HClO, HC15, and NC conditions. *P<0.05; **P<0.01.

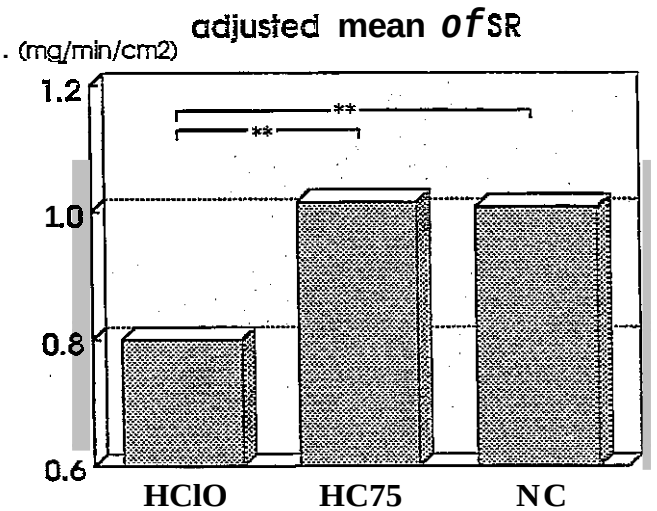

Fig. 5. Adjusted means of sweat rate (SR) under the HC10, HC15, and NC conditions. *P<0.05; **P<0.01.

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