THE EFFECT OF HEAD COOLING ON THERMOREGULATORY AND METABOLIC REACTIONS DURING PROLONGED HEAT STRESS.

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INTRODUCTION

The protective role of selective brain and head cooling in hot environments is widely discussed (1,2,3). The interference between lower brain temperature and an increase of core temperature in this case may cause changes in the pattern of thermoregulatory reactions in the heat: affecting sweating, peripheral vasomotor tone and metabolic rate.

There are physiological and adaptive aspects for this phenomenon:

a) protection of brain tissues, which are very sensitive to heat damage, and preservation of central regulatory mechanisms (4,5);

b) keeping the brain cooler in spite of body hyperthermia when evaporative heat loss is limited for water economy in hot arid climates (6).

The aim of our study was to evaluate the possible effect of head cooling (HC) in humans during prolonged heat exposure combined with water restriction, simulating a survival scenario in a hot desert climate.

METHODS

Six healthy non heat acclimated volunteers were exposed twice to hot dry environment (50°C, 20% rh), each exposure lasted 10h. The subjects were resting in a horizontal position and received 500 ml of water for the entire exposure. During one of the exposures they were using a special designed water-cooled helmet (35 W). Heart rate, rectal and skin temperatures were measured and recorded continuously. Metabolic rate was obtained every 30 minutes of exposure. Water for evaporative heat dissipation was calculated from total weight loss corrected for water consumed and urine output. Samples of venous and capillary blood for hemoglobin, protein and hematocrit were taken twice, before and after exposure, for calculations of changes in plasma volume (7).

RESULTS

The calculated metabolic rate over the ten hours period were significantly lower with the head cooling device (2400±270 kJ) than in the control exposure (3200±300 kJ). The thermoregulatory water loss was also lower with HC (3273±142 ml, 4.21±0.1% of initial weight) comparing to exposures without HC (4406±147 ml, 5.47±0.13% of initial weight); there were no difference in urine output (453±45 ml and 485±55 ml, without and with HC). The plasma volume decreased less in the case of HC (10.5±3.4% vs. 15.1±2.1%). Heart rate at the end of exposure was also lower with than without HC (83.6±3.5 bpm vs.96.8±5.6 bpm with and without, respectively). The rectal and skin temperatures were similar in both groups.

CONCLUSIONS

Body temperature was similar in HC and control groups in spite of lower sweat rate in the former. Therefore, it can be suggested that HC reduces sweat rate directly via selective brain cooling. Our data prove that head cooling in hot dry (desert type) environment not only protects the brain but also ensures a "water economy" strategy for surviving in hot deserts (8); however this effect can be seen only in the case of appropriate level of dehydration (more then 2% of initial weight loss) and prolonged heat exposure. These findings rise a question whether artificial head cooling might mimic the natural phenomenon of selective brain cooling in desert animals, as a part of water conservation mechanisms.

REFERENCES

1. Baker M.A. 1982, Brain cooling in endotherms in heat and exercise, *Ann. Rev. Physiol.* 44, 85-96.

2. Shvartz E. 1970, Effect of a cooling hood on physiological responses to work in a hot environment, *J. Appl. Physiol. 26, 36-39.*

3. Frim J. 1989, Head cooling is desirable but not essential for preventing heat strain in pilots, *Aviat. Space Environ. Med. 60, 1056-1062.*

4. Brinnel H., Cabanac M. & Hales J.R.S. 1987, Critical upper levels of body temperature, tissue thermosensitivity and selective brain cooling in hyperthermia, in J.R.S Hales and D.A.B. Richards (eds.) *Heat Stress: Physical exertion and environment* (Excerpta Medica, Amsterdam), 209-240.

5. Caputa M. 1980, Selective brain cooling: an important component of thermal physiology, in Z. Selenyl and M. Szekely (eds.) *Contributions to thermal physiology* (Pergamon Press, Oxford), 183-192.

6. Taylor C.R. 1970, Dehydration and heat: effects on temperature regulation in East African ungulates, *Am. J. Physiol.* 219, 1136-1139.

7. Dill D.B., Costill D.L. 1974, Calculation of percentage changes in volume of blood, plasma and red cells in dehydration, *J. Appl. Physiol.* 37(2), 241-248.

8. Caputa M., Cabanac M. 1988, Precedence of head homoeothermia over trunk homoeothermia in dehydrated men, *Eur. J. Appl. Physiol.* 57, 611-615.