

STUDY OF SKIN AND TYMPANIC TEMPERATURES DURING MENTAL WORK

Esther Mietzsch and Jurgen Werner
Institut für Physiologie
Ruhr-Universität
MA4/59
D-44780 Bochum, Germany

INTRODUCTION

Mental workload is known to influence a range of physiological parameters. Therefore involuntary physiological variations can be used to quantify the workload imposed by the task on the subject. Physiological measures investigated are for example heart rate, blood pressure, EMG, galvanic skin reaction, EEG and ECP (evoked cortical potentials) (1,2). The influence of mental work on skin temperature has, however been little explored. The aim of the present study was to investigate skin and core temperature variations during mental work compared to changes in heart rate.

METHODS

9 volunteers (7 male, 2 female) aged between 20 and 36 years took part in this study. After at least 12 min rest, instructions for the task were given. The subjects then performed a standard concentration test based on mental arithmetic at a computer monitor for 30 min, followed by at least 10 min rest. Tympanic temperature and skin temperatures on forehead, neck, cheek, and on the back of the left and the right hand were measured using thermistor probes (YSI). All temperatures were registered every minute. Heart rate was continuously recorded. In four subjects, skin blood flow in the neck was measured with a laser Doppler flowmeter (Periflux 4000) and registered continuously. Ambient temperature was kept constant between 21 and 23 °C. Experiments were carried out in the morning or late afternoon, according to the peak activity time of the subjects.

Mean values of the first rest period, the work period and the second rest period were calculated for all parameters and compared with the Wilcoxon U-test.

RESULTS

In most subjects, heart rate was highest during instruction for the task or at the onset of work and declined during the work period. The mean value was higher during work (80.0/min) than in the first (74.7/min) or second (73.7/min) rest period in all subjects.

Neck temperature began to rise during the instructions and usually reached its highest values at the end of the work period. As a result, the mean value (33.7 °C) was significantly higher during work than during rest (32.9 °C in the first, 33.3 °C in the second rest period). The highest mean difference between work and the second rest period was 1.5 °C in a single subject. In all subjects tested the mean value of neck skin blood flow was higher during work than during rest.

Forehead temperature was higher during work in five subjects, but did not show any change in four subjects. With a maximum difference of the mean value of rest and work of 0.4 °C, this temperature rise was also smaller than the effect on neck temperature. Overall changes of tympanic temperature never exceeded 0.3 °C and there was no change related to the work period. Cheek temperature, too, was either nearly constant, or variations were not related to work or rest periods.

In three subjects, the skin temperature on the back of the left (unused) hand fell during work, in all other subjects changes occurring were independent of rest or work. Concerning the right hand, which was used for typing the results on the computer keyboard, a fall of the skin temperature was observed in the same subjects. All these subjects had mean hand skin temperatures above 33 °C during the first rest period.

No relationship between the task performance score and the rise of neck temperature or heart rate was to be found. Those subjects with the highest rise of neck temperature did not show the largest variation of heart rate, nor was there any other relationship between the two parameters.

CONCLUSIONS

The given task imposed enough workload to cause changes in the physiological state of the subjects. Not only heart rate, but also neck skin temperature showed a rise during work. The reason for this rise in neck skin temperature seems to be a higher skin blood flow. Another factor could be a higher subcutaneous blood flow, which might be a result of higher sympathetic activity. Ephedrine, which has a sympathicomimetic effect, is known to cause a rise of interscapular and neck skin temperature due to higher subcutaneous blood flow (3). The decrease of heart rate from a high level at the beginning of work might be explained as some form of adaptation to work.

Tympanic temperature did not change during mental work in our study. It has been supposed to rise due to a higher brain activity (4), in spite of multiple evidence in the literature that brain metabolism does not change with mental work. Moreover, it has been questioned that tympanic temperature is a reliable index of brain temperature (5).

Concerning hand skin temperature, vasoconstriction in hands and feet during mental stress is known to depend of high skin temperatures and high baseline blood flow (6). This explains why in our study only those subjects with a high hand skin temperature showed a decrease of skin temperature on the extremities.

As there was no correlation between the change of any physiological parameter and the task performance, neither changes of heart rate nor of any specific skin temperature can serve as a predictor of performance of the working subject. It is even very difficult to use these physiological parameters as an indicator for the stress experienced by the subject, as one and the same person might show a large rise of heart rate and a small change of neck skin temperature. More physiological parameters have to be investigated to find a measure for mental stress or work load.

The changes of hand skin temperature show that the physiological variations induced by mental work might be influenced by the thermal state of the subject. On the other hand, skin temperature changes will interfere with thermoregulatory mechanisms.

REFERENCES

1. Hart S. 1986, Theory and measurement of human workload, in J. Zeidner (ed.) *Human Productivity Enhancement* (Praeger, New York, Westport, London), 396-455.
2. Wierwille W.W. 1979, Physiological measures of air crew mental workload, *Hum. Fact.* 21,575-593.
3. Astrup A., Billow J., Christensen N.J. and Madsen J. 1984, Ephedrine-induced thermogenesis in man: no role for interscapular brown adipose tissue, *Clin. Sci.* 66,179-186.
4. Hancock P.A., Meshkati N. and Robertson M.M. 1985, Physiological reflections of mental workload, *A viat. Space Environ. Med.* 56,1110-1114.
5. Langer T., Nielsen B. and Jessen C. 1994, Non thermometric means of assessing changes of brainstem temperature: the question of selective brain cooling in humans, in A.S. Milton (ed.) *Temperature regulation: recent physiological and pharmacological advances* (Birkhäuser, Basel, Boston, Berlin), 145-149.
6. Elam M. and Wallin B.G. 1987, Skin blood flow responses to mental stress in man depend on body temperature, *Acta Physiol. Scand.* 129,429-431.