THE THRESHOLD IN ESOPHAGEAL TEMPERATURE FOR HAND BLOOD FLOW

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INTRODUCTION

It is a common observation that cold hands are inevitable when the human body core is cold, and that a high body core temperature (T_c) is accompanied by warm hands. For every subject there seems to be a rather fixed threshold in T_c above which the blood flow through the hands suddenly increases (1). The threshold decreases as the average skin temperature ($\bar{T}_s$) increases (1,2,3). However, in their investigations the temperature of the skin of the hand was kept constant, making it impossible to assess the influence of hand skin temperature ($\bar{T}_h$) upon hand blood flow. Cooper et al. (4) investigated the relation between blood flow of the hand and hand skin temperature. They found a sharp increase in blood flow when $\bar{T}_h$ was higher than 30°C. In their studies, however, T_c and $\bar{T}_s$ were not varied. In this study the blood flow through the hands is investigated in dependence of T_c, $\bar{T}_s$, and $\bar{T}_h$. The relative contribution of the averaged temperatures to the regulation of hand blood flow is of importance for the development of thermoregulation models of blood flow through the human extremities.

The current method to determine local blood flow is strain gauge plethysmography. For low blood flows this method in unreliable, because circumference changes are almost undetectable. Therefore, another method was developed using the increase in heat flux from the hand as an indicator of the moment of local blood flow increase.

METHOD

Four males and two females participated in the study. Subjects reported to the laboratory in the morning of two consecutive days. The experiments were carried out in a climate chamber. The ambient temperature was set at 12, 19 or 26°C resulting in ?, of 28.4, 30.2 and 32.6°C respectively.

An esophageal thermolineair probe (YSI 702a) was inserted through the nasal passage to a point 415 cm beyond the external nares to determine the core temperature. The mean skin temperature ($\bar{T}_s$) was assessed by thermocouples on the upper arm, chest and thigh (5). The temperature of the hand ($\bar{T}_h$) and the heat flux (HF · Concept Engineering type FRM-200-T) was measured at the index finger, the palm and the back of the left hand.

Every subject was lightly dressed (T-shirt and shorts) and seated on a speaal chair. The hands of the subjects were immersed in water of 15, 20 or 25°C. The resulting $\bar{T}_s$ was 15.9, 20.6 and 25.4°C respectively. The left hand was immersed in a calorimeter, the right hand in a water bath with the same temperature. As soon as the heat transfer from the index finger to the water had decreased to zero, the subjects started cycling on an ergometer (Lode Angio) with an external power of 80 W. The exercise was stopped about two minutes after the occurrence of a sharp increase of the heat flux of the index finger. Exercise was restarted when the HF of the index fmger had decreased to zero. The maximal immersion time never exceeded two hours.

Every subject participated in four out of nine possible experimental conditions (two different ambient and two different water temperatures).

RESULTS

The esophageal temperature at the moment of HF-increase showed a good reproducibility within every experimental condition (Fig.1). The average standard deviation for all experiments with at least two exercise periods was only 0.07°C. At the moment of maximal HF of the fmgers, the decrease in T_c was also maximal, indicating a significant effect of peripheral heat loss on T_c.

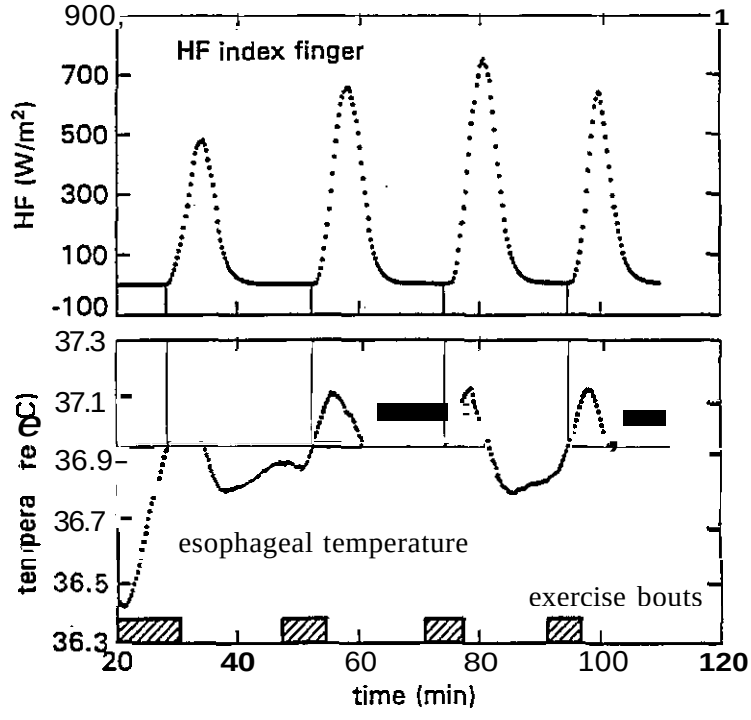

Fig.1 Relationship between HF of the index finger and T_c. The threshold **is** indicated by a horizontal line. The moments of **HF** increase are calculated by a computerized detection routine and are shown by vertical lines. The exercise bouts are shown by hatched boxes.

The thresholds were significantly different between subjects and varied from **36.8** to 37.5°C. T_a also significantly influenced the thresholds. **A** comparison of T_a of 12 and 19°C showed **a** decrease in $\bar{T}_s$ **of 1.8°C,** which corresponded with an increase in T_c of 0.06°C. T_w showed the same significant results, but the threshold differed only 0.02°C for a T_w of 15°C compared to 25°C.

CONCLUSIONS

Every subject has a threshold in core temperature above which the blood flow through the hand suddenly increases. This threshold is lowered by an increased average **skin** temperature and slightly lowered by an increased hand skin temperature.

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