SYNCHRONIZATION OF COLD INDUCED VASODILATION IN THE FINGERS

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INTRODUCTION

The mechanism responsible for cold induced vasodilation (CIVD) is still not clear. Some authors supposed that the phenomenon acts purely local. Aschoff (1) for example postulated that a dilating substance was formed when the temperature decreased under a certain threshold. The increased blood washed the substance away, leading to oscillations in local temperature. Lewis (2) concluded from his denervation experiments that a local axon reflex was responsible for the occurrence of CIVD. More recently, Shephard e.a. (3) showed that the affinity of a-receptors for norephinephrine increases due to cold. The vasoconstriction causes a decrease of the local tissue temperature and a nervous blockade occurs, leading to CIVD. However, a central influence on CIVD has to be present too, as many authors (4,5,6) described the decreasing magnitude of CIVD as the body core was cooled.

In this experiment the amount of local/central influence on CIVD was estimated by a comparison of the temperature fluctuations of the fingers during immersion in cold water. The Pearson correlation coefficient (PCC) was used to estimate the amount of correspondence between the fingers. A PCC close to zero would mean that the fluctuations were independent, indicating a purely local mechanism. A PCC of 1 means that the shape of the fluctuations is perfectly the same, indicating central control. The PCC is a very sensitive parameter to estimate correspondence: when CIVD occurs in one finger and the other reacts later, a drastic decrease of the PCC is the result. A calorimeter measured the overall heat transfer from the hand to the water and enabled determination of the 'hunting response', integrated over the whole hand.

METHODS

Twelve males participated in the study. The experiments were carried out in a climatic chamber. The ambient temperature was 22°C and the relative humidity was 22%. The subjects were sitting on a chair with their left hand immersed in a calorimeter. The immersion was performed in water of about 5°C for at least 40 minutes.

The temperature of the index fmger and of the palmar and dorsal side of the hand was measured by a thermocouple, integrated in a miniature heat flux sensor. A copper-constantane thermocouple was placed on the distal phalanx of the thumb, middle fmger, ring finger and little finger. The heat transfer was determined by a calorimeter (7). A time period of 30 minutes was analyzed, starting 10 minutes after immersion.

The PCC was calculated for every combination of thermocouple locations. Because the PCC values do not have a normal distribution, differences are tested by Kruskal-Wallis one-way analysis of variance by ranks.

RESULTS

The PCC's between the temperature registrations are shown in Table I for every possible combination. The finger temperatures were related, especially those of neighbouring fingers. The larger the distance between the fingers the lower the PCC. Neighbouring fmgers had a mean PCC of 0.67 (n=48) versus 0.48 (n=72) for the other fingers. This was significantly different (P=0.008). This means that CIVD is not purely local and that crosstalk between neighbouring fingers is present.

Neighbouring fmgers can be approximately differentiated in those innervated by the same nerves or by different nerves. The highest PCC was found between the index and middle finger (both mainly innervated by the n. medianus, originating C7) and the ring and little finger (both mainly innervated by the n. ulnaris, originating C8). Fingers mainly innervated by the *Same* nerve had a mean PCC of 0.80 (n=24) versus *055* (n=24) for the fingers with separate innervation. This was significantly different (P=0.049) and indicates that the innervation may play a role in CIVD. The axon reflex theory is in accordance with this finding. The somatic nerve impulses originating in a cooled finger may be transmitted to the parallel sympathetic nerves and change the diameter of the peripheral blood vessels. The temperatures of the palm and back of the hand were almost independent of the finger temperatures.

Table I. Pearson correlations averaged over 12 subjects for every combination of temperature registrations.

	thumb	index	middle	ring	little	palm	back
thumb	X						
index	0.42	X					
middle	0.46	0.83	X				
ring	0.30	0.63	0.68	X			
little	0.36	056	055	0.76	X		
palm	0.17	0.24	0.29	0.31	0.20	X	
back	-0.20	0.12	0.09	0.16	0.13	0.44	X

The average power transferred from the hand to the water was **34.6** W. The coefficient of variation (CV) of the power was about **31%** of the CV of the difference between fmger and water temperature. An almost identical CV would have indicated perfect **synchronization;** absence of **synchronization** would have resulted in a very low CV of the power transfer. **Our** results indicate that a **central** component was clearly present.

CONCLUSIONS

Immersion of the hand in water of 5°C resulted in temperature oscillations in the finger tips which showed a considerable degree of correspondence. Theories with only a local explanation of the CIVD mechanism therefore are incomplete. Oscillations of well separated fmgers showed less **synchronization** than those of neighbouring fingers. Neighbouring fmgers showed more synchronization when somatic innervation was shared, which is consistent with the theory that an **axon** reflex is responsible for CIVD.

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