EVALUATION OF THE SET-POINT MODEL OF HUMAN THERMOREGULATION BY EXERCISE IN WATER

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INTRODUCTION

The set-pointmodel of human temperature regulation postulates that core temperature during exercise is governed by an altered set-pointwhich is related to the relative intensity of the exercise rather than to the available capacity for heat loss. This model was evaluated during cycle ergometry by exercising eight well-trained male cyclists aged 18-30 years at 50% and 70% maximal oxygen uptake (VO_2 max) in air at 20°C and in water. With thermal inputs from the skin equated, the set-pointmodel predicts a rise in core temperature proportional to the %VO_2 max.

METHOD

VO, max was determined by open circuit spirometry during an incremental cycle ergometer test. On subsequent occasions, each subject exercised for 30 min, first at 50% and then at 70% VO_2 max, in air at 20°C and then immersed to the neck in water with its temperature controlled to match the skin temperature in air. The tests were then repeated, first in water and then in air, to provide a measure of reliability and to balance any ordering effect. Tests were conducted a week apart on the same day of the week and at the same time of day. All tests were performed in a cylindrical fiberglass tank on a modified cycle ergometer linked by a long chain to a Quinton constant workload ergometer.

Core temperature (T_c) was measured as esophageal temperature and mean skin temperature (T_s) was calculated as the weighted mean of eight sites (1). Oxygen uptake and temperatures were measured in the last minute of every five minutes.

Changes in T, were analysed by 3-wayANOVA for repeated measures with main effectsof work rate, environmental condition and trial. Stability of skin temperatures and oxygen uptakes across environmental conditions was tested by paired t-tests. Significance was accepted at the 0.05 level.

RESULTS

The 8 subjects were relativelyfit (VO_2 max = 4.4 $\pm$ 0.6 $l.min^{-1}$) and lean (sum of ten skinfolds = 64 +14 mm) (mean $\pm$ SD).

No significant differences in oxygen uptakes or T_s were observed between repeated trials in air or water at either exercise intensity, indicating good replication of these variables. ANOVA showed that there was no significant effect of test order on the rise in T,. T, rose significantlymore in air than in water (Figure 1). Post-hoc analysis (Table 1) showed that core temperature rose significantlymore at 70% VO_2 max (1.53 $\pm$ 0.46°C) than at 50% (1.11 $\pm$ 0.37°C) in air, but not in water(0.35 $\pm$ 0.68 and 0.46 $\pm$ 0.45°C repectively). In water, some subjects showed a slight drop in T_c in the first few minutes, as heat loss temporarily exceeded gain. The subsequent rise was the same for both work intensities in water, indicating that the capacity for heat loss, rather than a shift in set-point,was determining heat storage.

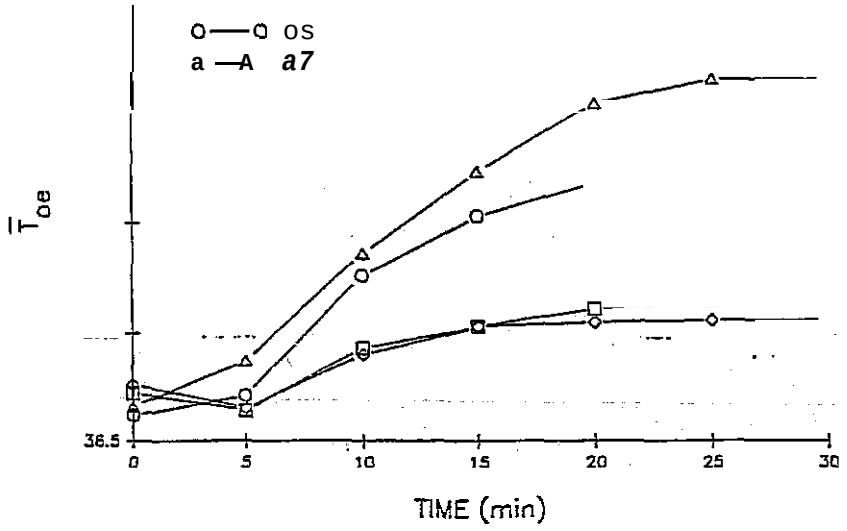

Figure 1. Mean esophageal temperature during repeated trials of ergometer cxcrcise at *50%* and 70% VO_2 max in air and water with skin temperatures equated.

a5 = work in air at *50%* VO_2 max SD = 0.36
a7 = work in air at 70% VO_2 max SD = **0.46**
w5 = work in water at 50% VO_2 max SD = 0.47
w7 = work in water at 70% VO_2 max SD = 0.66

Table 1. Rise in esophageal temperature (mean ± SD °C) during repeated trials of ergometer exercise at **50%** and 70% VO_2 max **in** air and water with skin temperatures equated.

Environment	Trial	50% VO_2 max	70% VO_2 max
Air	T_1	1.08 (0.43)	1.40 (0.44) *
	T_2	1.15 (0.31)	1.66 (0.48)
Water	T_1	0.50 (0.24)	0.36 (0.67)
	T_2	0.42 (0.67)	0.34 (0.70)
		**	**

* sig. diff. between work rates
** sig. diff. between environments

CONCLUSIONS

We conclude that, within the range of thermal control, core temperature during exercise in water is not determined by readjustment of a set-point, but is related to the heat loss capacity of the system.

REFERENCES

1. Nadel, E. R. A brief overview ... In Problems with Temperature Regulation during Exercise, edited by Nadel, E.R., p. 3, New Yotk, Academic Press.