

EFFECT OF DRY AND HUMID HEAT ON PLASMA CATECHOLAMINES DURING PROLONGED LIGHT EXERCISE

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INTRODUCTION

During dynamic exercise in the heat plasma noradrenaline (NA) levels are higher than during the same exercise in a thermoneutral environment (1). However, the exponential noradrenaline-heart rate relationship is unaltered in exercise with exogenous heat (1). Heat stress seems to have no added effect on plasma adrenaline (A) concentration (1).

The aim of our study was to determine the effect of dry and humid heat on plasma NA and A concentrations during prolonged light exercise, and their relation to core temperature and hemodynamic variables.

METHOD

Eight healthy, physically fit, and unacclimated men volunteered for the study. Their mean (± 1 SD) age, height, weight, and maximal oxygen uptake ($\dot{V}O_{2max}$) were 32 ± 3 years, 175 ± 6 cm, 72 ± 6 kg, and 59 ± 5 ml/min/kg, respectively.

The tests included three prolonged treadmill tests at $30\% \dot{V}O_{2max}$ in 0.7 clo standard work clothing as follows: once in a thermoneutral ($20^\circ\text{C}/40\%$), once in a warm humid ($30^\circ\text{C}/80\%$), and once in a hot dry ($40^\circ\text{C}/20\%$) environment. The tests were done at one week intervals in a random order at the same time of day. The exercise consisted of seven 30 min work periods separated by 5 min pauses (total duration 4 hours) for weighing and blood sampling. During the tests, water was offered ad libitum, and drinking was encouraged.

Before each test, a Teflon catheter was inserted into an antecubital vein, and the subject then lay in a supine position at least 30 min before the resting blood sample was taken. During exercise, blood samples for NA and A analysis were taken after 1 h and 3 h of exercise. Plasma NA and A were analyzed by a single-isotope radioenzymatic technique (2). The intra-assay coefficients of variation for A and NA were 12.6% (at the level of 0.25 nmol/l) and 6.4% (2.2 nmol/l), respectively. In addition, rectal temperature (Tre), heart rate (HR), cardiac output (CO) (CO_2 -rebreathing technique), stroke volume (SV), and skin thermal conductance (C) were determined. The methods and results of these variables have been presented elsewhere (3).

RESULTS

At rest, NA, Tre, and HR were not significantly different between the three climates. At rest, NA averaged 0.88 ± 0.35 , 0.88 ± 0.22 , and 0.92 ± 0.24 nmol/l in the thermoneutral, warm humid, and hot dry environment tests, respectively. Plasma A was slightly lower ($p < 0.05$) before the test in the thermoneutral environment (0.17 ± 0.04 nmol/l) as compared to the hot dry environment (0.23 ± 0.09 nmol/l), but similar to the warm humid environment (0.19 ± 0.07 nmol/l).

During exercise, HR, Tre, and C were significantly higher and SV was lower in the warm humid and the hot dry environment in comparison to the thermoneutral environment. Cardiac outputs did not differ significantly between the climates (Table 1). The mean $\dot{V}O_2$ was approximately 1.3 l/min with no difference between the three climatic conditions.

In all climates, NA and A were significantly higher during exercise as compared to rest. As compared to thermoneutrality, heat stress had a significant added effect on NA and A concentrations both after 1 h and 3 h of exercise (Table 1).

Plasma NA correlated significantly with HR (0.90), Tre (0.79), C (0.70), and SV (-0.44). Plasma A correlated significantly with HR (0.81), Tre (0.76), C (0.54), and SV (-0.34).

Table 1. Plasma catecholamines, rectal temperature, and hemodynamic variables after 3 hours of light exercise in a thermoneutral, a warm humid, and a hot dry climate. Mean \pm SD for eight subjects.

Variable	Thermo-neutral			Warm humid			Hot dry		
Noradrenaline (nmol/l)	1.93	\pm	0.46	4.54	\pm	1.09 ^a	4.34	\pm	1.56 ^a
Adrenaline (nmol/l)	0.47	\pm	0.13	1.00	\pm	0.40 ^a	0.98	\pm	0.39 ^a
Rectal temperature (°C)	37.7	\pm	0.2	38.3	\pm	0.2 ^a	38.2	\pm	0.3 ^a
Cardiac output (l/min)	11.8	\pm	1.9	12.8	\pm	0.9	12.3	\pm	2.4
Heart rate (beats/min)	90.0	\pm	6.0	136.0	\pm	16.0 ^a	125.0	\pm	14.0 ^a
Stroke volume (ml)	131.0	\pm	24.0	100.0	\pm	14.5 ^a	106.0	\pm	22.0 ^a
Conductance (Km ² /W)	33.6	\pm	4.9	112.6	\pm	35.6 ^a	106.5	\pm	26.1 ^a

^a p < 0.05 as compared to the thermoneutral environment

CONCLUSIONS

In our study, very little difference in heat strain was observed between the two hot climates. Dry and humid heat stress during prolonged light exercise had an added effect on NA and A. Heightened skin blood flow under heat stress presumably required greater compensatory visceral vasoconstriction because CO was unaltered. Thus, increased NA levels probably indicated greater sympathetic outflow to splanchnic area and kidneys. Elevated A levels may be related to metabolic factors or psychologic factors accompanying prolonged physical work in the heat.

REFERENCES

1. Rowell L.B., Brengelmann G.L. and Freund P.R. 1987, Unaltered norepinephrine-heart rate relationship in exercise with exogenous heat, *J. Appl. Physiol.* 62(2), 646-650.
2. Endert E. 1979, Determination of noradrenaline and adrenaline in plasma by a radioenzymatic assay using high pressure liquid chromatography for the separation of the radiochemical products. *Clin. Chim. Acta* 96, 233-239.
3. Smolander J., Ilmarinen R., Korhonen O. and Pyykkö L. 1987, Circulatory and thermal responses of men with different training status to prolonged physical work in dry and humid heat. *Scand. J. Work Environ. Health* 13, 37-46.