

CHANGES IN HEART RATE VARIABILITY AS A RESULT OF TEN DAYS OF EXERCISE-HEAT EXPOSURE

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INTRODUCTION

Study of heart rate variability (HRV), by means of power spectral analysis of RR interval fluctuations, may serve as a reliable noninvasive method for the assessment of the autonomic cardiovascular regulation and sympatho-vagal interaction (1,2). It has been shown that a single bout of exercise in hot environment activates the sympathetic autonomic tone (3). The dynamics of changes in the components of the autonomic nervous regulation has not been elucidated. It was the aim of the present study to examine the changes in the sympatho-vagal balance during repeated exposures to exercise in heat.

MATERIALS and METHODS

Subjects: Eight healthy male subjects underwent ten consecutive days of repeated exercise-heat exposures. Anthropometric data of the subjects (mean \pm SD) were: age **23.4** \pm **0.9** years, height **172.3** \pm **7.8** cm, mass **71.02** \pm **9.3** kg, body surface area (BSA) **1.84** \pm **0.1** m², and body mass to body surface area ratio (BM/BSA) **38.5** \pm **2.4** kg/m². None of the subjects was under any medication treatment. All subjects were carefully instructed about the procedures, and gave their written consent to be tested in this study.

Protocol: The subjects, dressed in shorts, socks, and sneakers, were exposed for **130** min to heat (40 °C, 40 % rh, air velocity 1 m/s) according to the following protocol: **5** min of rest and two bouts of mild exercise (walking on a treadmill **5** km/h, **2%** grade, $\dot{V}O_2 \approx 1$ L O₂/min) separated by 10 min of rest. The subjects were allowed to drink tap water *ad libitum*.

Measurements: Heart beats (HB) were accumulated through bipolar chest leads using Polar belt electrodes (Polar CIC, Inc., USA) by the Alma **1000** System (Alma, Israel). RR intervals were on-line processed by a specially developed software from HB data.

Calculations and statistical analysis: Time and frequency domain of **256** RR intervals toward the end of the second bout of exercise on the first and tenth days were analyzed. The heart rate variability (HRV) was evaluated by standard deviation and the difference between maximal (RR_{max}) and minimal (RR_{min})

intervals in the sample. The frequency domain analysis was performed by the fast Fourier transformation after subtracting the linear trend. RR intervals were time equidistant transformed, using an IPFM algorithm (2). Power spectral density (PSD) was calculated for frequencies in the band 0–0.5 Hz and the total PSD area (TPSDA) was estimated. TPSDA was divided into low - $0 < f < 0.15$ Hz (LO) and high - $0.15 < f < 0.5$ Hz (HI) frequency bands (4). The ratio LO/HI and their percentage of TPSDA were obtained. The results are presented as mean \pm SD. Paired t-test was applied to detect significant difference between the experimental conditions.

RESULTS

All of the parameters of HRV on the tenth day of exposures were statistically different ($p < 0.001$) from those, recorded on the 1st day (Tab.1, Fig. 1).

Table 1. The values ($\bar{x} \pm SD$) of the measured parameters

	1st day	10th day	p
HR (bpm)	138.9 \pm 9.92	116.62 \pm 6.09	<0.001
RR interval (msec)	433.17 \pm 35.15	517.37 \pm 27.17	<0.001
SD (msec)	7.87 \pm 3.02	16.32 \pm 6.35	<0.001
RR _{max} -RR _{min}	36.50 \pm 13.64	93.13 \pm 43.06	<0.001
TPSDA (msec ² Hz ⁻¹)	4.17 \pm 3.09	26.20 \pm 23.10	<0.001
LO/HI	0.84 \pm 0.66	2.53 \pm 1.10	<0.001
LO/TPSDA (%)	40.57 \pm 17.06	68.82 \pm 10.94	<0.001
HI/TPSDA (%)	59.43 \pm 17.06	31.18 \pm 10.94	<0.001

The rise in SD and RR_{max}-RR_{min} values demonstrate an increase in HRV on the 10th day compared to the 1st day of exposure. This increase was matched with a larger TPSDA (Fig.2) and a distinct shift of PSD towards the lower frequency band (Fig. 3). This shift suggests a higher sympathetic activity in spite of a decrease in HR on the 10th day of exposure in all the subjects.

Both LO and HI components rose significantly during ten days of exposure to heat (LO: from 1.97 \pm 2.26 to 18.85 \pm 17.78 msec²/Hz ($p < 0.01$); HI: from 2.2 \pm 1.08 to 7.35 \pm 5.81 msec²/Hz ($p < 0.05$)), but the effect of the LO band on TPSDA was greater than that of the HI band.

Fig. 1. Typical changes in HR variability parameters in one of the subjects.

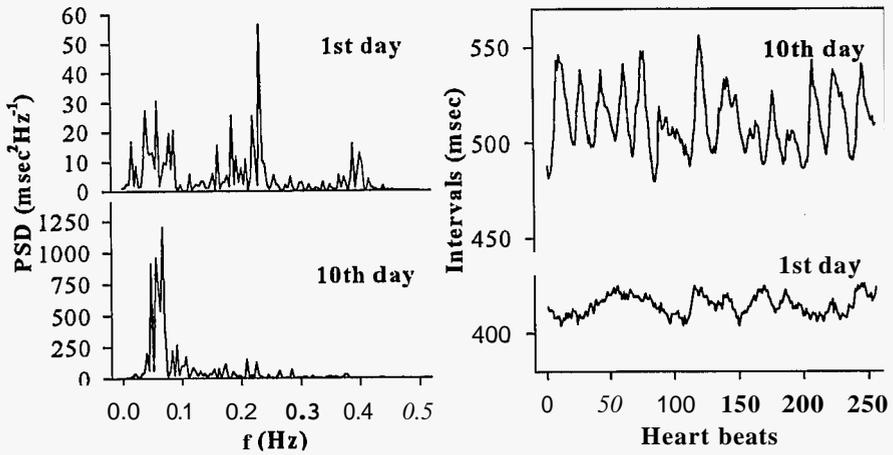


Fig. 2. Mean power spectral density on the 1st and 10th days.

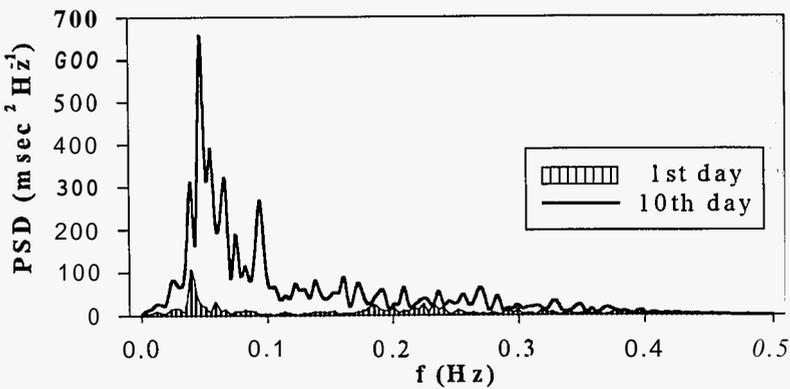
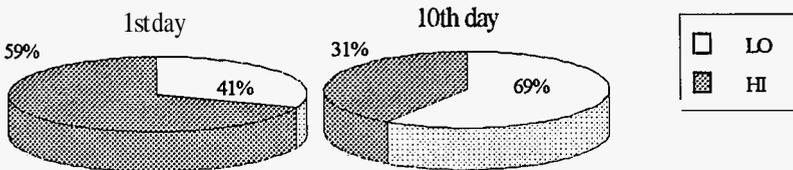


Fig. 3. The ratio between LO and HI components of PSD on the 1st and 10th days.



CONCLUSIONS

It is generally considered that ten days of repetitive exercise-heat exposures induce heat acclimation which is manifested by a lower increase in core temperature and HR during the exposure. In the present study a decrease in final HR on the 10th day of exercise-heat exposures was concomitant with an increase in HRV. Although a decrease in HR may suggest a higher parasympathetic drive, the increase in HRV suggests a paradoxical increase in the sympathetic component of the sympatho-vagal balance of autonomic nervous regulation. It is suggested that ten days of exercise-heat exposure does not eliminate the stressful effect of such an exposure, in spite of relative improvement in physiological state.

REFERENCE

1. Akselrod, S., Gordon, D., Ubel, F.A., Shannon, D.C., Barger, A.C. and Cohen, R.J. 1981 Power spectrum analysis of heart rate fluctuation: A quantitative probe of beat-to-beat cardiovascular control. *Science*, 213,220-222.
2. DeBoer, R., Karemaker, J. and Strackee, J. 1985, Spectrum of a series of point events, generated by the integral pulse frequency modulation model. *Medical and Biological Engineering and Computing*, **23**, 138-142.
3. Brenner, I., Thomas, S., Shek, P. and Shephard, R. 1995, Spectral analysis of heart rate variability (HRV) during repeated moderate exercise and heat stress. *Medicine and Science In Sports and Exercise*, 27 (Suppl.), S181.
4. Liao, D., Barnes, R., Chambless, L., Simpson, R., Sorlie, P. and Heiis, G. 1995, Age, race, and sex differences in autonomic cardiac function measured by spectral analysis of heart rate variability - the ARIC study. *American Journal of Cardiology*, 76, 906-912.