THERMOREGULATORY AND CARDIOVASCULAR RESPONSES TO RAPID CHANGES IN ENVIRONMENTAL CONDITIONS

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INTRODUCTION

The effects of exercise and environmental conditions, in either hot or cold climates, on physiological variables have been well investigated (1-3). When rapid changes in environmental conditions are induced, the sense of effort is largely influenced by the use of heat. Neither the effect of rapid fall in ambient temperature, nor the effect of acute, alternate exposures to heat and cold climates are fully described. This might be of importance to workers exposed to rapid changes in climate conditions.

The purpose of this study was to examine the effects of rapid changes in environmental conditions on the thermoregulatory and the cardiovascular systems.

MATERIALS and METHODS

Subjects: Eight young (23±2 yrs.) fit ($VO2_{max}$= 3.89±0.2 l/min) male volunteers participated in the study. Prior to the experiment, each subject underwent a complete medical examination. Subjects were informed as to the nature of the study and the potential risks of exposure to exercise in a hot climate. All subjects signed a form of consent.

Protocol: Prior to experimental exposure all subjects underwent a 5 day acclimatization process (40°C, 40%RH). Each day they walked for 100 min on a treadmill at a speed of 1.4 $m{\cdot}sec^{-1}$ and 5% grade wearing shorts, T shirt and athletic shoes. A day after the acclimatization process, subjects were tested to determine their aerobic power. Oxygen uptake at maximal exercise was analyzed by computerized metabolic chart (CPK - MGC, Medical Graphic). A progressive treadmill running test was done at a constant speed of 3.13 $m{\cdot}sec^{-1}$ and stepwise grade increments of 2% every 2 min until exhaustion. Established criteria were used to determine oxygen uptake (4).

Experimental protocol: Each subject was tested under the 4 experimental combinations depicted in table 1. The combinations were assigned at random to the subjects. The exercise bout comprised 60 min of steady state cycling on a mechanical cycle ergometer (Monark 181). During that time, rapid climatic

changes were induced in the following sequence: normothermia - cold - hot [NCH] or normothermia - hot - cold [NHC]. All tests were conducted in the climatic chamber, and exposure to each climate was 20 min. During all the exposures participants wore shorts, T shirt and athletic shoes. During exposures, heart rate (HR), rectal (T_{re}) and skin (T_{sk}) temperatures and blood pressure (BP) were monitored on line. T_{re} was measured from a thermistor probe (YSI 401) inserted 10cm beyond the anal sphincter, and T_{sk} was measured by skin thermistors (YSI 409) at 3 locations (chest, arm, leg). Weighted mean skin temperature was calculated according to Burton (5). HRs were continuously radiotelemetered to an oscilloscope tachometer (Life Scope 6, Nihon Kohden) with electrocardiogram chest electrodes. To determine metabolic rate and cardiac output respiratory gases were measured every 18 min towards the end of the experimental exposure. Expiratory gases were sampled and analyzed every 15 seconds by an automatic metabolic chart (CPX-MGC, Medical Graphic); a mean value of 2 min was used for determining VO_2. Cardiac output was determined by CO_2 rebreathing technique (6). BP was measured using an automated monitor (Paramed 9300).
Statistical analysis was performed with JMP software, using mixed model analysis of variance. All values are presented as mean±SD; p values less than 0.05 were considered significant.

Table 1: Experimental combinations

metabolic rate:	mild	(125 watt)
	moderate	(200 watt)
climatic condition:	normothermia-cold-hot [NCH]	
	normothermia-hot-cold [NHC]	

where: normothermia 21°C, 55%RH; cold 12°C, 60%RH; hot 41°C, 35%RH.

RESULTS

Heart rate (HR), skin (T_{sk}) and rectal temperature (T_{re}) in subjects subjected to mild and moderate work loads under the 2 climatic combinations (NHC and NCH) are depicted in Fig. 1. It is evident that in both work loads HR and T_{sk} responded rapidly to any change in environmental conditions. These rapid changes were not reflected in T_{re}, which responded to work load rather than to environmental conditions. Thus, upon temperature shift from hot to cold environment, T_{re}

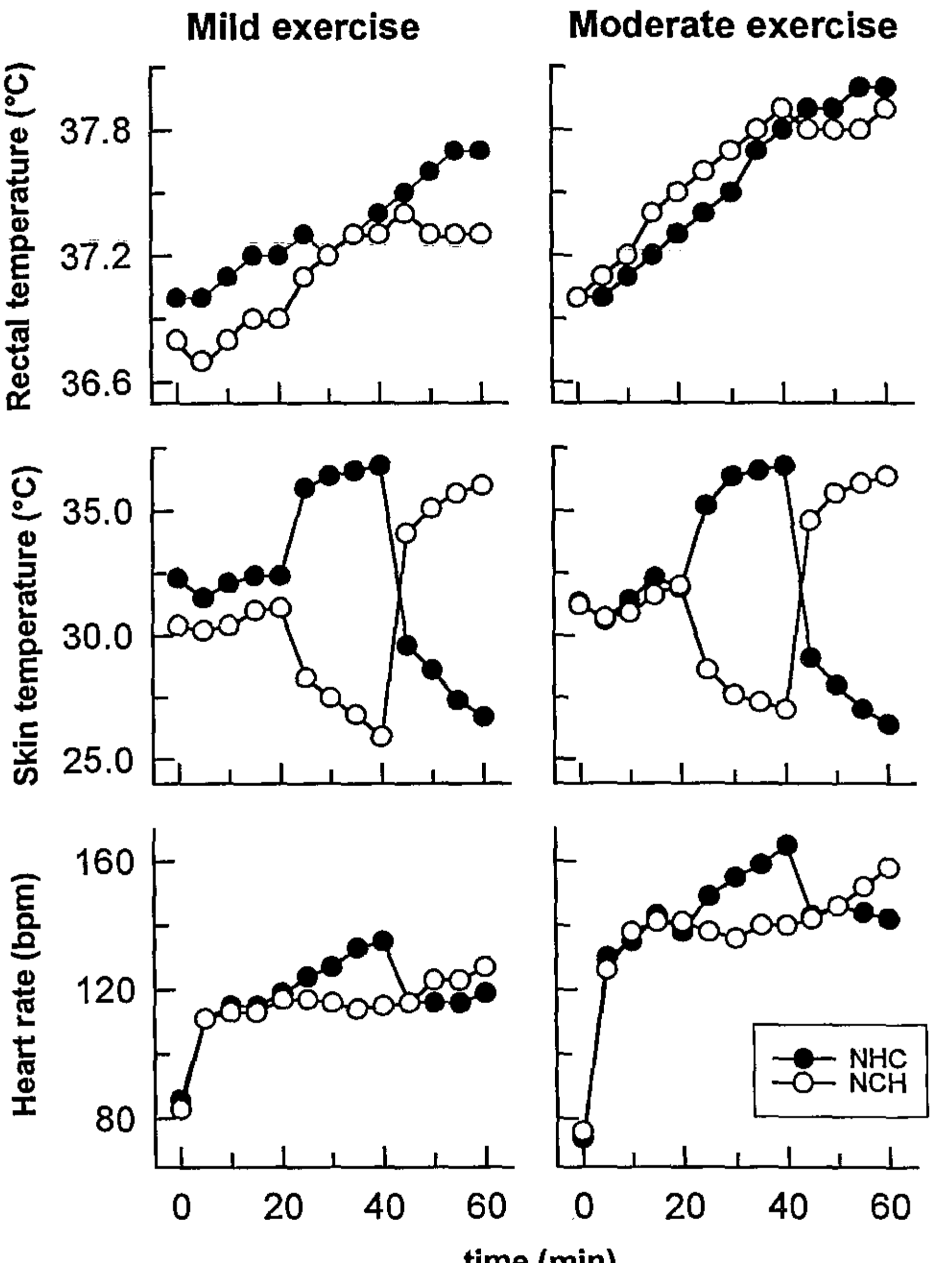

Figure 1. Rectal temperature, skin temperature and heart rate dynamics during 60 min mild and moderate workout under 2 climatic conditions: normothermia-cold-hot [NCH] and normothermia-hot-cold [NHC].

continued to rise despite the cold environment. In contrast, T_{sk} and HR decreased immediately after the transition to the cold climate.

Normothermia VO_2 values differed by 100 ml/min from those obtained in hot and cold climates. Hot climate induced VO_2 elevation, whereas cold climate produced lower VO_2 values compared to those obtained in normothermia. Blood pressure values obtained in [NHC] were significantly higher than in [NCH] ($p<0.03$). No significant difference in cardiac output (Q) was found between [NHC] and [NCH] at the same work load.

DISCUSSION

Upon changes in the climate conditions the rapid parallel changes in T_{sk} and HR to the compared slow changes in T_{re} may suggest that upon rapid ambient temperature shifts afferent peripheral thermoreceptors, and the subsequent vasomotor responses predominates in the control of body temperature. In contrast, upon changes in work load the impact of metabolic heat production was more pronounced. The slower response of the metabolic system compared to that of the heat dissipation mechanisms, which depend on thermal conductivity is of significance to workers exposed to rapid climate changes, especially to those who active physically and move from hot to cool climate and aware of the thermoregulatory system pattern.

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