Moving between hot dry and warm humid climates

Barbara Griefahn, Paul Schwarzenau, Peter Bröde
Institute for Occupational Health, Enviromental Physiology and Occupational Medicine, Ardeystr. 67, D-4600 Dortmund 1, FRG

Introduction

Numerous studies executed in the laboratory and in the field describe the process of acclimatization to either continuous or intermittent exposure to heat. The control climate (where the subjects are habituated to) was mostly moderate and the experimental climate was either hot dry or warm humid. Thus, little is known about the effects of abrupt alterations between hot dry and warm humid climates. The present paper deals with this problem.

Hypotheses

Presupposing equivalent climates in terms of the WBGT-index acclimatization to a particular combination of air temperature, humidity, and velocity induces acclimation to any other combination as well. Alterations from e.g. hot dry to warm humid climates within this range then does not affect heart rates or core temperatures but sweat rates must alter as they are highly determined by humidity. However, acclimation to either of these climates with the same WBGT enables the organism to sweat adequately in the other climatic conditions.

Methods

9 subjects (2 female, 7 male, 20-32 yrs) participated in the study. They were acclimated in 2 experimental series to either a hot dry (series 1) or to a warm humid climate (inverse series 2). Both these climates were equivalent in terms of the WBGT (33.6 °C, 33.5 °C) but differed considerably with regard to air temperature (50 °C, 37 °C) and humidity (15.4%, 70.5%). Velocity was 0.3 m/s in both these conditions and radiation temperature was equal to air temperature.

Both series began with an acclimation period of 15 consecutive days, where either the hot dry or the warm humid climate was applied throughout. During the following 2 experimental days the subjects were exposed to the opposite climate that is the climate which was applied for acclimation in the inverse series.

Four subjects completed first series 1 and therafter the inverse. series 2. The other subjects followed the reverse order. The time between both series was sufficient for a complete loss of acclimation (52,123 days).

The experimental procedure was maintained throughout the overall 17 days of each series: After the electrodes and the thermocouples were fixed, the subjects rested 10 minutes on a chair in a reference climate (t_a = 22 °C, RH = 40 - 60 %). Then they moved into the climatic chamber where they first rested another 10 minutes. Thereafter they walked during four 25-minute periods on a treadmill (4 km/h) and rested finally 15 minutes again in the reference climate. All these periods were separated by a 3 minutes pause each.

Heart rates, core temperatures (rectum), and skin temperatures (forehead, chest, leg) were continuously recorded throughout. After each period the subjects were weighed and they completed a short questionnaire.

The subjects were clad with shorts, socks, and shoes (0.1 clo), the females additionally with a T-shirt (0.2 clo). Drinking was permitted ad libitum.

Results

After full acclimation was statistically confirmed for the last 2 days of the acclimation period in both series, further statistic calculations were executed with the physiologic data averaged over the last 2 acclimation days and those averaged over the following 2 days with the opposite climate.

If these data are compared within the series none of the alterations - from dry to humid (series 1) or from humid to dry (inverse series 2) - caused an additional cardiac strain or an increased core temperature (Table 1). Sweat rate, however, decreased significantly in series 1 ($p<0.01$) after the climate was altered from hot dry to warm humid (dry - humid = 446 g/h) and it increased in the inverse series 2 where the climate was altered in the opposite direction from warm humid to hot dry (humid - dry = -392 g/h, $p<0.01$).

The same climate was applied during the acclimation period of one series and during the final 2 days of the inverse series. The differences between both these situations - calculated separately for the dry and for the humid condition - were nevertheless negligible for all the 3 physiologic variables (Table 2). They are far below the acclimation effects which are significant on the 2%-level at least for any variable (the acclimation effects are the differences between the first exposure to heat and the end of the acclimation period, days 14 and 15).

Table 1: Physiologic variables compared between 2 different (opposite) climates within *the same series.* Average over the last 2 acclimation days (14,15) compared with the average over the final 2 days (16.17) of the same series.

Acclimation to: Alteration to: Differences:	Series 1 hot dry (hd) warm humid (wh) (hd - wh)	 p-value	Series 2 warm humid (wh) hot dry (hd) (wh - hd)	 p-value
Heart rates (bpm)	3.83	0.078	2.30	0.461
Core temperatures (°C)	0.03	0.844	-0.09	0.109
sweat rates (g/h)	445.5	0.008	-391.8	0.008

Table 2 Physiologic variables compared *between* the same climatic conditions of different series. Average over the last 2 acclimation days (14,15) of one series compared with the average over the final 2 days (16,17) of the inverse series.

Climate Differences between:	Hot dry climate series 1 - series 2 difference	 p-value	Warm humid climate series 2 - series 1 difference	 p-value
Heart rates (bpm)	6.39	0.047	-0.62	0.813
Core temperatures (°C)	-0.002	0.938	0.074	0.219
sweat rates (g/h)	26.20	0.047	18.86	0.406

A very few authors registered acclimation to both, hot dry and warm humid climates. During a particular series they exposed their subjects exclusively to either of these climates and statistic comparisons were made only between series using the criteria heartrates, core temperatures, and sweat rates. The contradictory results published so far are - among other reasons - related to the fact that the climates were not equivalent in terms of the WBGT or any other index, that different subjects participated in different series, etc..

In the present study 2 considerably different (opposite) climates with the same WBGT were chosen. After acclimation to either of these conditions the subjects were exposed to the opposite climate. The results verify the hypothesis: The physiologic responses to an abrupt climatic alteration (in whatever direction) within one series as well as the physiologic data recorded in the same climate of different series and at different times (last 2 acclimation days of one series, final 2 days of the inverse series) reveal that acclimation to either of these climates enables the organism to respond adequately (as if especially acclimated) to the opposite climate as well.

Far-reaching conclusions are, however, premature as only 2 climates were applied. The experiments are continued and extended to other climates, again with the same WBGT but with varied radiation temperatures.