ACCLIMATION INDUCED BY EQUIVALENT STRAIN DUE TO EXOGENOUS AND ENDOGENOUS HEAT LOAD

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INTRODUCTION

Heat acclimation is an important physiological counter-mechanism to avoid or reduce extreme thermal states of the body involving serious health problems including heat stroke. Adaptive adjustments may be evoked, e.g., within prophylactic health care programs in occupational medicine, either by (A) repetitive external heat load (e.g., in a climatic chamber) or (B) by repetitive endogenous heat load via muscular endurance training (e.g., on an ergometer).

This project aimed at a comparative quantification of the adaptational physiological responses to the processes induced by treatment (A) and (B). The extent and the time course of the responses, as well as the thermal and circulatory efficiency, were determined.

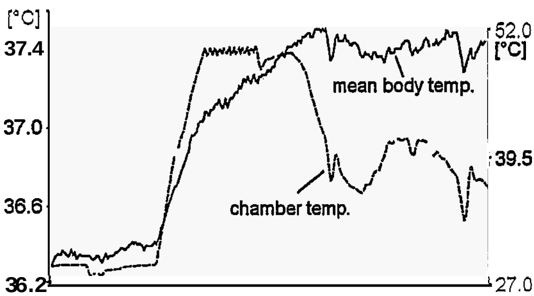
METHODS

In contrast to former investigations (1,2,3) we guaranteed an equivalent thermoregulatory strain by experimental feedback of mean body temperature as physiological strain index, in case (A) to the temperature of the climatic chamber, and in case @) to the mechanical power to be achieved on the ergometer.

By this, an increase of 1°C for mean body temperature ($T_b = 0.87\ T_{re} + 0.13\ T_{sk}$) was maintained during 2 h. Each type of experiment was repeated during 9 consecutive days. Before and after each series, a heat tolerance test was carried out: starting from a neutral environment, the temperature of the climatic chamber was increased every 30 min by 5°C, and a temperature of T_a = 45°C (RH 20 %, wind speed 0.2 m·s) was kept for 45 min. After a second neutral phase, we determined the shivering threshold. Acclimation series (A), see Figure 1, started with a 60-min neutral phase and heating of the climatic chamber to T_a = 50°C. As soon as T_b was 1°C above the initial level, a computer controlled T_b at this level by adjusting T_a.

In series (B), see Figure 2, which was started not earlier than 4 weeks after the end of series (A) to guarantee sufficient de-acclimation, the subjects worked at T_a = 29 to 32°C and performed 100 to 180 W mechanical power on a bicycle ergometer (after the initial resting phase) until T_b was 1°C above initial level.

The computer maintained this deviation by adjusting the workload. The intent in the second series was to reproduce the time course of T_b of the first series. One half of the 6 male subjects started with series (A), the other half with



any case, the temporal integral of the deviations of T_b from the value recorded at neutral initial conditions was equal in series **(A)** and (B). Measurements consisted of 10 skin temperatures, core temperature (rectal and radio

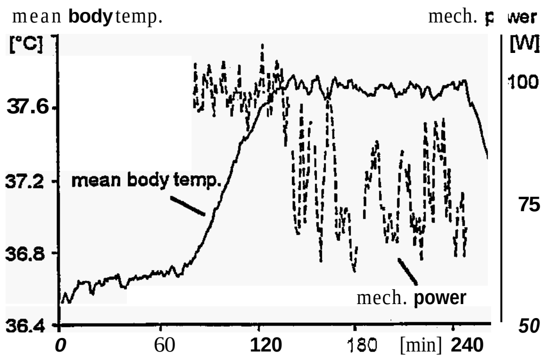


Figure 2. Mean body temperature and mechanical power in an experiment with endogenous load.

(before the heat tolerance tests: protein and electrolyte content and hematocrit) and sweat. The subjects did not take part in any sports or sauna, before or during the period **of** the experiments and attempted to avoid increased body temperature, heart rate and blood pressure, while at home during the period of the study.

RESULTS

The prominent adaptive heat adjustments were a significant reduction of mean body temperature T_b revealed in the heat tolerance test before and after series **(A)** and (B), both for the neutral and the warm phase (Figure **3).** The effect was primarily due to the decrease of core temperature, whereas we observed no clear effect on mean **skin** temperature. Differences between the two series were not evident, although a tendency of a stronger effect of the endogenous load occurred

Sweat production was significantly enhanced after both acclimation procedures (Figure **4);** again significant differences between the procedures could not be detected.

The effect of increased sweating rate should be primarily due to the decrease **of** the sweating threshold, an effect that was statistically significant only in series **(B).**

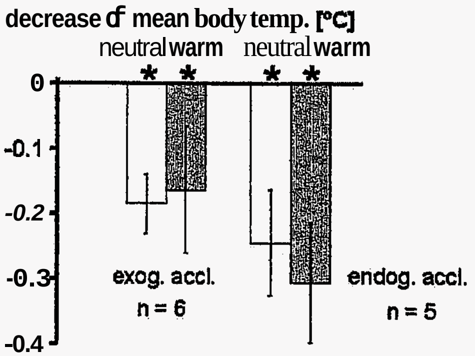


Figure 3. Decrease **of** mean body temperature after exogenous and endogenous acclimation (white bars: neutral phase; **shaded** bars: heat phase of **heat** stress test)

Also, heart rate was significantly reduced after both series in the heat stress phase (Figure 5), with a significantly greater effect by ergometer training. **A** uniform tendency of a decreased shivering threshold was obvious in both series. Also, the tendencies of increasing skin perfusion, blood electrolytes and decreasing hematocrit and sweat electrolytes after acclimation procedures were not significant.

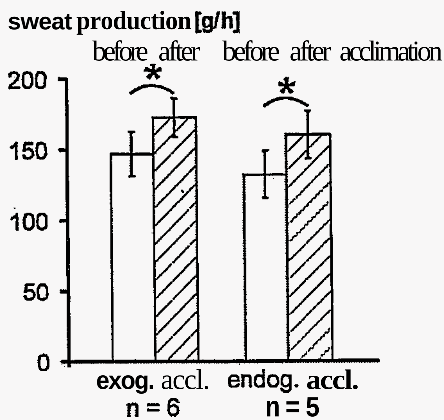


Figure 4. Sweat production after exogenous and endogenous acclimation (white bars: before; hatched bars: after acclimation.

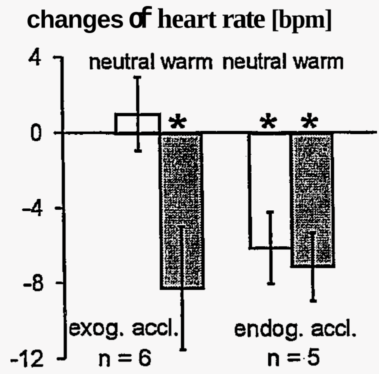


Figure 5. Changes **of** heart rate after exogenous and endogenous acclimation (white bars: neutral phase; shaded bars: heat phase of heat stress test).

CONCLUSIONS

The results suggest that the temporal integral of the deviations of mean body temperature from the value recorded at neutral, initial conditions should be regarded as the essential indicator for the acclimation stimulus. With an equivalent value of this strain index, differences in the overall thermal adaptation grade could not be recorded. Successful and equivalent acclimation may be achieved by both external and internal heat production.

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