

THE APPLICABILITY OF THE WBGT DURING ACCLIMATION

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INTRODUCTION

Acclimation to a particular combination of air temperature, radiant temperature, humidity and velocity induces acclimation to any other combination as well presupposing the same WBGT-number; and alterations between these equivalent climates cause no additional strain. This hypothesis was verified for equivalent dry and humid heat (1). The present study was extended to a climate with radiant load. Mood was additionally assessed.

METHODS

3 experiments with 17 consecutive days each were executed in the lab. During the first 15 days the subjects were acclimated to either of 3 equivalent but differently composed climates:

- humid heat: $T_A = 37\text{ }^\circ\text{C}$, $\text{RH} = 70.5\%$, $V_A = 0.3\text{ m/s}$, $T_R = T_A$, $\text{WBGT} = 33.5\text{ }^\circ\text{C}$,
- dry heat: $T_A = 50\text{ }^\circ\text{C}$, $\text{RH} = 15.4\%$, $V_A = 0.3\text{ m/s}$, $T_R = T_A$, $\text{WBGT} = 33.6\text{ }^\circ\text{C}$,
- radiant heat: $T_A = 25\text{ }^\circ\text{C}$, $\text{RH} = 39.7\%$, $V_A = 0.5\text{ m/s}$, $T_R = 90.8\text{ }^\circ\text{C}$, $T_G = 58.2\text{ }^\circ\text{C}$, $\text{WBGT} = 33.4\text{ }^\circ\text{C}$.

During the following 2 days the humid condition was applied after acclimation to dry heat, and dry heat after acclimation to the humid heat respectively to the radiant heat condition. Another 12 days experiment was executed in a neutral climate ($T_A = 25\text{ }^\circ\text{C}$, $\text{RH} = 60.0\%$, $V_A = 0.3\text{ m/s}$, $T_R = T_A$, $\text{WBGT} = 21.1\text{ }^\circ\text{C}$).

The **experimental procedure** was strictly maintained during the daily experiments. The subjects rested in a temperate room (10 min, $T_A = 22\text{ }^\circ\text{C}$, $\text{RH}: 40\text{-}60\%$) and another 10 min in the climatic chamber. After a 5-min break, they walked on a treadmill (4 km/h, 0°) during 4 successive 25-min periods (each followed by 3-min breaks) and finally rested 15 min in the temperate room. The declaration of Helsinki was fully regarded (2).

Subjects: Each series was completed with 8 healthy subjects (6 males, 2 females, 21-32 yrs). Men wore cotton shorts, socks and gym shoes with 0.1 clo, females wore additionally a T-shirt, their clothing insulation reached 0.2 clo. During the experiments they received lukewarm herb tea ad libitum.

Heart rates and core temperatures (thermistors, 10 cm above the anus) were continuously monitored. Sweat loss was determined by weighing the subjects before the daily trials and after each period. Mood was assessed with 10 cm analogue scales ('how do you feel actually?' and 6 adjectives ranging from untrue to true, 3).

RESULTS AND DISCUSSION

The **courses of acclimation** are in accordance with the literature. Heart rates and core temperatures increase initially and decrease again during repeated heat exposure and level off to a higher plateau as compared to the neutral condition. Sweat loss increased gradually during several days, then remained at higher levels (figure 1).

A few authors compared acclimation to dry with acclimation to humid heat. Some argue from higher sweat loss that acclimation is better and faster in dry heat, others argue the same for humid heat as the increase of sweat loss is then steeper. But it is certainly not sufficient to assess acclimation only on sweat loss as the increase of sweat loss during humid heat concerns merely sweat dripping, not evaporation (4).

Apart from sweat loss the daily differences between the 3 climates were not significant (t-test).

Acclimation occurred first in the humid, then in the dry and finally in the radiant heat condition, but this was significant only for sweat loss. These

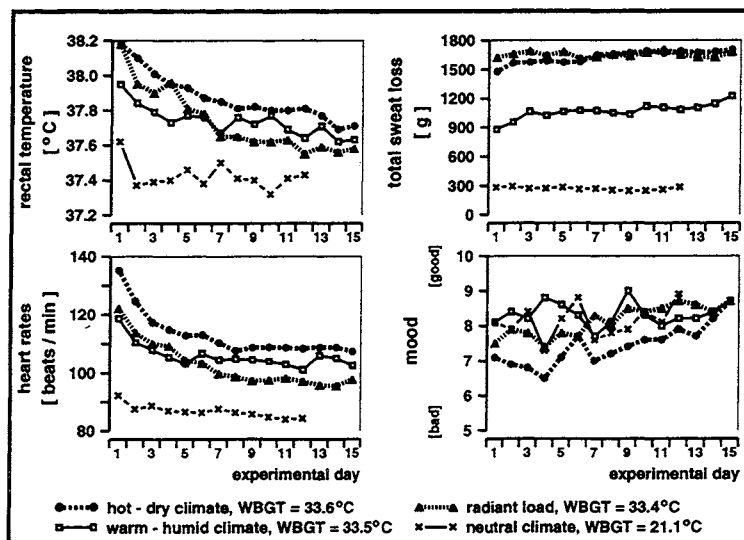


Figure 1: Course of acclimation of mood and physiologic variables.

minor differences are supported by Nielsen (2).

Iampietro & Goldman (5) altered the thermal stress within a series and their subjects interrupted their treadmill walk more often in humid heat than during dry heat. Their conclusion, however, that acclimation to warm-humid takes longer than to hot-dry is certainly wrong, as the thermal stress was considerably higher in the latter condition ($T_A = 48.9^\circ\text{C}$ in both climates, $\text{RH}=31.7\%$ or $\text{RH}=17.4\%$, as indicated by several thermal indices.

After acclimation the thermal conditions were altered during the following 2 days while maintaining the WBGT. Subjects acclimated to humid or to radiant heat were now exposed to the dry heat those acclimated to hot-dry were exposed to the humid heat.

In figure 2 the 3 physiologic variables and mood are presented one below the other, the 3 possible alterations side by side. The first of every 2 columns presents the average over the initial 2 days (solid line) and over the final 2 days of the acclimation period (dotted line). This difference (the extent of acclimation) is significant on the 1%-level for each variable and for each climate, except for sweat loss during repeated exposure to radiant load. In this climate, sweat loss was already high in the beginning and did scarcely increase thereafter.

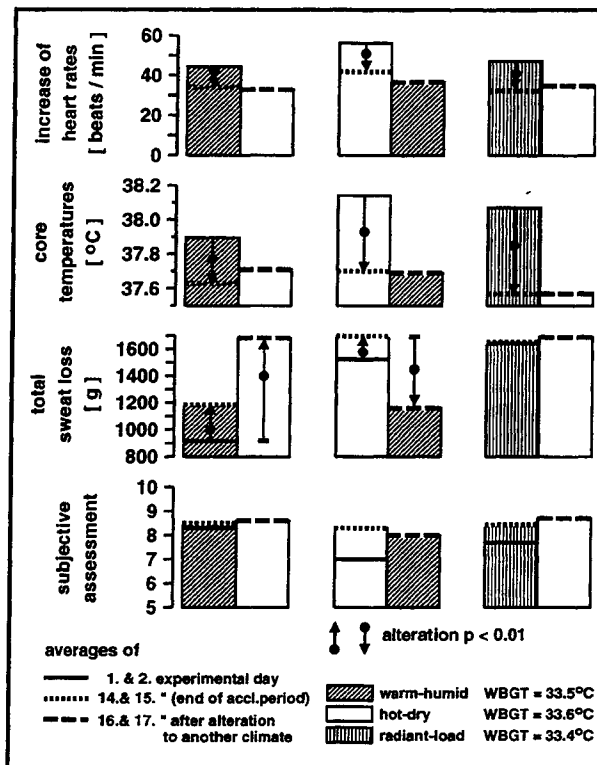


Figure 2: Responses to equivalent climates.

The second columns, also indicated with broken lines, present the average over the following 2 days after the alteration to another but equivalent climate. Comparing the broken and the dotted lines of both neighboring columns the alteration of the thermal parameters did not induce an additional strain neither for core temperatures nor for heart rates. Sweat loss, however, altered but reached exactly the same level as in those subjects who were acclimated to the respective climate.

These results verify the previously formulated hypothesis. After the organism is adapted to a defined thermal stress the consecutive alteration to another but equivalent climate the physiologic parameters and mood behave as if the subjects were acclimated to the respective climate.

Many **thermal indices** were developed in the last 7 decades. The thermal parameters are condensed to a single number to predict the thermal strain. Only a few are accepted for a limited range of climates. Wet bulb globe temperature (WBGT), a most simple index was not developed on a physiologic basis. But nevertheless, disregarding some minor differences the WBGT proved to be a useful predictor for thermal strain in the present paper.

CONCLUSIONS

The previously defined hypothesis was verified for the 3 thermal conditions applied in this study and the WBGT-index seems to be a suitable predictor not only for subjective assessment but also for physiologic strain. Acclimation to a defined thermal stress enables the organism to behave adequately in other equivalent climates. Regarding occupational exposure, workers can be transferred without reservations to other workplaces with the same WBGT-number. The results suggest also that preacclimation before the departure to hot countries could be achieved without regarding the specific conditions of the destination apart from the WBGT-number.

REFERENCES

1. Griefahn B. and Schwarzenau P. 1992, Moving between hot dry and warm humid climates, 5 ICEE '92, 18-19.
2. Declaration of Helsinki 1976, Medical Journal of Australia 7(1), 206-207.
3. Griefahn B. and Di Nisi J. 1992, Mood and cardiovascular functions during noise. J Sound Vib 155,111-123
4. Nielsen B. 1994, Adaptation to dry an humid heat. Polish-Czech Int. Symposium, Zakopane, Poland 1994.
5. Iampietro P.F. and Goldman R.F. 1965, Tolerance of men working in hot, humid environments. J. Appl. Physiol. 20, 73-76.