

TOLERANCE LIMITS FOR MAN UNDER HEAT STRESS, EVALUATION AND ITS PROBLEMS

H.G.Wenzel, C.Mehnert, P.Schwarzenau

Institute of Occupational Health at the University of Dortmund,  
Federal Republic of Germany  
Address for reprints:  
Institut für Arbeitsphysiologie  
Ardeystr. 67  
D-4600 Dortmund  
Federal Republic of Germany

Quite a number of proposals are known indicating combinations of elevated ambient temperatures and air humidities which are supposed to be just barely tolerable to man. Respective proposals take into consideration that the effects of a given combination of temperature and humidity differ with various boundary conditions such as air movement, work level and clothing, etc. Even in the case of equal boundary conditions, however, the limits proposed by various authors may differ considerably, a fact which hinders the evaluation of severe heat stress conditions.

It is often difficult to find out in detail the reasons of such divergences. Sometimes the number of single observations is different, depending on where the proposals have been derived from. Additionally, various physiological responses were used as criteria for evaluation and different values of the responses were considered as being "maximally tolerable" in order to provide sufficient safety margins. Some proposals were not derived directly from human studies, but from calculations of the heat balance of the human body. In this case, the assumptions regarding the heat transfer coefficients etc. that should be used for such calculations differ. Some upper limits were described with various "heat stress indices". Furthermore, individual differences in the responses to given heat stress will certainly be reflected by diverging proposals.

The following climatic chamber experiments carried out in the past few years in our labs throw light on some possibilities, but also on the problems of making statements about upper tolerable limits. 13 young healthy men wearing shorts and adapted to work in heat served as volunteers, each of them in a series of 20 to 40 single experiments. The subjects were exposed every other day to various elevated ambient (air-radiant) temperatures between 20 and 55°C combined with various relative air humidities between 5 and 97 % performing equal treadmill work (MR about 850 kJ/h) at 0.3 m/s air speed. Within the total range of ambient temperature mentioned above, the individual ranges of experimental temperatures were chosen in such a way that each respective person was able to tolerate the chosen conditions up to about 4 hours.

Among other physiological responses, rectal temperature was measured, the individual relationship between this response and the given heat stress was worked out and compared with simultaneous changes in heart rate, sweat loss, skin temperature etc. Mean rectal isotherms from 37.2 to 38.2°C, applying to all the 13 test subjects, and their standard deviations were calculated and plotted in a psychometric chart. The isotherms agree fairly very well with comparable data published by WYNDHAM.

These results were used to examine how far various "heat stress indices" correspond to the mean rectal isotherms. The comparison showed that the extent of agreement and disagreement differed in climates producing relatively mild and relatively severe heat stress respectively. Details are presented in psychometric charts.