

A CRITICAL COMPARISON OF HEAT STRESS INDICES INCLUDING CLOTHING

R. Ilmarinen* and H.G. Wenzel **

Finnish Institute of Occupational Health*
Institute of Occupational Health at the University of Dortmund**

Address for reprints:
R. Ilmarinen
Institute of Occupational Health
Topeliuksenkatu 41 a A
SF-00250 Helsinki, Finland

Considerable differences are found between the statements of the heat stress indices, which are commonly used to describe the physiologically equivalent combinations of the factors significant to heat stress (i.e., air temperature, air humidity, air velocity, radiant temperature, metabolic rate, and clothing).

The aim of this study was to compare the physiologically equivalent combinations of the six heat stress factors based on the experiments on human subjects and on the statements on physiological equivalence given by four heat stress indices including clothing.

In 213 climatic chamber experiments four young healthy, acclimated men performed light (260 W) and moderate (335 W) work on a treadmill. They were exposed successively to different combinations of ambient temperature and air humidity varying within the range of 15°C to 55°C and 10% to 98% with a constant air velocity of 0.3 m/s; wall and air temperatures were approximately equal. Two sets of work clothing with an insulation value of 0.7 clo and 1.0 clo were used. The combinations of work, clothing, and thermal parameters were selected in such a way that the subjects were able to tolerate the conditions for as long as four working hours. The exposure time of each single experiment consisted of working periods of 30 min interrupted by 3-min rest pauses between work bouts. During the work, rectal temperature, ear temperature next to eardrum and heart rate were measured continuously. Metabolic rate was measured every half an hour. During the 3-min pauses skin surface temperature at nine sites and body weight were measured. Sweat loss corrected for oxygen intake, carbon dioxide loss and water intake was calculated from the changes in body weight.

It was found that body temperatures and heart rate, but not sweat loss, were suitable criteria for indicating equal heat stress conditions. The derived mean lines of physiological equivalence (MEL) were compared with the statements of Normal Effective Temperature Index (NET), Predicted Four-hour Sweat Rate Index (P4SR), Index of Relative Strain (RS), and Index of Physiological Effect (IPE).

The best agreement of MEL was with IPE, and in some ranges of climate also with NET and RS. The agreement with P4SR was poor under the given experimental conditions. It seems that in practice the prediction of work/rest regimens and the recommendation for medical surveillance for hot workers based on the use of indices may be misleading.