A FIELD EVALUATION OF THERMAL STRESS FOR ESTIMATION OF STRAIN IN INDUSTRY

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INTRODUCTION

Selection of suitable individuals for work in hot environmental conditions has often been a challenge to the practicing managers of industries in India. Use of a simple physiological parameter to assess an individual's capacity for work in hot environments is explored in this paper. Studies available for Indian conditions on this aspect pertain to laboratory conditions (Sen Gupta, et al, 1977; Dutta and Ganguly, 1975) which are difficult to translate to field conditions. The complexity of such problems requires relationships and formulas to be established for easy evaluation of strain without hampering either the production process or the routine activities of the employees. The present study is an attempt to obtain a relationship of heart rate with thermal stress in field conditions.

METHOD

The study was carried out in two textile industries and a steel plant, which together employ 33,000 individuals. Heat stress was evaluated in terms of WBGT from the readings of air temperature, humidity, wind velocity and radiation. Heart rates of individuals were recorded during rest, work and recovery. Work heart rates were recorded after 5 min, 2 hrs, 4 hrs, and just before the end of the shift, and the average was computed. Data for a total of 188 individuals were collected.

RESULTS

Average heart rates at the end of 4 hours have been used in the analysis. Data from both types of industries have been pooled in this analysis. Relationships of heart rate (dependent variable) with age and WBGT on the one hand (independent variables) and with body surface area and WBGT on the other were established. Separate sets of regression equations were developed. They are:

(i) $Y = -6.94 + 0.49\,X1 + 3.45\,X2$ $(R=0.59)$ were Y is the heart rate in bpm; X1 represents age; and X2 represents WBGT in degrees C.

(ii) $Y = 2.08 - 2.43\,X1 + 3.81\,X2$ $(R=0.61)$ where Y is the heart rate in bpm: X1, represents BSA in square meters; and X2 represents WBGT in degrees C.

CONCLUSIONS

The physiological strain amongst individuals has been found to be beyond the premissible limit for safe work proposed by Sen Sara et al, (1985). The incremental heart rate per C of WBGT increase has been found to be 3 bpm. The heart rate increased on the average from 88 to 118 bpm for a rise of WBGT index by 10 C, and the working heart rate varied between 110 and 143 bpm. This

increase in heart rate exceeds the observations of increase of 7-10 bpm/10 C rise while carrying a load under dry ambient temperature of 20-45 C (Ramon and Belding, 1971). The present observations are quite close to the study data collected for harvest workers in South Eastern America where the heart rate was found to increase by 42.5 to 69.2% when the WBGT index ranged from 20 to 30.4 C. The difference between our observations and that above is due to the variation in physical characteristics of subjects. Also the present finding of increase in heart rate is yet more than what was predicted by Meese et al. (1984); i.e., 1 bpm/C above 25 C. Kenney (1986) suggests a physical limit of PL (min) = 83 - 0.53 (HR 5 P), and this in conjunction with the nomogram set can be used for determining the working time limit for individual workers.

Estimation of the physiological cost of work to determine the physical working capacity may satisfy the task of assessing the fitness of an individual. However, the inherent difficulties of the technique being laborious, time consuming, and restricting the freedom of movement of workers associated with its estimation in field situations, discounts its choice as a suitable technique. Heart rate, which fairly reflects the severity of work of an individual, by virtue of its established relationship with energy expenditure, can be a viable alternative under the circumstances. Two nomograms presented on the next page can be used as a tool in the hands of practising managers to overcome the above difficulties, while, at the same time, presenting a fairly good picture of the strain imposed.

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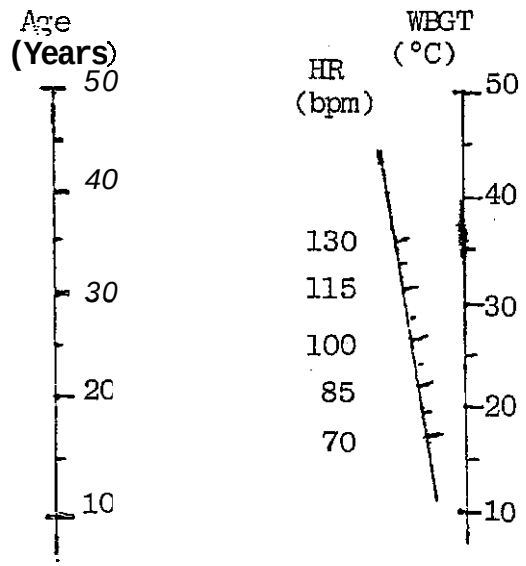
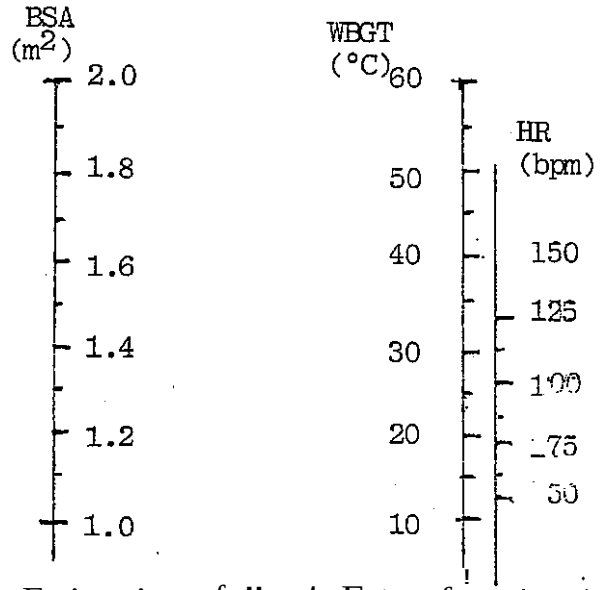


Estimation of Heart Rate after 4 Hours of Wok from Age

Fig. 1



Estimation of Heart Fate after 4 hours of Work from Body Surface Area and WBGT

Fig. 2