Prediction of Maximal Aerobic Power in Man

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Summary. A general prediction formula has been derived for predicting maximal aerobic power ($\dot{V}O_2\text{max}$) based on nonlinear relationship between aerobic stress and cardiorespiratory strains imposed on the subject during submaximal exercise on bicycle ergometer. The validity of the prediction formula has been tested for the data consisting of 135 observations on 45 moderately active young subjects who were asked to exercise on the bicycle ergometer at three submaximal and one maximal work rate. It has been found that product moment correlations of aerobic stress with respiratory strain and cardiac strain expressed logarithmically were 0.7651 and 0.7457 respectively. These correlations were significant ($P < 0.001$). The multiple correlation between observed and estimated aerobic stress expressed logarithmically in terms of cardiorespiratory strains was 0.8142 which was significant ($P < 0.001$). There is a significant improvement in multiple correlation from the product moment correlations of aerobic stress with either of two strains expressed logarithmically. It has been conclusively established that combined index of cardiorespiratory strains will be better predictor of aerobic stress than either respiratory or cardiac strain alone as commonly employed by several workers.

Key words: Prediction of $\dot{V}O_2\text{max}$ — Aerobic stress — Cardiorespiratory strains.

Introduction

Maximal aerobic power ($\dot{V}O_2\text{max}$) of an individual is perhaps the single most valid physiological measure of the functional capacity of the cardiorespiratory system to perform strenuous physical work (Åstrand and Rhyming, 1954; Taylor et al., 1955; Balke and Ware, 1959; I. Astrand, 1960; Hermansen and Saltin, 1969). This is also an extremely reproducible physiological parameter when measured under standardised conditions. However, direct measurement of $\dot{V}O_2\text{max}$ besides being time consuming, needs a well equipped laboratory and trained personnel. Moreover the exertion required to attain $\dot{V}O_2\text{max}$ requires motivation and cooperation from the subject.
and may be hazardous to the health and well being of the individuals particularly in higher age groups. Consequently, several workers have suggested methods for indirect estimation of $\dot{V}O_2\ max$ from heart rate measured at submaximal work loads (Åstrand and Ryhming, 1954; Fox, 1973; Maritz et al., 1961; Yuhasz, 1962; Margaria et al., 1965; Wyndham 1967). Some workers (Issekutz et al., 1962) have also used the respiratory exchange ratio at submaximal work loads for this purpose. Both these approaches, however, have some limitations and their relative merits and accuracy of predictions have been discussed by several workers (Rowell et al., 1964; Glassford et al., 1965; Davies, 1968). In our earlier studies (Sen Gupta et al., 1968, 1972) we have reported that exercise dyspnoea gives a good measure of endurance work capacity of an individual. Further it has been shown that a combined index of cardiac and respiratory strains during activity is able to predict the duration in endurance effort fairly accurately (Sen Gupta et al., 1974). An attempt has therefore been made in the present paper for indirect estimation of $\dot{V}O_2\ max$ from combined cardiorespiratory strains during submaximal effort.

Material and Methods

Forty five moderately active young volunteers participated in the study. Subjects after a light breakfast reported to the laboratory maintained at a comfortable temperature 20–22°C. After 1 h rest their resting heart rate ($HR_{rest}$), minute ventilation ($VE$) and oxygen consumption ($\dot{V}O_2$) were measured. Thereafter 15 s maximum voluntary ventilation ($MVV$) was measured by using 1001 meteorological rubber balloon while breathing through a low resistance breathing valve (Collins Triple J) at a frequency of 80–90/min. The test was repeated three times at an interval of 5–10 min and the maximum value was taken and converted into maximum ventilation/min. Then $\dot{V}O_2\ max$ was estimated on a bicycle ergometer by using a continuous method as described in an earlier paper (Joseph et al., 1973). Submaximal work rates of 600, 750 and 900 kgm/min were also administered on different days for indirect estimation of $\dot{V}O_2\ max$.

Results

The physical characteristics and directly estimated maximum oxygen uptake capacity ($\dot{V}O_2\ max$) and maximum voluntary ventilation ($MVV$) of subjects are shown in Table 1. The mean $\dot{V}O_2\ max$ of subjects was $2.53 \pm 0.33$ l/min and their $MVV$ 149.50 ± 17.09 l/min. The values of oxygen consumption ($\dot{V}O_2$) during various grades of submaximal work have been used for indirect estimation of $\dot{V}O_2\ max$ by the method of Åstrand and Ryhming (1954) as well as that of Maritz et al. (1961). To improve the predictability of the $\dot{V}O_2\ max$ by these two methods, which take into account the heart rate only, we have used the combination of respiratory and cardiac strains for this purpose. The respiratory strain has been considered by the exercise ventilation ($\dot{VE}_{ex}$) minus the resting ventilation ($\dot{VE}_{rest}$) expressed as percentage of maximum voluntary ventilation ($MVV$) minus the resting ventilation ($VE_{rest}$) i.e.

$$\text{Respiratory strain (μ)} = \frac{\dot{VE}_{ex} - \dot{VE}_{rest}}{MVV - \dot{VE}_{rest}} \times 100.$$