Evaluation of a Maximal Predictive Cycle Ergometer Test of Aerobic Power

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Summary. A maximal predictive cycle ergometer (CE) test for estimating maximal oxygen uptake ($\dot{V}O_2$ max) was evaluated in 15 male and 12 female subjects. The test consisted of pedalling a cycle ergometer (Monark) at 75 rev·min$^{-1}$, beginning at an intensity of 37.5 watts and increasing by this amount each min until the subject could no longer maintain pedal rate. The highest work rate achieved was recorded as the endpoint of the test and used to construct regression equations to predict $\dot{V}O_2$ max. This was compared with two direct measures of $\dot{V}O_2$ max [an interrupted treadmill (TM) run and an interrupted CE procedure at 60 rev·min$^{-1}$] and with the submaximal predictive test of Åstrand-Rhyming. When compared to TM $\dot{V}O_2$ max, $\dot{V}O_2$ measured during the final 30 s of the maximal predictive CE test was 16.0% and 16.2% lower for males and females respectively; compared to $\dot{V}O_2$ max determined by the direct CE test, it was lower by 2.9% for males and 5.2% for females. Correlation coefficients for $\dot{V}O_2$ max predicted from the maximal predictive CE test and $\dot{V}O_2$ max measured directly by CE and TM were 0.89 and 0.87 for males and 0.88 and 0.83 for females ($p < 0.01$), respectively. The $\dot{V}O_2$ max predicted from the Åstrand-Rhyming test correlated significantly with $\dot{V}O_2$ max measured by CE and TM only in the male group. Test-retest reliability coefficients for intensity (watts) on the maximal predictive CE test were 0.95 and 0.81 for males and females respectively ($p < 0.01$). The data suggest that this CE test gives a reliable and valid estimate of $\dot{V}O_2$ max.

Key words: Treadmill – Cycle ergometer – $\dot{V}O_2$ max – Aerobic power – Predicted $\dot{V}O_2$ max

Introduction

Maximal aerobic power as measured by maximal oxygen uptake ($\dot{V}O_2$ max) is perhaps the most valid single physiological measure of the functional capacity of the cardiorespiratory system and of a person’s ability to perform strenuous
physical exercise (Taylor et al. 1955; Hermansen and Saltin 1969; Åstrand and Rodahl 1977). The direct measurement of \( \dot{V}O_2 \) max using a motor driven treadmill is now widely accepted as the reference standard for assessing aerobic power. Such a procedure, however, besides being time consuming, needs a well equipped laboratory and trained personnel. Moreover, the exertion required to attain \( \dot{V}O_2 \) max requires motivation and cooperation from the subject. Consequently, such complexities have led to the development of several methods of estimating \( \dot{V}O_2 \) max based on heart rate (Åstrand and Rhyming 1954; Margaria et al. 1965; Wyndham 1967) or respiratory exchange ratio (Issekutz et al. 1962) measured during submaximal exercise. The obvious advantages of such tests are: (1) motivation might be eliminated as a factor in testing, (2) sedentary or older individuals can be tested without the discomfort and potential hazards attendant with a maximal effort and, (3) they can be administered to a large number of subjects in a short time period. These approaches, however, have some limitations and their relative merits and accuracy of prediction have been discussed by several workers (Rowell et al. 1964; Glassford et al. 1965; Davies 1968). Perhaps the most commonly used application of the predictive test has been the nomogram developed by Åstrand and Rhyming (1954). This was based on measurements made with young, physically active subjects and has been shown to consistently underestimate actual \( \dot{V}O_2 \) max from 10% to 27% by several workers (Rowell et al. 1964; DeVries and Klafs 1965; Keren et al. 1980). It would appear desirable, therefore, to have a test which is not dependent upon an individual’s submaximal response to exercise and at the same time does not require the complex equipment and expertise characteristic of direct determinations of oxygen uptake.

The development of an international test suitable for general military application in estimating aerobic power has been the concern of the NATO Research Study Group on Physical Fitness for the past few years. In an attempt to achieve some agreement on standardizing such methodology, it was decided among member nations to evaluate a maximal test for the prediction of \( \dot{V}O_2 \) max using the cycle ergometer as the mode of exercise. This paper evaluates such a test by comparing it with the measurement of \( \dot{V}O_2 \) max determined by both the treadmill and cycle ergometer and to the submaximal test of Åstrand and Rhyming (1954).

**Material and Methods**

Fifteen male and 12 female subjects from our Institute staff participated in the study. All subjects received a fully informed briefing and their voluntary consent was obtained. Individuals who had recently started any type of aerobic training program were excluded from participating in the study.

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1 Human subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to Army Regulation 70-25 and USA MRDC Regulation 70-25 on Use of Volunteers in Research.