MODIFICATION OF THE FOX METHOD TO PREDICT MAXIMUM OXYGEN UPTAKE IN FEMALE UNIVERSITY STUDENTS OF KOLKATA, INDIA

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The present study was aimed to develop a simple method, i.e. the modified Fox test protocol (MFT) to predict VO\(_2\)max in female sedentary university students of Kolkata, India. One hundred and eleven (111) healthy untrained female students of the University of Calcutta (mean age, body height and body mass of 22.76±1.72 years, 163.52±4.70 cm and 53.03±3.78 kg, respectively) were randomly sampled for the study. They were further randomly divided into the study group (n=60) and confirmatory group (n=51). Direct estimation of the maximum oxygen uptake (VO\(_2\)max) comprised an incremental bicycle exercise followed by expired gas analysis by the Scholander micro-gas analyzer. The submaximal heart rate (HR\(_{sub}\)) was measured at the completion of five min of exercise at 110W workload. HR\(_{sub}\) exhibited significant negative correlation (r=-0.87, P<0.001) with VO\(_2\)max. Application of the computed norm in the confirmatory group depicted insignificant difference between VO\(_2\)max and predicted VO\(_2\)max or PVO\(_2\)max. Limits of agreement between PVO\(_2\)max and VO\(_2\)max were substantially small. The standard error of estimate of the norm was also substantially small. From the present study, MFT is recommended for application in the sedentary female university students for accurate and reliable assessment of cardiorespiratory fitness in terms of VO\(_2\)max.

Key words: VO\(_2\)max; Fox test; MFT; sedentary; Indian females

INTRODUCTION

The maximum oxygen uptake (VO\(_2\)max) is the single most valid parameter to measure the functional capacity of the cardiorespiratory system. Nevertheless, the direct estimation of VO\(_2\)max involves a laborious, difficult and expensive experimental protocol (Fox, 1973). To bypass this trouble, Fox (1973) validated a prediction method for indirect estimation of VO\(_2\)max in 87 healthy college males of Ohio State University, Columbus, from their submaximal heart rate recorded during the 5th min. of bicycle exercise at 150 W. Similar studies are lacking in female populations.

Application of the Fox (1973) protocol in female university students of Kolkata, India, indicated that the workload was substantially high for them and the subjects reported some premature fatigue in their leg muscles and thus failed to sustain the exercise up to the recommended duration of 5 min. Similar test was conducted in lower workloads (140 W, 130 W, 120 W & 110 W) with at least gaps of four days (Chatterjee et al., 2004) between the tests in the same subjects. They satisfactorily performed the bicycle exercise for the stipulated duration of 5 min at the workload of 110 W which was therefore considered as the maximum sustainable workload in this population to complete the protocol successfully.

The present study was therefore aimed to modify and validate the Fox (1973) protocol with 110
W workload (i.e., modified Fox test or MFT) in the sedentary female university students of Kolkata, West Bengal, India.

METHODS

Subjects

One hundred and eleven (111) unmarried healthy sedentary female students of the same socio-economic background having mean age, body height and body mass of 22.76±1.72 years, 163.52±4.70 cm and 53.03±3.78 kg, respectively, were selected for the study by random sampling from the University of Calcutta, West Bengal, India. They were randomly separated into a study group (n=60) on which the experiment was carried out to compute the new regression formula and a confirmatory group (n=51) on which the modified regression formula was validated. The entire experimental protocol was well explained to all the participants and written informed consent was taken from them. They took light breakfast 2-3 hours before the test and refrained from any energetic physical activity for that period. The participants had no history of any major disease and received no physical conditioning programme except some recreational sports. All the subjects had normal duration of menstrual cycle (27–29 days) for the last six months and the experiments were conducted randomly in any phase of the menstrual cycle (to enable the modified protocol to be applicable in any phase of the menstrual cycle) excepting the menstrual or flow phase. The study was approved by the Human ethical committee, Department of Physiology, University of Calcutta.

The entire experiment was performed at a room temperature varying from 26-29°C and at relative humidity ranging between 72 to 83%.

Experimental design

Each subject came to the laboratory for three days. On the first day, they were familiarised with the experimental protocol. The direct evaluation of VO2max and MFT were conducted on the second and third visits at an interval of at least 4 days between the tests (Chatterjee et al., 2004; Chatterjee et al., 2005). These two experiments were conducted by random sequencing or cross-over design in which direct estimation of VO2max was followed by MFT in one half of the subjects whereas the MFT was followed by VO2max determination in the other half of the subjects to avoid any possibility of bias. Subjects were asked to take rest at least for half an hour prior to the exercise, so that pulmonary ventilation and pulse rate could come down to a steady state (Chatterjee et al., 2004; Chatterjee et al., 2005; Chatterjee and Chakravarti, 1986).

Procedure of MFT:

Muller’s magnetic brake bicycle ergometer (Model of Max-Plank Institute of Ergology, Germany) was used for the study. Subjects performed a warm up exercise at 50 W intensity for a duration of 5 min. Then the work load was increased to 110 W where they performed the exercise for 5 min. The submaximal heart rate corresponding to the peak heart rate at 5 min. (HRsub) was recorded manually from the time taken for ten carotid pulsations (Chatterjee et al., 2004; Chatterjee et al., 2005; Åstrand and Rodahl, 1970; Brooke and Knowles, 1974) immediately following the cessation of 5 min. of exercise at the 110 W.

Direct measurement of VO2max

The subjects first performed a warm-up exercise at 50 W intensity for a duration of 5 min. in the Muller’s magnetic brake bicycle ergometer (Model of Max-Plank Institute of Ergology, Germany). Immediately after performing the submaximal exercise, the intensity was increased to the first incremental intensity of 100 W and thereafter the intensity was increased by 20 W every 3 min, until the subject stopped due to exhaustion (Chatterjee et al., 2005). The oxygen uptake was considered maximum when (ACSM, 2006) :
i) A heart beat within 10 beats min⁻¹ of age-predicted maximum heart rate, i.e., (220-age in years) beats min⁻¹;

ii) A respiratory exchange ratio of more than 1.15;

iii) Levelling off, i.e., when no further increase in oxygen uptake took place despite further increase in intensity, or the increase in oxygen uptake was less than 100 mℓ·min⁻¹ in response to the next higher intensity for repeated tests followed at an interval of 4 days (Chatterjee et al., 2004; Chatterjee et al., 2005; Åstrand and Rodahl, 1970).

Low resistance high velocity Collin’s Triple “J Type” plastic valve was used for the collection of expired gas by the open circuit method (Chatterjee et al., 2004; Chatterjee and Chakravarti, 1986; Chatterjee et al. 2005). The valve was connected with the Douglas Bag (150 ℓ) and the expired gas was collected at the last min. of final intensity of exercise. Gas was also collected at the second min. of the exhausting (final) work load if signs of severe exhaustion supervened. No gas collection was made in the first min. of the work load. The volume of expired gas was measured in a wet gasometer (Toshniwal, Germany, CAT. No. CG05.10) and the aliquots of gas samples were analyzed in a Scholander micro-gas analysis apparatus following the standard procedure (Scholander, 1947). The peak heart rate was recorded manually from the time taken for ten carotid pulsations immediately following the cessation of exhaustive exercise (Chatterjee et al., 2004; Chatterjee et al., 2005; Åstrand and Rodahl, 1970; Brooke and Knowles, 1974). VO₂max values were corrected to standard temperature pressure dry (STPD).

**Statistical analysis**

Paired t-test, correlation and linear regression statistics and Bland and Altman approach for limit of agreement (Bland and Altman, 1986) were adopted for statistical analysis of the data. Level of significance was set at P<0.05.

**RESULTS AND DISCUSSION**

Fox (1973) proposed a method for prediction of VO₂max from submaximal heart rate (HRsub) taken during the fifth min of bicycle exercise at 160W intensity in the male university students. Similar studies among females are scanty and not yet been conducted in the Indian context.

The mean VO₂max and HRsub obtained in the study group (n=60) were 1938.74±340.32 mℓ·min⁻¹ and 170.43±12.15 beats.min⁻¹, respectively. The mean values corroborated with the values reported in similar population in previous studies (Chatterjee and Chakravarti, 1986; Chatterjee et al., 2005). HRsub exhibited significant negative correlation (r = -0.87, P<0.001) with the directly measured VO₂max in the study group. A regression formula for prediction of VO₂max (VO₂max) from HRsub has been computed on the basis of this significant correlation (Fig. 1).

Application of the regression formula in the confirmatory group (n=51) depicted insignificant difference (P>0.05) between the VO₂max (1965.12±188.82 mℓ·min⁻¹) and PVO₂max (2032.40±189.82 mℓ·min⁻¹). The analysis by means of the Bland and Altman (1986) method (Fig. 2) revealed that the limits of agreement between PVO₂max and VO₂max were substantially small (52.07 to 82.47 mℓ·min⁻¹). Predicted values of maximum oxygen uptake from the currently derived equation were within the range of mean±2SD (Fig. 2). Similar attempts to establish the applicability of indirect protocols by the Bland and Altman method of limits of agreement analysis have been reported in earlier studies (Chatterjee et al., 2004; Chatterjee et al., 2005). The limits of agreement reported by Chatterjee et al. (2004) and Chatterjee et al. (2005) were -2.5 – 3.42 mℓ·kg⁻¹·min⁻¹, 0.4 – 6 mℓ·kg⁻¹·min⁻¹, respectively.

The standard error of estimate (SEE) of the norm was also considerably small enough (SEE = 168.25 mℓ·min⁻¹) to use the MFT for accurate and reliable assessment of VO₂max in the sedentary female university students of Kolkata. The obtained value of SEE is lower than that of the original
Figure 1. Relationship between VO$_2$max and HR$_{sub}$ in the study group.

![Graph showing the relationship between VO$_2$max and HR$_{sub}$ in the study group.](image)

\[ Y = 6100.98 - 24.422X; \ r = -0.87 \]
\[ P<0.001, \ SE = 168.25 \text{ mL min}^{-1} \]

Figure 2. Plotting of difference between VO$_2$max and PVO$_2$max values against their means in the confirmatory group (n=51).

![Graph showing the plotting of difference between VO$_2$max and PVO$_2$max values against their means.](image)

Prediction of VO$_2$max from this new equation showed a variation of less than 5% in 82 participants, 5–9% in 25 participants and 10–14% in 4 participants from their respective directly measured value of VO$_2$max. The analysis of intra-class relationship between VO$_2$max and PVO$_2$max

study of Fox (1973). Chatterjee et al. (2005) reported a considerably higher value of SEE to validate the applicability of Queen’s College Step Test in the same population.
in the confirmatory group depicted a correlation coefficient (r) value of 0.96 (P<0.001) which further established the authenticity for the application of this currently derived regression formula in the studied population.

Therefore, from the present study, the modified method of Fox (1973) protocol or MFT is recommended as a valid method to evaluate cardiorespiratory fitness in terms of VO₂max in the young sedentary female university students of Kolkata, West Bengal, India.

REFERENCES