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SHORT COMMUNICATION

VALIDITY OF HEART RATE BASED NOMOGRAM FORS ESTIMATION OF MAXIMUM OXYGEN UPTAKE IN INDIAN POPULATION

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Abstract : Maximal oxygen uptake (VO_2max) during a graded maximal exercise test is the objective method to assess cardiorespiratory fitness. Maximal oxygen uptake testing is limited to only a few laboratories as it requires trained personnel and strenuous effort by the subject. At the population level, submaximal tests have been developed to derive VO_2max indirectly based on heart rate based nomograms or it can be calculated using anthropometric measures. These heart rate based predicted standards have been developed for western population and are used routinely to predict VO_2max in Indian population. In the present study VO_2max was directly measured by maximal exercise test using a bicycle ergometer and was compared with VO_2max derived by recovery heart rate in Queen's College step test (QCST) (PVO_2max I) and with VO_2max derived from Wasserman equation based on anthropometric parameters and age (PVO_2max II) in a well defined age group of healthy male adults from New Delhi. The values of directly measured VO_2max showed no significant correlation either with the estimated VO_2max with QCST or with VO_2max predicted by Wasserman equation. Bland and Altman method of approach for limit of agreement between VO_2max and PVO_2max I or PVO_2max II revealed that the limits of agreement between directly measured VO_2max and PVO_2max I or PVO_2max II was large indicating inapplicability of prediction equations of western population in the population under study. Thus it is evident that there is an urgent need to develop nomogram for Indian population, may be even for different ethnic sub-population in the country.

Key words : heart rate nomogram maximal oxygen consumption

INTRODUCTION

Maximum Oxygen Uptake during maximal graded exercise testing (VO_2max) is considered as an objective, gold standard measure to assess the cardiorespiratory fitness and is largely used as a predictor of cardiovascular morbidity and mortality (1).

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For field studies, many investigators use either nomograms based on heart rate response to sub-maximal exercise or equations based on anthropometric parameters and age to predict VO_2max. Among various indirect protocols (2, 3) the Queen's College step test or QCST is the simplest one and uses the prediction equations to calculate the VO_2max from recovery heart rate (4). Even though the heart rate based predicted standards have been developed for western population, they are widely used in field studies with the presumption that they are valid for Indian population as well. Hence, there is an urgent need to test the validity of these nomograms for applicability in Indian population.

MATERIAL AND METHODS

In the present study, symptom limited VO_2max was directly measured and compared with predicted VO_2max using equation based on recovery heart rate in Queen's College step test (QCST) (PVO_2max I) and with VO_2max derived from Wasserman equation based on anthropometric parameters and age (PVO_2max II). Healthy male sedentary students (n=19) were recruited for the study in the age group of 20 to 30 years. The study was approved by the institute ethics committee. Maximum oxygen uptake of each subject was directly measured during maximal exercise test. The VO_2max was also estimated during QCST using Prediction equation based on recovery heart rate (PVO_2max I). Height and weight of the subject was measured. FEV_1 and FVC was measured on the day of the maximal exercise testing.

Direct measurement of VO_2max

The exercise was done on electronically braked cycle ergometer (Lode-2003, corival, Netherlands) with a continuous, incremental exercise (ramp) protocol as per recommendation of the European guidelines (5). During exercise, the subjects inhaled fresh air through non-breathing "T" valve and exhaled to a mixing chamber continuously (Vista MX system, Vacumed, Germany). The software was configured to provide various ventilatory parameters. ECG, heart rate, respiratory rate, O2 uptake, CO_2 output, respiratory exchange ratio, were recorded continuously.

Estimation of VO_2max by Queen's College Step test (PVO_2max I)

The step test was performed on a step of 16.25 inches (41.3 cm) height for a total duration of 3 minutes. Immediately after stepping for a period of 3 minutes, the recovery pulse rate was determined for a 15-second period starting 5 seconds into recovery and the maximum oxygen uptake (PVO_2max I) was calculated. The predicted values based on Wasserman equation were computed by the Vacumed software and were noted as PVO_2max II. Statistical treatment of the data was done by Student's t test, Pearson's product moment correlation, linear regression statistics and Bland and Altman approach for limit of agreement (6).

RESULTS

Means and standard deviation of Age (years) was 27.42±3.024, Height (cm) was 168.68±6.76, Weight (kg) was 66.16±6.067, BMI (cm/kg^2) was 23.28±1.97, VO_2max (ml/kg/min) was 28.747±6.64.Mean VO_2max predicted by recovery heart rate during QCST was 49.136 ml/kg/min with a range of

36.60-57.60 ml/kg/min. The mean predicted VO_2max by equation based on anthropometric variables by Wasserman was 41.891 ml/kg/min with a range of 32.76-50.49 ml/kg/min.

Analysis of data by Bland and Altman method of approach for limit of agreement revealed that the limits of agreement between directly measured VO_2max and PVO_2max I was large (5.934 to 34.84 ml/kg min) with poor confidence intervals, indicating inapplicability of current protocol of Queen's College Step Test in this particular population (Fig. 1). Similarly, Analysis of data by Bland and Altman method of approach for limit of agreement between VO_2max and PVO_2max II revealed that the limits of agreement between directly measured VO_2max and predicted VO_2max based on anthropometric parameters was large (0.977 to 25.31 ml/kg/min) with poor confidence intervals (Fig. 2), indicating inapplicability of prediction equations based on anthropometric parameters of western population in the population under study.

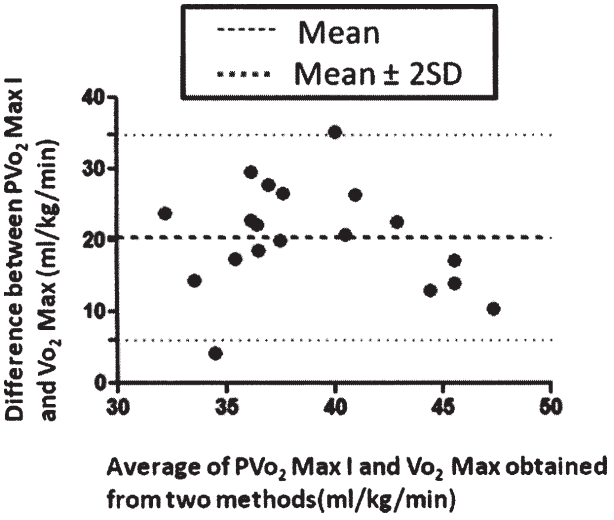

Fig. 1 : Plotting of difference between the VO_2max values estimated by vacumed and VO_2max predicted by QCST (PVO_2max I) against their means.

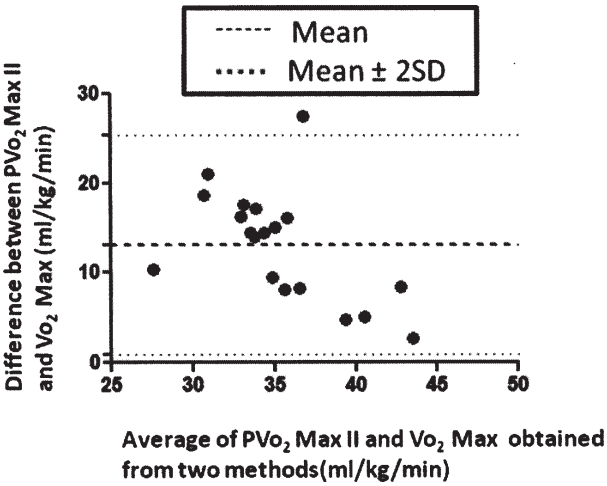

Fig. 2 : Plotting of difference between the VO_2max values estimated by vacumed and VO_2max predicted values based on equation by Wasserman (PVO_2max II) against their means.

The mean value of VO_2max measured by direct method also did not have any significant correlation with VO_2max evaluated by prediction equation by Jones et al (7) based on physical parameters (r=0.034) or ergometer exercise based prediction equations by Hansen et al (8). The prediction equations by Jones et al (7) and Hansen et al (8) are also based on data derived from western population.

DISCUSSION

The values of VO_2max directly measured by exercise testing in our subjects is much lower as compared to VO_2max predicted by equation based on recovery heart rate in Queen's step test (PVO_2max I) and also the VO_2max predicted by the Vista MX system by Vacumed derived from Wasserman

equation based on anthropometric parameters (PVO_2max II).

The mean value of VO_2max measured by direct method also did not have any significant correlation with VO_2max evaluated by prediction equation by Jones et al (7) based on physical parameters (r=0.034) or ergometer exercise based prediction equations by Hansen et al (8). The values of VO_2max directly measured by exercise testing in our subjects is much lower as compared to VO_2max predicted by equation based on recovery heart rate in Queen's step test (PVO_2max I) and also the VO_2max predicted by the Vista MX system by Vacumed derived from Wasserman equation based on anthropometric parameters (PVO_2max II). The low values of directly measured VO_2max indicate that the studied population has lower aerobic capacity and poor physical fitness with respect to population from other countries for comparable height, weight and age (9-13). Similar observations were made by Chatterjee and Bandhopadyay who measured the VO_2max in the Kolkata and Uttar Pradesh (14).

The values of directly measured VO_2max showed no significant correlation either with the estimated VO_2max with QCST or with VO_2max predicted by Wasserman equation. Bland and Altman's method of limit of agreement approach, revealed that the bias between the directly measured VO_2max and VO_2max estimated by other two methods is not systematic (large range of limit of agreement, Fig. 1, 2). This large range of limit agreement precludes application of VO_2max by QCST and Wasserman equation to sedentary population under study. The lower values obtained by direct method could have been due to the difference in the actual physical abilities of the subjects. No correlations could be found between the directly measured VO_2max with other equation based methods viz. Jones et al (7) (r=0.034) or ergometer exercise based prediction equations (r=0.03) (8).

We agree with the conclusion drawn by similar reports that had questioned the validity of the recovery heart based nomogram. We have not attempted to develop new equation given the small sample size. The present study substantiates the earlier reports that there is an urgent need to develop nomogram for Indian population, may be even for different ethnic sub-population in the country.

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