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VALIDITY OF 20 METER MULTI-STAGE SHUTTLE RUN TEST FOR ESTIMATION OF MAXIMUM OXYGEN UPTAKE IN MALE UNIVERSITY STUDENTS

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Abstract : Direct estimation of cardiorespiratory fitness in terms of VO_2max is restricted within well equipped laboratory. Eighty four (84) sedentary male university students (Age 22.77±1.73 years, Body height 167.73±4.07 cm and Body mass 58.25±4.02 kg) of same socio-economic background were recruited from students of University of Calcutta, Kolkata, India to validate the applicability of 20 meter shuttle run test (SRT) for indirect estimation of VO_2max in young male sedentary university students of Kolkata, India. They were further asigned to "study group" (N=54) on which the existing experimental protocol of SRT was tested and "confirmatory group" (N=30) on which the modified equations were validated. VO_2max of each participant was determined by direct procedure and indirect SRT method with a gap of four days in between the tests. The difference between the mean values of directly measured VO_2max and indirectly predicted VO_2max (PVO_2max) in the "study group" was statistically significant (P<0.001). Limit of agreement analysis revealed poor confidence level for application of current method of SRT in the studied population. VO_2max was significantly correlated with age (r=0.70, P<0.001), body mass (r=0.64, P<0.001), body height (r=0.58, P<0.001), speed (r=0.94, P<0.001) and PVO_2max (r=0.89, P<0.001). Modified norms in the form of simple and multiple regression equations have been computed. Our results suggest that SRT in its original form cannot be applied in the young males of Kolkata, India, due to its poor agreement with the direct method but is applicable with the modified equations. The SEE of these currently proposed norms arc substantially small enough to recommend the modified equations in the studied population to evaluate VO_2max.

Key words : indian males, sedentary, shuttle run test, VO_2max

INTRODUCTION

Determination of cardiorespiratory fitness in terms of maximum oxygen uptake (VO_2max) is restricted within the laboratory because of its exhausting, laborious,

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complicated and expensive experimental protocol. The direct estimation of VO_2max is often hazardous regardless of the type of ergometer used (1). It is therefore desirable to find simple procedure for evaluation of VO_2max in large number of population, especially in the field and in absence of well equipped laboratory (1–4). Among various indirect protocols (1–6) 20 meter multi-stage shuttle run test (SRT) is globally very popular one and has been widely used in different studies (7–11). Application of such indirect test needs proper validation in the particular population. Suminski et al. (12), Cooper et al. (13) and Chatterjee et al. (14) have studied the validity of SRT in different populations, but authentic validity of SRT with population-specific simple and multiple regression norms in male university students of West Bengal, India is unavailable. Therefore, the present study was aimed to assess the suitability for application of SRT to predict VO_2max in sedentary male university students of West Bengal, India and also to recommend valid norms not only in the form of simple regression equation, but also in the form of multiple regression equations in the studied population.

MATERIAL AND METHODS

Study population

Eighty four (84) apparently healthy sedentary male students of same socio-economic background having mean age, body height and body mass of 22.77±1.73 years, 167.73±4.07 cm and 58.25±4.02 kg, respectively were selected for the study by random sampling from the post-graduate section of the University of Calcutta, Kolkata, West Bengal, India. They were randomly separated into study group (N=54) on which the existing experimental protocol of SRT (5) was tested and confirmatory group (N=30) on which the modified equations were validated. The entire experimental protocol was well explained to all the participants to allay apprehension. 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.

The whole experiment was performed at a room temperature varying from 26–29°C and at a relative humidity ranging between 72 to 83%. Written informed consent was taken from all the subjects and human ethical committee of the Department of Physiology, University of Calcutta provided necessary approval to conduct the study.

Study design

Maximum oxygen uptake (VO_2max) of each subject was determined by both indirect SRT method and direct method, respectively, at an interval of 4 days by random sequencing or cross-over design in which direct procedure was followed by indirect one in half of the subjects whereas the indirect one was followed by direct in 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 (15, 16).

Prediction of maximum oxygen uptake capacity (PVO_2max) by SRT (5)

Subjects ran back and forth on a 20

meter course and must touched the line marked as "20 meter" at an initial speed of 8.5 $km.hr^{-1}$. The speed of the shuttle runs got progressively increased at the rate of 0.5 $km.hr^{-1}$ every minute, as dictated by the frequency of adjusted "beep" sound signal from a pre-recorded audio tape. Several shuttle runs made up each stage, and subjects were instructed to keep running pace with the sound signal for as long as possible. The last stage of the running pace was determined when subjects could no longer follow the pace. The last stage number announced by the pre-recorded audio tape was used to predict the PVO_2max from the equation : $Y = 31.025 + 3.238X - 3.248A + 0.1536AX$ [where X = speed ($km.h^{-1}$) calculated corresponding to the stage : Speed = 8+0.5 stage No., A = age (year)]

Direct measurement of maximum oxygen uptake capacity (VO_2max)

Muller's magnetic brake bicycle ergometer (Model of Max Plank Institute of Ergology, Germany) was used for the study. All the subjects performed warm up exercise at submaximal intensity of 75 watt for 5 minutes. Immediately after performing the warm up, the intensity was increased to the first incremental intensity of 155 watt and thereafter the intensity was increased by 25 watt every 3 min until the subject stopped due to exhaustion. In the present study, the oxygen uptake was considered maximum when peak heart rate was greater than 180 $beats.min^{-1}$ and also by 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 (16).

Low resistance high velocity Collin's Triple "J Type" plastic valve was used for the collection of expired gas by open circuit method (15, 16). The valve was connected with the Douglas Bag (150 L) and the expired gas was collected at the last minute of final intensity of exercise. Gas was also collected at the second minute of the exhausting (final) work load if signs of severe exhaustion supervened. No gas collection was made in the first minute 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 (17). The peak heart rate was recorded manually from the time taken for 10 carotid pulsations immediately following the cessation of exhaustive exercise (15, 16).

Statistical analysis

Paired t-test, correlation statistic, simple and multiple linear regression statistics and Bland and Altman approach for limit of agreement analysis (18) were adopted for statistical analysis of the data.

RESULTS

The mean value of PVO_2max (35.35±4.90 $ml.kg^{-1}.min^{-1}$) showed significant difference ($P<0.001$) with VO_2max (39.80±4.06 $ml.kg^{-1}min^{-1}$) in the study group. Analysis of data by Bland and Altman (18) method of limit of agreement revealed that the limits of agreement between PVO_2max and VO_2max were large enough (0.09 to 9.30 $ml.kg^{-1}.min^{-1}$) with poor confidence intervals (Fig. 1), indicating inapplicability of the existing protocol of SRT (Leger 1988) in this

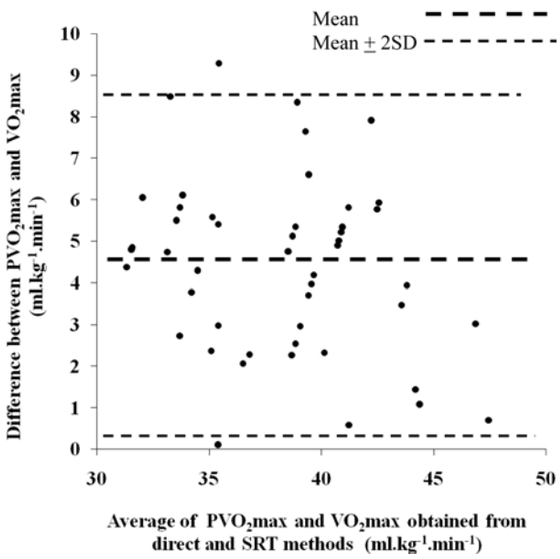

Fig. 1: Plotting of difference between PVO_2max and VO_2max values against their means.

particular population. Moreover, significant (P<0.001) difference between PVO_2max and VO_2max indicated that it would not be justified to accept the prediction of maximum oxygen uptake in the studied population by applying the original existing protocol of SRT (5).

VO_2max was significantly correlated with age (r = 0.70, P<0.001), body mass (r = 0.64, P<0.001), body height (r = 0.58, P<0.001), speed (r = 0.94, P<0.001) and PVO_2max (r = 0.89, P<0.001) in the present study. On the basis of such significant correlations, prediction norms for VO_2max have been computed in the form of simple and multiple regression equations (Table I) for accurate and reliable assessment of VO_2max by using this 20 meter multi stage shuttle run test in the young males of Kolkata, India.

DISCUSSION

The present finding is contradictory to the observation of Chatterjee et al (14). Their study revealed insignificant difference between the directly measured and indirectly predicted values of VO_2max. They validated the SRT in male university students of West Bengal, India, and found insignificant difference between the directly measured and indirectly predicted values of VO_2max. Such contradiction with the present study might be due to the lower sample size (N=31) in the study of Chatterjee et al. (14) that recruited a pooled population from three different Universities of West Bengal, India. Their study delimited the subjects to all over the subcontinent of India, in respect of which a sample size of 31 was substantially small. Moreover, validity of such norm, should be more population specific (rather than to a pooled population) as attempted in the present investigation. Earlier studies in the relevant field (14, 16, 19, 20) also found

TABLE I: Simple and multiple regression norms for accurate assessment of maximum oxygen uptake from 20 meter multi stage shuttle run test in young males of Kolkata, India.

The simple regression norm is:	
1. VO_2max (ml.kg^{-1}min^{-1}) = 3.89776 × Speed – 5.39463	[r=0.94, P<0.001, SEE=1.4112 ml.kg^{-1}.min^{-1}]
The multiple Regression norms are:	
2. VO_2max (ml.kg^{-1}.min^{-1}) = 3.93 × Speed – 0.027 × Age – 5.17	[R=0.93, R^2=0.87, P<0.001, SEE=1.4917 ml.kg^{-1}min^{-1}]
3. VO_2max (ml.kg^{-1}.min^{-1}) = 3.96 × Speed – 0.035 × BM – 4.097	[R=0.94, R^2=0.88, P<0.001, SEE=1.3828 ml.kg^{-1}.min^{-1}]
4. VO_2max (ml.kg^{-1}.min^{-1}) = 4.14 × Speed – 0.089 × BH + 6.704	[R=0.94, R^2=0.88, P<0.001, SEE=1.3828 ml.kg^{-1}.min^{-1}]

BM = Body mass, BH = Body height, SEE = standard error of estimate.

significant difference between the directly measured and indirectly predicted values of VO_2max as also depicted in the current investigation. Chatterjee et al. (14) provided only a simple regression equation and no multiple regression norm was proposed in their study.

The values of correlation coefficients (r and R) are highly significant (P<0.001) in the present study. In multiple correlations highest value of correlation coefficient was obtained when VO_2max was correlated with speed and height as well as with speed and body mass (R=0.94, R^2=0.884, P<0.001). The standard errors of estimate (SEE) of all the regression norms are substantially small (Table I).

Application of the newly derived equations (Table I) in the confirmatory group revealed insignificant difference (P>0.05) between PVO_2max (38.73±3.70 ml.kg^{-1}.min^{-1}, 38.56±3.17 ml.kg^{-1}.min^{-1}, 38.94±4.77 ml.kg^{-1}.min^{-1} and 39.12±4.63 ml.kg^{-1}.min^{-1} calculated from equations 1, 2, 3 and 4, respectively) and VO_2max (39.27±4.55 ml.kg^{-1}.min^{-1}). Prediction of VO_2max from these equations showed a variation of less than 5% in 61 participants, 5–9% in 16 participants, 10–14% in 4 individuals and 15–19% in 3 participants from their respective directly measured value of VO_2max. Furthermore, the values of SEE of the currently proposed regression norms were also substantially small and well comparable with previous studies that validated other indirect norms for prediction of VO_2max.

From the present investigation it may be concluded that the existing norm of SRT for prediction of VO_2max is not suitable for application in the studied population. However, the presently derived or modified regression norms would predict VO_2max more accurately and therefore these equations are recommended for application of 20 meter multi-stage shuttle run test as a valid method to evaluate the cardiorespiratory fitness in terms of VO_2max in sedentary male university students of Kolkata, West Bengal, India.

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