Indian J Physiol Pharmacol 2013; 57(1) : 77–83

*SHORT COMMUNICATION*

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

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**( Received on November 21, 2011 )**

**Abstract :** Indirect protocols for determination of cardiorespiratory fitness in terms of $VO_2$max have been developed to avoid the complicated experimental protocol of direct $VO_2$max estimation especially in clinical setting. 20-meter multi stage shuttle run test (SRT) is one of such indirect protocols developed in Western population. Eighty eight (88) sedentary young healthy female university students (Age 22.8±1.79 years, Body height 159.0±4.28 cm and Body mass 52.47±4.17 kg) of same socio-economic background were recruited in the study by simple random sampling from University of Calcutta, Kolkata, India to validate the applicability of SRT in the studied population. They were randomly separated into "study group" (N=58) on which the existing experimental protocol of SRT was tested and "confirmatory group" (N=30) on which the modified equations were validated. $VO_2$max of each participant was determined by direct procedure and indirect SRT method. The difference between the mean values of directly measured $VO_2$max and indirectly predicted $VO_2$max ($PVO_2$max) 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. However, $VO_2$max was significantly correlated with age ($r = 0.71$, $P<0.001$), body mass ($r = 0.58$, $P<0.001$), body height ($r = 0.55$, $P<0.001$), speed ($r = 0.92$, $P<0.001$) and $PVO_2$max ($r = 0.89$, $P<0.001$). Modified norms in the form of simple and multiple regression equations were applied in the Confirmatory Group. Results suggested a good agreement of the modified equations of SRT in this population with substantially small SEE. Hence, the currently proposed modified norms are recommended to predict $VO_2$max in the studied population.

**Key words :** Indian females shuttle run test sedentary $VO_2$max

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## INTRODUCTION

Determination of cardiorespiratory fitness in terms of maximum oxygen uptake ($VO_2$max) is restricted within the laboratory because of its exhausting, labourious, complicated and expensive experimental protocol. In spite of immense clinical and physiological importance of the parameter, the direct estimation of $VO_2$max is often hazardous regardless of the type of ergo meter used (1). It is therefore desirable to find simple procedure for evaluation of $VO_2$max especially in clinical settings where large number of subjects is to be evaluated either in the field or 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 the SRT with population specific simple and multiple regression norms in female University students of Kolkata, India is unavailable.

Therefore, the present study was aimed to

i) Assess the suitability for application of 20-m multi stage shuttle run test to predict $VO_2$max in sedentary female university students of Kolkata, India.

ii) Valid norms not only in the form of simple regression equation but also in the form of multiple regression equations in the studied population.

## MATERIALS AND METHODS

**Study population**

Eighty eight (88) healthy sedentary female students of same socio-economic background having mean age, body height and body mass of 22.8±1.79 years, 159.0±4.28 cm and 52.47±4.17 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=58) 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 28-31°C and at a relative humidity ranging between 64 to 75%. 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.

**Experimental design :**

Maximum oxygen uptake ($VO_2$max) 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 the direct one 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 (15–17).

*Prediction of maximum oxygen uptake capacity ($PVO_2max$) by SRT* (5, 6)*:*

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 audiotape was used to predict the $PVO_2max$ from the following equation:

$$Y = 31.025 + 3.238\ X - 3.248A + 0.1536AX$$

[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 a submaximal intensity of 50 watt for 5 minutes. Immediately after performing the warm up, the intensity was increased to the first incremental intensity of 100 watt and thereafter the intensity was increased by 20 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 (15, 17).

Low resistance high velocity Collin's Triple "J Type" plastic valve was used for the collection of expired gas by open circuit method (15–17). 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) workload if signs of severe exhaustion supervened. No gas collection was made in the first minute of the workload. 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 (18). The peak heart rate was recorded manually from the time taken for 10 carotid pulsations immediately following the cessation of exhaustive exercise (16, 17).

**Statistical analysis:**

Paired t-test, correlation and linear regression statistics and Bland and Altman

approach for limit of agreement (19) were adopted for statistical analysis of the data.

## RESULTS AND DISCUSSION

Mean vales of age, body height, body mass, body mass index (BMI), $VO_2$max and $PVO_2$max have been tabulated in Table I. Insignificant difference was depicted in all the parameters except the mean value of $PVO_2$max that showed significant difference ($P<0.001$) with $VO_2$max in the study group. Analysis of data by Bland and Altman (19) method of limit of agreement revealed that the limits of agreement between $PVO_2$max and $VO_2$max were large enough (0.135 to 10.12 $ml.kg^{-1}.min^{-1}$) with poor confidence intervals (Fig I), indicating inapplicability of the existing protocol of SRT (Leger et al. 1988) in this particular population. Moreover,

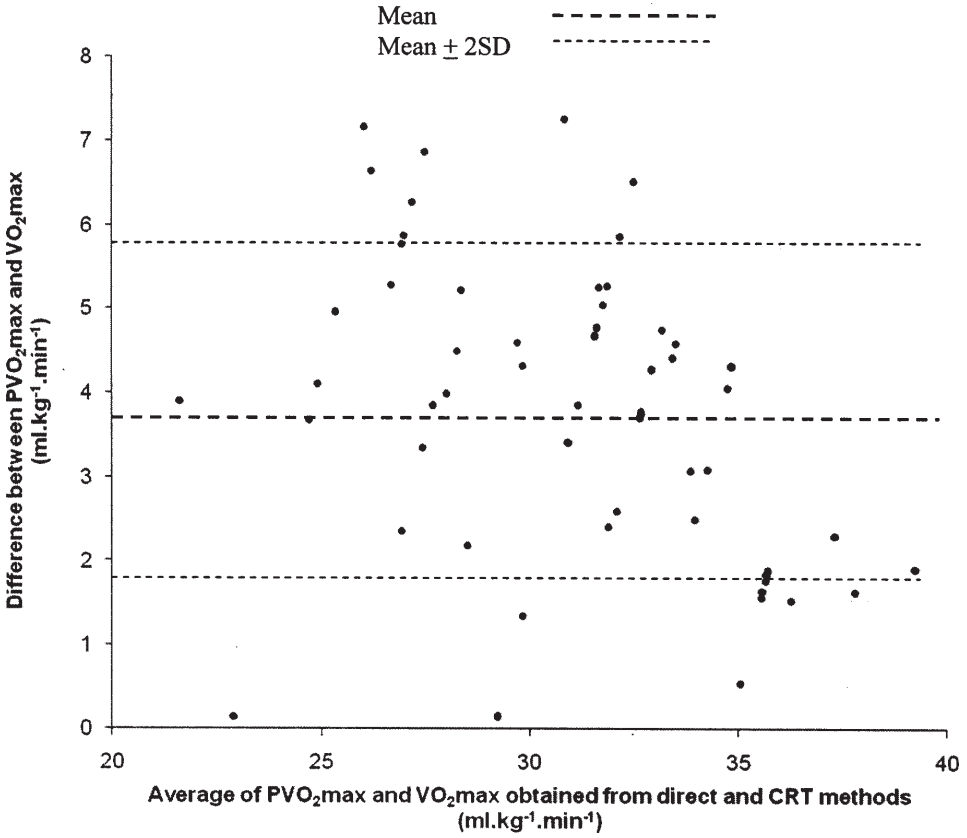


Fig. 1: Plotting of difference between $PVO_2$max and $VO_2$max values against their means.

TABLE I: Physical and physiological parameters of the subjects.

| *Category* | *Age (yrs)* | *Body height (cm)* | *Body mass (kg)* | *$VO_2$max ($ml.kg^{-1}.min^{-1}$)* | *$PVO_2$max* |
|---|---|---|---|---|---|
| Study Group (N=58) | 22.83±1.79 | 159.20±4.28 | 52.48±4.17 | 32.82±3.67 | 29.03±4.26* |
| Confirmatory Group (N=30) | 22.74±1.64 | 160.03±4.39 | 51.89±3.86 | 32.48±3.17 | 32.1±2.95 |

Data are expressed as mean±SD. *$P<0.001$ when compared with $VO_2$max in the same group.

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).

The present finding is contradictory to the observation of Chatterjee et al. (14). Their indirectly predicted $VO_2max$ value (32.6±3.4 $ml.kg^{-1}.min^{-1}$) was significantly (P<0.001) higher than the present observation (29.03±4.26 $ml.kg^{-1}.min^{-1}$). They validated the SRT in female 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=32) 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 32 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, 17, 20, and 21) also found 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 postulated.

$VO_2max$ was significantly correlated with age (r = 0.71, P<0.001), body mass (r = 0.58, P<0.001), body height (r = 0.55, P<0.001), speed (r = 0.92, 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 II) for accurate and reliable assessment of $VO_2max$ by using this 20-meter multi stage shuttle run test in the young females of Kolkata, India.

The values of correlation coefficients (r and R) are highly significant (P<0.001) in the present study. In multiple correlation statistics highest value of correlation coefficient was obtained when $VO_2max$ was correlated with speed and height (R=0.94, $R^2$=0.88, P<0.001). The standard errors of estimate (SEE) of all the regression norms are substantially small (Table II). However, the regression norm that predicts $VO_2max$ from height and speed, exhibited the lowest value of SEE among all the regression norms.

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

| | |
|---|---|
| ***The simple regression norm is:*** | |
| 1. $VO_2max$ ($ml.kg^{-1}.min^{-1}$) = 3.538 × Speed – 4.9137 | [r=0.92, P<0.001, SEE=1.373 $ml.kg^{-1}.min^{-1}$] |
| ***The multiple Regression norms are:*** | |
| 2. $VO_2max$ ($ml.kg^{-1}.min^{-1}$) = 4.406 × Speed – 0.5417 × Age – 1.781 | [R=0.93, $R^2$=0.87, P<0.001, SEE=1.373 $ml.kg^{-1}.min^{-1}$] |
| 3. $VO_2max$ ($ml.kg^{-1}.min^{-1}$) = 4.2827 × Speed – 0.2213 × BM – 1.222 | [R=0.93, $R^2$=0.87, P<0.001, SEE=1.373 $ml.kg^{-1}.min^{-1}$] |
| 4. $VO_2max$ ($ml.kg^{-1}.min^{-1}$) = 4.261 × Speed – 0.218 × BH + 22.103 | [R=0.94, $R^2$=0.88, P<0.001, SEE=1.271 $ml.kg^{-1}.min^{-1}$] |

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

Application of the newly derived equations (Table I) in the confirmatory group revealed insignificant difference (P>0.05) between $PVO_2max$ (32.1±2.95 $ml.kg^{-1}.min^{-1}$, 32.48±3.17 $ml.kg^{-1}.min^{-1}$, 32.35±2.77 $ml.kg^{-1}.min^{-1}$ and 32.46±2.63 $ml.kg^{-1}.min^{-1}$ calculated from equations 1, 2, 3 and 4, respectively) and $VO_2max$ (32.66±3.33 $ml.kg^{-1}.min^{-1}$). Prediction of $VO_2max$ from these equations showed a variation of less than 5% in 62 participants, 5–9% in 17 participants, 10–14% in 5 individuals and 15–19% in 4 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.

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 female university students of Kolkata, West Bengal, India.

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