Regression Equations to Predict VO_2 Max in Untrained Boys and Junior Sprinters of Kolkata

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Abstract

The purpose of the study was to validate the applicability of the 20-m multi stage shuttle run test (20-m MST) in untrained boys and junior sprinters of Kolkata, India. 35 sedentary boys from different schools and 25 sprinters from different sports academies (age range 13 ~ 16 yr.) were recruited for the study. Direct estimation of VO_2 max comprised treadmill exercise followed by expired gas analysis by scholander micro-gas analyzer whereas VO_2 max was indirectly predicted by 20-m MST. In case of sedentary boys, the difference between the mean (+/- SD) VO_2 max values of direct measurement (VO_2 max = 42.99 +/- 5.16 ml/kg/min) and 20-m multi stage shuttle run test ($SPVO_2$ max = 42.69 +/- 5.06 ml/kg/min) was statistically significant ($p<0.01$). In case of sprinters, the difference between the mean (+/-SD) VO_2 max values of direct measurement (VO_2 max =52.31 +/- 3.04 ml/kg/min) and 20-m multi stage shuttle run test ($SPVO_2$ max = 51.97 +/- 2.92 ml/kg/min) was also statistically significant ($p<0.01$). Although, for both the cases of sedentary boys and junior sprinters, limits of agreement analysis suggest that 20-m MST may be applied in the studied populations for estimation of maximum oxygen uptake. For better prediction of VO_2 max in the studied populations, new equations have been computed based on present data.

Key Words: VO_2max, Aerobic capacity, Cardiorespratory fitness, Beep test, Sprinters, Sedentary

Introduction

Maximum oxygen uptake (VO_2 max), when directly determined after exercise involving a sufficient number of muscle group, is considered as a good index of physical fitness of an individual (*Astrand and Rodahl, 1970*). But the test of direct measurement of VO_2 max is difficult, exhausting and often hazardous to perform regardless the type of ergometer used (*Fox, 1973*). This is why scientists often perform this test in indirect protocols to predict VO_2 max (*Das & Bhattacharya, 1995*). But before applying any indirect protocol for the prediction of VO_2 max, the validity of the test should be established in particular population to be assessed. The 20-meter multistage shuttle run test (*Leger et al, 1988, Leger & Gadoury, 1989*), popularly known as Beep test, is often used world wide for measurement of aerobic capacity (*Wong et al, 2001; Mota et al, 2002; Guerra et al, 2002; Vicente-Rodriguez et al, 2003, Vicente-Rodriguez et al, 2004*). *Cooper et al (2005)* studied the repeatability and criterion related validity of the 20-m multistage fitness test as a predictor of maximal oxygen uptake in active young men. *Suminski et al, (2004)* established the validity of the 20-m MST for measuring aerobic fitness of Hispanic youth of 10 to 12 years of age. However, studies on the validity and suitability of this test are scanty in India (*Chatterjee et al, 2005*) and it has not been undertaken in an organized way for different Indian populations.

Recent study has indicated that there are sport-specific differences when predicting VO_2 max from the multistage

shuttle run test (*Gibson et al, 1998*). In another recent study by *Cetin et al. (2005)* on Taekwondo athletes, the authors conclude that Maximal oxygen consumption (VO_2 max) can be predicted from shuttle run test scores, but not as indicated with the test package. In order to obtain the true score one must apply a regression equation. Keeping in view, all these aspects, we wanted to examine the applicability of the 20-m MST to predict VO_2 max in untrained boys and junior sprinters of Kolkata, India.

Materials and Methods

Subjects: 35 untrained boys from different schools of Kolkata and 25 sprinters from different sports academies of Kolkata volunteered for this study. The physical characteristics of the subjects are shown in table 1 and table 2. All the sprinters have a training background of 2-3 years. All the subjects signed a statement of informed consent. All institutional policies concerning the human subjects in research were followed. An approval from competent local ethics committee was taken.

Experimental Design: Maximum oxygen consumption of each subject was determined in a random counter-balanced order by both indirect and direct methods at an interval of 4 days. Subjects were asked to take complete rest at least for half an hour prior to the exercise, so that pulmonary ventilation and pulse rate might come down to steady state. They had a light breakfast 2 - 3 hours before the test and refrained from any energetic physical activity for that period.

Prediction of maximum Oxygen uptake capacity by 20-m MST: Subjects started running back and forth a 20 m course and must touched the 20 m line. The initial speed was 8.5 km/h which got progressively faster (0.5 km/h. every minute), in accordance with a pace dictated by a sound signal on an audiotape. Several shuttle runs made up each stage, and subjects were instructed to keep pace with the signal for as long as possible. When the subjects could no longer follow the pace, the last stage announced was used to predict maximal oxygen uptake using the equation of *Leger et al (1988)*.

Direct measurement of maximum oxygen uptake capacity: The subjects walked on a treadmill to warm up at a speed of 4 km/h at a 4.5 inclination for duration of 5-min. Running at a constant speed of 7 km/h. for a maximum duration of 5 min followed this. The gradient was increased successively from 4.5 until the subject was unable to continue the task. In no case did it exceed 7.5 inclinations. The criteria for maximality was exhaustion and withdrawal from running within the scheduled 5 min period, when the heart rate was about their predicted maximum heart rate and when a further increase of inclination did not bring about any significant rise in oxygen uptake.

Gas Analysis: Low resistance high velocity Collin's Triple "J type" plastic valve was used for the collection of gas by open circuit method. The valve was connected with the Douglas bag (150-liter) and the expired gas was collected in 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 expired gas measured in a wet gasometer (Toshniwal, Germany CAT No. C G 05.10) and the aliquots of gas samples were analyzed in

a Scholander micro gas analysis apparatus (India) following the standard procedure *(Consolazio et al, 1963).*

Validity of the results: Repeatability was investigated where 22 subjects performed the test (20-m MST) twice. The results showed non-significant bias between the two applications of the 20-m MST (mean of the difference +/- standard deviation of the difference = -0.1+/-1.0 ml /kg/min; t = -0.48 p = 0.73 with 95% limits of agreement).

Statistical Analysis: Paired t-test, Pearson's product moment correlation, linear regression statistics and Bland and Altman approach for limit of agreement were adopted for statistical analysis of the data. Statistical Package for Social Sciences (SPSS) MS windows Release 11.5 was used for statistical analysis.

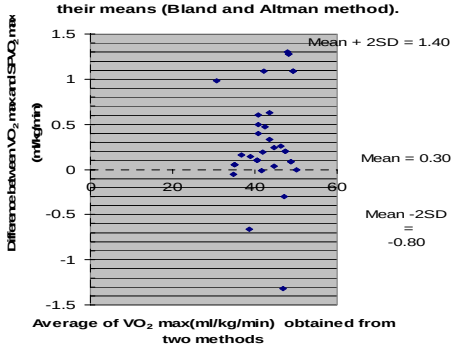
Results and Discussion:

Table 1. Physical parameters, predicted and measured VO_2 max of the untrained boys (n=35)

Parameters	Min	Max	Mean	SD
Age (yr.)	14.0	16.0	15.23	0.69
Height (cm)	150	175	162.22	5.68
Weight (kg)	32.0	71.0	46.93	9.00
VO_2max (kg/ml/min)	31.30	50.30	42.99	5.16
$SPVO_2$max (kg/ml/min)	30.32	50.25	42.69	5.06
Maximal Shuttle run Speed (km/h)	9.0	12.5	10.95	0.92

Means and standard deviations of physical characteristics, shuttle predicted VO_2 max ($SPVO_2$ max) by 20-m multi stage shuttle run test and directly measured VO_2 max of the untrained boys and junior sprinters are presented in the table 1 and table 2 respectively. For untrained boys the mean value of the VO_2 max determined by direct method was 42.99 +/- 5.16 ml/kg/min (range 31.30~50.30 ml/kg/min). The mean value of the predicted VO_2 max by 20-m MST was 42.69 +/- 5.06 ml/kg/min (range 30.32~50.25 ml/kg/min). These two values showed significant variation ($p<0.01$). The mean difference between VO_2 max and predicted VO_2 ($SPVO_2$max) max was 0.30 ml/kg/min with 95% confidence interval -0.49 to -0.11 ml/kg/min indicating that 20-m MST predict the maximum oxygen uptake capacity within the range of -0.49 to -0.11ml/kg/min.

Figure 1: Sedentary Boys: Plotting of difference between VO_2max values against their means (Bland and Altman method).



Analysis of data by *Bland and Altman (1986)* method of approach for limits of agreement between VO_2 max and predicted VO_2 max ($SPVO_2$max) reveals that limits of agreement are 1.40 and -0.80. These are small enough parameter for 20-m MST to be used confidently in place of direct procedure, and from Bland & Altman analysis it is indicated that 20 meter MST may be used within the sedentary boys' population of Kolkata. But significant difference ($p<0.01$) between VO_2 max and shuttle predicted VO_2 max ($SPVO_2$ max), indicated that it would not be justified to accept the prediction of maximum oxygen uptake as an equivalent to the direct value in the studied population in its existing form. For obtaining a better score, a regression equation should be computed. Highly significant correlation (r =0.97, p

< 0.01) existed between the maximal speed of the 20-m MST and VO_2max measured by direct method. The following equation, derived on the basis of present data will better predict the aerobic fitness in untrained boys.

$$Y= 5.77 + 5.66X -1.63A$$

Where

Y= VO_2max (ml/kg/min)
X= Maximal shuttle run speed (km/h)
A= Age (yr.)

Figure 2: Sprinters: Plotting of difference between VO_2 max values against their means (Bland and Altman method)

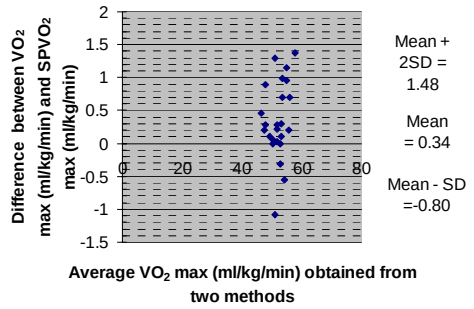


Table 2. Physical parameters, predicted and measured VO_2 max of the junior sprinters (n=25)

Parameters	Min	Max	Mean	SD
Age (yr.)	13.0	16.0	14.80	0.95
Height (cm)	143.5	172.5	158.50	7.80
Weight (kg)	29.50	54.00	43.04	6.49
VO_2max (kg/ml/min)	46.50	58.50	52.31	3.04
SPVO_2max (kg/ml/min)	46.00	57.10	51.97	2.92
Maximal Shuttle run Speed (km/h)	12	14	12.52	0.54

For the junior sprinters, the mean value of the VO_2 max determined by direct method was 52.31 +/- 3.04 ml/kg/min (range 46.50 ~ 58.50 ml/kg/min). The mean value of the predicted VO_2 max by 20-m MST was 51.97 +/- 2.92 ml/kg/min (range 46.00 ~57.10 ml/kg/min). These two values showed significant variation ($p<0.01$). The mean difference between VO_2 max and predicted VO_2 (SPVO_2max) max was 0.34 ml/kg/min with 95% confidence interval -0.57 to -0.10 ml/kg/min indicating that 20-m MST predict the maximum oxygen uptake capacity within the range of -0.57 to - 0.10 ml/kg/min.

Analysis of data by *Bland and Altman (1986)* method of approach for limits of agreement between VO_2 max and predicted VO_2 max (SPVO_2max) reveals that limits of agreement are 1.48 and -0.80. These are small enough parameter for 20-m MST to be used confidently in place of direct procedure, and from Bland & Altman analysis it is indicated that 20 meter MST may be used within the junior sprinters population of Kolkata. But as there is significant difference ($p<0.01$) between directly measured (VO_2 max) and shuttle predicted VO2 max (SPVO_2 max), it is concluded that 20 meter MST can be applied for the studied population but not in its present form. For more accurate and reliable assessment of VO_2 max in junior sprinters, a regression equation should be computed.

Highly significant correlation ($r = 0.89$, $p < 0.01$) existed between the maximal speed of the 20-m MST and VO_2max measured by direct method. The following equation, derived on the basis of current data will better predict the aerobic fitness in junior sprinters of Kolkata, India.

$$Y= 2.36 + 5.62X -1.38 A$$

Where

Y= VO_2max (ml/kg/min)
X= Maximal shuttle run speed (km/h)
A= Age (yr.)

Conclusions

Therefore, from the present observations it is concluded that the 20-m multistage shuttle run test is recommended as a valid method to evaluate aerobic fitness in terms of VO_2max within the untrained boys and junior sprinters (age 13~16 yr.) of Kolkata, India. For better prediction of VO_2max in the studied populations we recommend the equations developed on the basis of the present data.

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