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Original Article

Validity of 20 meter multi stage shuttle run test for prediction of maximum oxygen uptake in Indian female university students

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Abstract

Background: The 20-meter multi stage shuttle run test (20-m MST) has not yet been used by Indian scientists and validity of the test has not been studied for use with any of the Indian population.

Aims: The purpose of this study was to validate the applicability of the 20-m MST in Indian adult female.

Materials and methods: For application of direct method cross over design was followed. For validity of the results repeatability was used. Methods and Material: 32 female university students (age range 20.4 ~24.8 years) from three different universities of West Bengal, India 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 the 20-m MST.

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.

Results: The difference between the mean (SD) VO_2 max values of direct measurement (VO_2 max = 32.84 ± 2.92 ml/kg/min) and the 20-m MST ($SPVO_2$ max = 32.60 ± 3.40 ml/kg/min) was statistically insignificant ($p>0.10$). Limits of agreement analysis also suggest that the 20-m MST can be applied for use with the studied population.

Conclusions: The results suggest that the application of the present form of the 20-m MST be justified in the studied population. For better prediction of VO_2 max a new equation has been computed based on present data for use with Indian female university students.

Key words: VO2 max, Cardiovascular fitness, Sedentary, Female.

Maximal aerobic capacity (VO_2 max), when directly determined during exercise involving a sufficient number of muscle group, is considered as a good index of physical fitness of an individual[1]. But the test of direct measurement of VO_2 max is difficult, exhausting and often hazardous to perform regardless of the type of ergometer used[2] .This is why scientists often perform this test using indirect protocols to predict VO_2 max[3]. Before applying any indirect protocol, the validity of the test should be established in the specific population to be assessed. The 20-m multistage shuttle run test (20-m MST)[4,5], popularly known as Beep test, is often used world wide for the measurement of aerobic capacity[6, 7, 8, 9, 10]. But in India the scientists have not yet used this test. Cooper *et al*[11] 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. The findings of their study revealed that in the population assessed it provided results that were repeatable but it underestimated VO_2 max when compared to laboratory determinations. Suminski *et al*.[12] established the validity of the 20-m MST for measuring aerobic fitness of Hispanic youth of 10 to 12 years of age. However, the validity and suitability of this test have not been studied in an Indian population until now.

Recent study suggests that gender distinct equations provide more accurate prediction of VO_2 max from 20-m multistage shuttle run test[13]. For this reason, only female adults were recruited as subjects and not the male and female-pooled population. Keeping in view, all these facts, the present study was undertaken with an objective to assess the applicability of the 20-m MST to predict VO_2 max in female university students of West Bengal, India.

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Materials and methods

Subjects: 32 female university students from University of Kalyani, University of Calcutta and University of Jadavpur volunteered for the study. The subjects had a mean age of 21.9 years, height of 157.3 cm and mass of 49.6 kg. The experimental protocol was fully explained to the participants. They had a 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 did not follow any physical-conditioning program, except for some recreational sport participation. The tests were demonstrated to the subjects before actual administration and they agreed to sign a statement of informed consent. All institutional policies concerning the human subjects in research were followed. Ethical approval from competent authority 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. This was done so as to avoid any possibility of bias. Subjects were asked to take complete rest at least for half an hour prior to each exercise test, so that pulmonary ventilation and pulse rate returned to steady state[14].

Prediction of maximum oxygen uptake capacity by the 20-m MST: Subjects started running back and forth a 20-m course and must touch the 20-m line. The initial speed was 8.5 km/h. The speed 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. The speed of the tape was checked and calibrated before the test. Depending on the speed, the distance (20m) was adjusted (like 19.3m, 20.5 m), so that running speed would be the same.

The subjects were instructed to keep pace with the signal as long as possible. When the subjects could no longer follow the pace, and could no longer reach the 20m line consecutively twice with the beep, the last stage announced was used to predict the maximal oxygen uptake using the equation of Leger *et al.*, 1989. The equation:

Y= -27.4+6.0X, Where Y= VO_2max (ml/kg/min) & X= Maximal shuttle run speed (km/h)

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 degree inclination for a duration of 5 min. (15). Running at a constant speed of 7 km/h for a maximum duration of 5 min followed this. The inclination gradient was increased successively from 4.5 until the subject was unable to continue the task. In no case did it exceed 7.5 degrees. 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 (14).

Gas analysis: Low-resistance high-velocity, Collin's Triple "J type" plastic valves were used for the collection of gas by an open circuit method (14). The valve was connected with a 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 was 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 following the standard procedure (16).

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 (17). Statistical package for Social Sciences (SPSS), MS windows Release 6.1 was used for statistical analysis.

Results

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 participants are presented in the table 1.

Reliability of the results: Repeatability was investigated where 22 subjects performed the 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 = -0.13+/- 1.9 ml /kg/min; t = -0.32 p = 0.74 with 95% limits of agreement).

Table 1: Physical parameters, predicted and measured VO_2 max of the subjects (N=32)

Parameter	Minimum	Maximum	Mean	Std. Deviation
Age (y)	20.4	24.8	21.9	1.0
Height (cm)	154.1	160.3	157.3	1.8
Mass (kg)	42	57	49.6	4.5
VO_2max (ml/kg/min)	26.9	38.0	32.8	2.9
$SPVO_2$max (ml/kg/min)	26.6	38.6	32.6	3.4
Maximal shuttle run Speed (km/h)	9.0	11.0	10.0	0.6

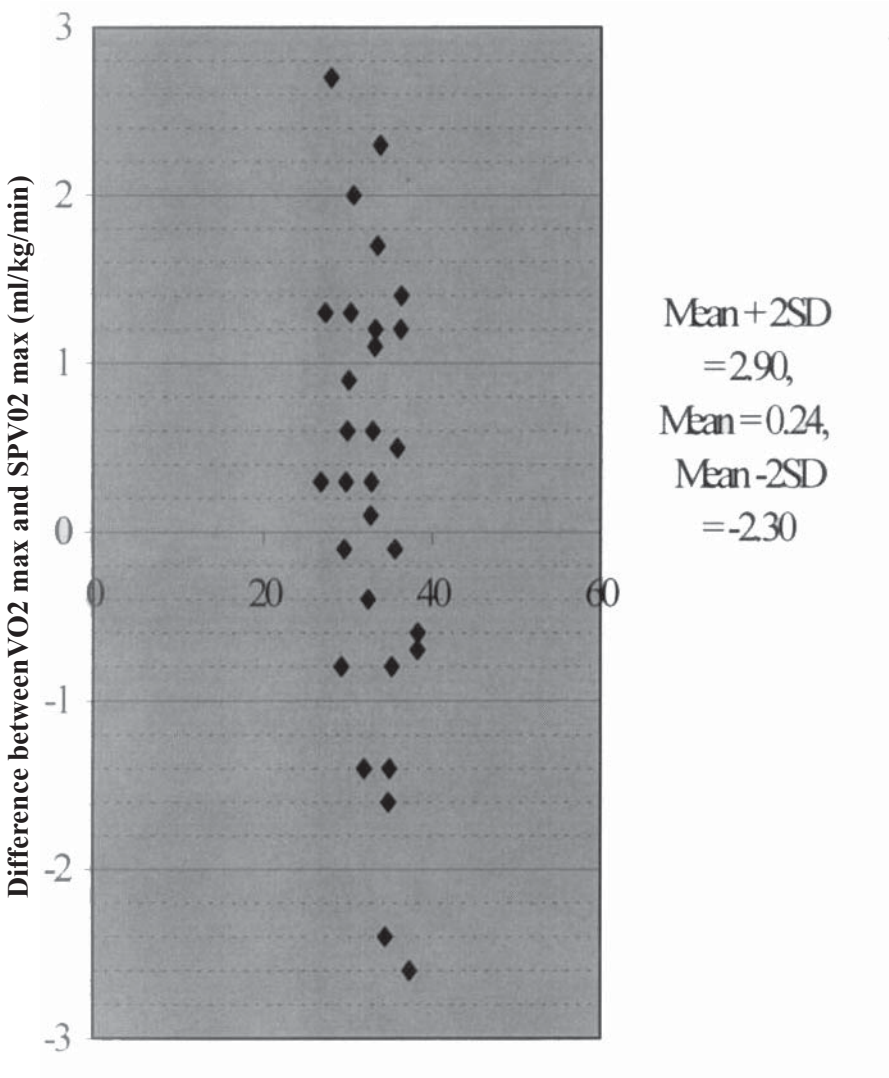

Fig 1: Plotting of difference betweenVO_2max values against their means.

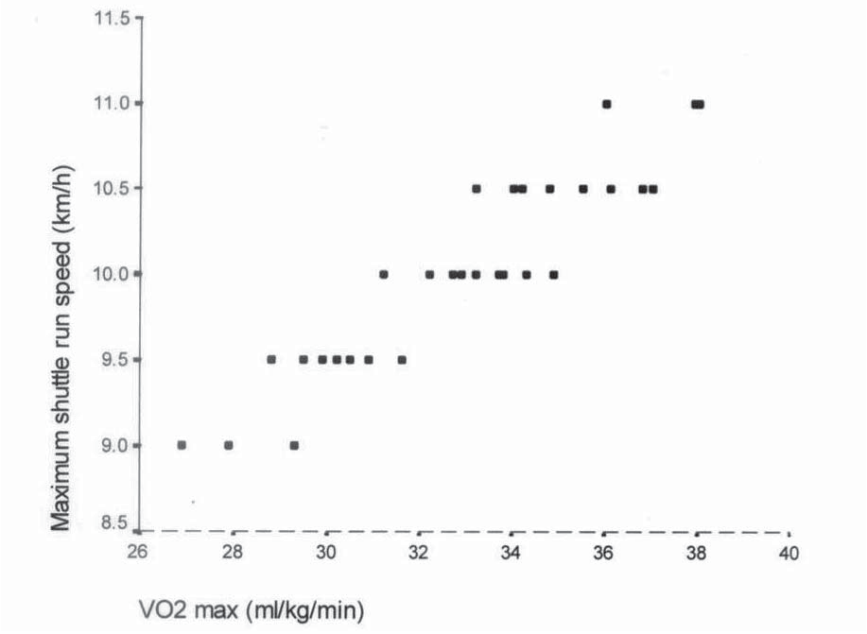

Figure 2: A Scatterplot of Maximal Shuttle Run Speed and Directly Measured VO_2 max (ml/kg/min)

Discussion

No significant variation was observed (P >0.10) between the values of directly measured VO_2 max and predicted $SPVO_2$ max. The mean difference between VO_2 max and predicted VO_2 max ($SPVO_2$max) was 0.24 ml/kg/min with 95% confidence interval (-0.22 to 0.71 ml/kg/min) indicating that 20-m MST predicted the maximum oxygen uptake capacity by -0.22 to 0.71 ml/kg/min.

Analysis of data by Bland and Altman[17] method of approach for limits of agreement between $SPVO_2$max and VO_2 max reveals that limits of agreement are –2.30 to 2.90. These are small enough parameter for the 20-m MST to be used confidently in place of direct method. Limits of agreement analysis suggest that application of the present form of the 20-m MST should be justified for the studied population.

Highly significant correlation (r =0. 93, p < 0.01) existed between the maximal speed of the 20-m MST and VO_2max. The following equation, derived on the basis of present data (r = 0.93, R2 = 0.84 and Standard Error of the Estimate (SEE) = 1.09) will better predict the aerobic fitness in female university students of West Bengal, India.

Y= -14.956 + 4.780 X, Where Y= VO_2max (ml/kg/min)

X= Maximal shuttle run speed (km/h)

Using the above new equation the limits of agreement between directly measured VO_2 max and predicted VO_2 max from the 20-m MST ($SPVO_2$ max) are -2.16 to 2.16 units. The result suggests that better limits of agreement exist between the two methods when this newly developed equation is used for prediction of VO_2 max from the 20-m MST.

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_2 max within female (age 20.4~24.8 y) adults of West Bengal, India. The equation developed on the basis of present data is recommend to be used. This is particularly most useful method when a large number of subjects are to be evaluated without the help of a well-equipped laboratory, in less expense and within a short period of time.

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