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Six-minute step test performance in asymptomatic adults

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Abstract

The objectives of this study were i) to measure a six-minute step test (6MST) in asymptomatic adults; ii) to determine the applicability of Arcuri *et al*.'s reference equation to Indian adults; iii) to develop a prediction equation for Indian adults. 110 adult males and females aged 18-40 years were recruited for this prospective cross-sectional study conducted in India. Participants underwent 6MST. Applicability was assessed by comparing the findings of the 6MST with the values derived from Arcuri *et al.*'s predicted equations using the Bland-Altman plot. A multiple regression analysis was used to develop the prediction equation. The mean±SD six-minute step count was 159.42±17.60 steps and 150.78±14.39 steps in males and females respectively. The 6MST for males can be determined by males (steps)=204.371-1.521×age(years) and females (steps)=179.567-1.06×age (years). Arcuri *et al*.'s equation cannot be used to predict 6MST in Indian adults. Region-specific equations are useful to assess the values.

Introduction

The ability to exercise plays an important role in determining quality of life and prognosis. Despite the fact that assessing exercise capacity can provide valuable information about a population's health, it is rarely employed in primary care.[1] The step climbing activity necessary in daily life is used to assess exercise ability. Step test has been used to assess functional capability for a long time, particularly in healthy people. Six-minute step test is a quick, easy, inexpensive method of measuring exercise tolerance. Also, it requires the least amount of space.[1] The six-minute step test (6MST) is extensively used in field testing and is linked to disease prediction, estimated oxygen use, and the identification of functional limitations.[2]

The six-minute step is more commonly used for pulmonary pathologies like chronic obstructive pulmonary disease, interstitial lung disease, *etc*. if there is a lack of space and the six-minute walking test (6MWT) cannot be conducted. The 6MST is found to be valid and reliable when compared with 6MWT.[3,4] The 6MST is valid and reproducible, producing greater cardiovascular stress than the 6MWT in cardiac pathologies.[5] The 6MST has also been characterized as a submaximal test for the assessment of exercise tolerance in individuals with obstructive sleep apnea treated with continuous positive airway pressure.[6]

One of the earliest equations for the prediction of 6MST is that of Arcuri *et al*.[1] Prediction equations that predict the expected value in the absence of pathology allow the magnitude of an individual's functional limitation to be quantified. Ethnic and geographic variations have been reported as some of the factors responsible for the discrepancies in physical test scores.[7] The present study therefore aimed to measure 6MST in Indian adults, to check the applicability of Arcuri *et al.*'s reference equation to this group and, to develop a prediction equation.

Materials and Methods

The sample size was calculated by using the equation, N>50+8K,[8] where K represents the number of independent variables. Seven variables [age, height, weight, body mass index (BMI), waist circumference, hip circumference, and waist-hip ratio] were used, resulting in at least 106 participants. 110 participants were recruited by purposive sampling for this prospective cross-sectional study. The study was approved by the Institutional Ethical Committee, Project No. IEC-11F.

Participants were volunteers recruited over a period of eight months from among the students and staff of the institute, relatives of the patients, and nearby community dwellings. Participants were included if they were asymptomatic males and females aged 18-40 years with stable vitals, nonsmokers, absence of any disease in the 6 weeks preceding the study, and were able to step up and down without using any external support. Exclusion criteria included resting heart rate (HR) ≥100bpm; systolic blood pressure (BP) >139 mmHg, diastolic BP >89 mmHg; any documented health problem or use of medication such as impaired sensation or cognition, metabolic, cardiac, neurologic, or orthopedic disease; use of walking aids; pregnant females and lactating mothers. All the participants provided written informed consent regarding the study. The body weight (kg) was measured with a beam balance scale. Body height (m) was measured using a height scale and BMI [weight/height^2 (kg/m^2)] was calculated.

Using a non-elastic, flexible measuring tape, the circumference of the hips and waist were measured, and the waist-hip ratio was calculated. The 6MST was performed according to the guidelines of the American Thoracic Society for conducting the six-minute step test,[9] the 6MST was carried out on a portable 20-cm-high step with a non-slip rubber surface, physiotherapist counting the steps. Participants were told to sit at rest for five minutes before the test while the physiotherapist explained the exam to them.[10] Participants were given six minutes to climb up and down as many times as they could while maintaining their own rhythm. Participants were motivated using phrases like "you're doing well" and "keep it up".[10,11] When the timer was less than 15 seconds away from finishing the test, the participants were informed. The level of exertion was quantified using the modified Borg scale.

For each participant, maximum HR was estimated using HRmax=220-age in years, and submaximal HR was defined as 85 percent of maximal HR. The participants might also choose to take a break from the test to rest, but the timer was not halted in either scenario. The test score was recorded at the end and the total number of steps taken in the time limit of 6 minutes.[9]

Statistical analyses

A statistical package for the social sciences IBM version 26 statistical software (IBM, Armonk, 97 NY, USA) was used to analyze the data. Correlations were estimated using Pearson's coefficient of correlation. Comparisons between males' and females' step count included an independent t-test. Bland-Altman comparison was performed between the measured and predicted 6MST, based on Arcuri *et al*.'s reference equation: Male 6MST= 209-[1.05 × age (years)], Female 6MST=174- [1.05 × age] (years)].[1] Limits of agreement, calculated as mean difference between measured and predicted 6MST±1.96 standard deviation (SD), were used for comparison. Comparisons between measured and predicted 6MST also included paired t-test. Comparison of pre and post-test heart rate and oxyhemoglobin saturation were assessed through paired t-test. Stepwise multiple regression analysis was used to develop the gender-specific reference equation for 6MST. $P<0.05$ was considered significant.

Results

All the enrolled participants (N=110) completed the test, and there were no dropouts. The baseline characteristics of the study population and results of the six-minute step test along with correlations are summarized in Table 1. The mean±SD six-minute step count was 159.42±17.60 steps and 150.78±14.39 steps in males and females respectively. The 6MST reference values determined in the

study were found to overestimate the step count in Indian males by 24.84±15.75 steps and underestimate in females by 4.73±13.93 steps. There was a significant difference between the 6MST count between males and females (p=0.032). There was a significant difference between pre- and post-6MST heart rate (p<0.0001). Also, there was a significant difference between pre- and post-6MST oxyhemoglobin saturation (p<0.0001).

Figures 1 and 2 show the Bland-Altman comparison between the measured and predicted 6MST between males and females. There was a systematic bias between measured and predicted 6MST with Arcuri *et al.*'s reference equation. The 6MST reference value determined in the study was found to be substantially different from previously reported values.[1] Hence new prediction equations were developed.

Based on the results of the regression analysis, the 6MST for males can be determined by 6MST (steps) males =204.371-1.521×age (years), R^2=0.38 and 6MST (steps) females =179.567-1.065×age (years), R^2=0.23.

Discussion

The present study established normative values for the number of steps climbed during the 6MST in adult participants from India. Males climbed more steps than women. This study also provided gender-specific reference equation for the 6MST.

The 6MST reference value determined in the study was found to be substantially different from previously reported values.[1] The 6MST reference values determined in the study were found to overestimate the step count in Indian males by 24.84±15.75 steps and underestimate in females by 4.73±13.93 steps. The discrepancies may have been due to geographic and ethnic variability as ethnicity influences physical fitness test performance.[12] Anthropometric characteristics of participants may also differ, as Asians have a higher body fat percentage for the same age, gender, and BMI when compared to the European white population.[13] Also, the participants included in the present study were non-obese and adults of 18-40 years. We did not want to dilute the sample by merging young adults and older adults due to physiological alterations with advancing age.

Age and gender were found to have an association with 6MST.[14] There was a significant negative association of 6MST count with age in the total population, males as well as females in agreement with the previous study.[15] Age was the predominant variable in the regression equation as well. The 6MST values decreased in a linear fashion with respect to the increase in age. This may probably be due to the reduced lower limb muscle strength. Although we included normal individuals in our study, this could be attributed to normal age-related changes in the musculoskeletal systems. Other age-

related anthropometric and physiological changes, such as increased passive tissue stiffness, aerobic and anaerobic capacity, due to reduced cardiovascular function and alterations in oxidative capacity, also, skeletal muscle structure and function may contribute to the decline in test performance.[16,17] There was a significant difference in the 6MST values between males and females. The participants, both men and women, in our study were independent. Certain physiological variances between the genders, such as body composition, cardiovascular, and lung function, may affect performance.[18] The participants in the present study reached an average of 65.84% of their HR max% predicted. On the contrary, there was no correlation of 6MST with weight, waist and hip circumference, BMI as all our participants were non obese and healthy.[10] Thirty-eight percent and 23% of variance was explained in males and females respectively for 6MST, this put forth the need for future large multicenter studies with the inclusion of varied age, weight, and other anthropometric data categories.

Limitations

This study was limited by several factors. We had a nonrandom sampling method but stringent selection criteria to prevent the risk of bias. Finally, we did not evaluate additional probable variables such as peripheral muscle strength, or body fat composition. Also, the prospective validity of the developed equation was not checked.

Conclusions

This study brings an important contribution as region-specific reference values are needed for use in clinical settings. Arcuri *et al.*'s equation cannot be used to predict the 6MST in Indian adults. The region-specific values will provide a better interpretability for clinicians to use for assessment and rehabilitation purposes. The new gender-specific regression equations are expected to prove useful for assessment and rehabilitation in Indian adults.

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Table 1. Baseline characteristics of the participants and results of the six-minute step test.

	Total (n=110)	Males (n=54)	Females(n=56)
Variables	Mean±standard. Deviation	Mean±standard. Deviation	Mean±standard. Deviation
Age (years)	28.26±6.928**	29.56±7.19**	27.02±6.48**
Height (cm)	1.65±.057	1.68±.06	1.62±.045
Weight (kg)	63.68±9.56	66.82±8.78	60.64±9.36
Body mass index (kg/m^2)	23.35±3.10	23.74±2.68	22.98±3.45
Waist circumference (cm)	90.04±7.70	90.61±6.89	89.50±8.43
Hip circumference (cm)	96.67±7.027	96.17±6.48	97.16±7.54
Waist hip ratio	.93±.04	.94±.03	.92±.045
Rate of perceived Exertion	4.14±.97	4.33±1.05	3.96±.87
Resting heart rate (Beats per minute)	79.09±7.04	79.87±7.52	78.34±6.53
Post-test heart rate (Beats per minute)	126.25±16.47	123.50±16.15	128.91±16.47
Pre SPO_2 (%)	99.00±.62	98.90±.59	99.09±.64
Post-test SPO_2 (%)	98.42±.83	98.42±.77*	98.43±.89
HR max	191.74±6.93**	190.44±7.19**	192.98±6.48**
Six-minute step count	155.03±16.55	159.42±17.60	150.78±14.39
Predicted six-minute step count‡	-	184.27±8.50	146.07±8.05

6MST, six-minute step test; HR, heart rate; SPO_2, Oxy-haemoglobin saturation. *P<0.05; **P<0.001; ‡ Using Arcuri *et al.*'s equations: Male 6MST= 209-[1.05 × age (years)], Female 6MST=174- [1.05 × age] (years)].:

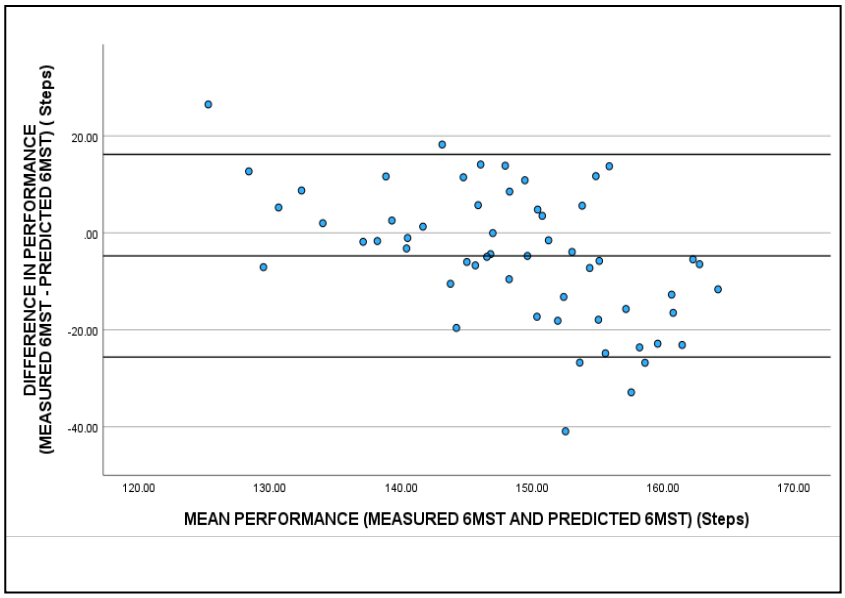

Figure 1. The Bland-Altman representation of measured and predicted six-minute step test using Arcuri *et al.*'s equation 6MST (steps) females = Female 6MST=174- [1.05 × age] (years)]. 6MST= six-minute step test.

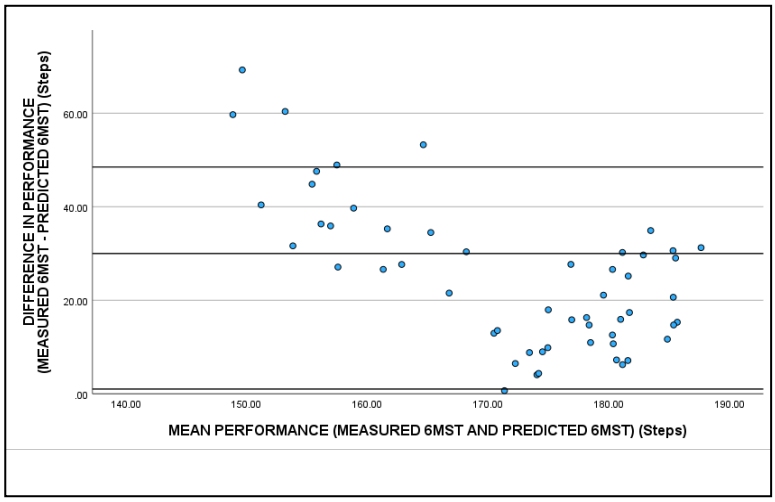

Figure 2. The Bland-Altman representation of measured and predicted six-minute step test using Arcuri *et al.*'s equation 6MST (steps) males =209-[1.05 × age (years). 6MST= six-minute step test.

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