

Normative Reference Values For 6 Minute Step Test in Healthy Individuals: An Observational Cross-Sectional Study

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ABSTRACT

Background: Exercise capacity plays an essential role in determining quality of life in both disease & health. Field tests can be used to determine aerobic capacity since they are easy to perform. The step test is another exercise test that can be used to assess aerobic capacity. An alternative to 6MWT is 6-minute step test which is a self-paced test. The 6-minute step test (6MST) requires less time and space to be performed and might be used as an alternative to assess exercise capacity in primary care.

Materials and methodology: 300 healthy participants of both genders were included. Each participant performed a 6-minute step test on a 20 cm high wooden step. The participants were instructed to walk up and down the step as much as possible within the time duration. Individuals with neuromuscular, orthopedic, or cardiopulmonary diseases were excluded from study. Pre & post vitals such as heart rate & SPO2 were recorded. The steps were counted by the therapist.

Results: The included participants were divided by age range, in years: 20-29 (n= 60), 30-39 (n=54), 40-49 (n=51), 50-59 (n=51), 60-69 (n=44), 70-80 (n=40). The normality of the data was assessed using Shapiro-wilk test. The mean number of steps climbed during the 6MST for men and women in the age group of 20-80 years was 139±27 & 137±24 respectively. The difference in the number of steps according to the age group was found to be statistically significant (p<0.001). Difference in the number of steps according to the gender was also seen (p<0.05).

Conclusion: These normative reference values for 6 MST found in our study will help determine & compare deviations from these norms. The study found that number of steps decreased as the age advanced, younger adults performed better than older adults & men performed better than women.

Keywords: 6-minute step test, exercise tolerance test, Normative values, field test, fitness testing

INTRODUCTION

Exercise capacity plays an essential role in determining quality of life in both disease & health ⁽¹⁾. Although the maximal cardiopulmonary test is considered as the gold standard for assessing exercise tolerance as it assesses the performance and

abnormal responses of the musculoskeletal, cardiovascular, and respiratory systems, it is limited for its use as it is a complex test that requires controlled environment, expensive equipment, and trained personnel that are often not available for physical therapy ^(2,3). Field tests can be used to determine aerobic

capacity because they are easy to perform⁽⁴⁾. The step test is another exercise test that can be used to assess aerobic activity⁽⁴⁾. Almost 80 years of research has demonstrated the value of step tests in assessing physical fitness in healthy individuals by identifying possible abnormalities in physiological responses.⁽²⁾ Step tests usually require only a room to be performed and are relatively inexpensive compared to other field tests.⁽¹⁾ An alternative to the 6MWT is the six-minute step test (6MST) which is performed on a 20-cm step. In which patients are instructed to climb up and down the step as fast as possible in 6 minutes⁽⁵⁾. Similarly, as the 6MWT, 6MST is self-paced test and the height of the step is similar to a step from a regular stair, leading to a better tolerability of 6MST when compared with other step tests.⁽¹⁾ The level of exertion required to perform a step or a walk test is closely related to exertion required for activities of daily living⁽⁸⁾. Additionally, by increasing movements that require vertical movement of the body, 6MST promotes greater oxygen uptake (VO_2)⁽³⁾. The 6MST was found to be a valid and reliable measure of physical activity in different populations, such as healthy individuals, patients with COPD, heart failure, etc.⁽¹⁻³⁾ Six-minute step performance was reliable (ICC = 0.9;) in a study with healthy subjects. It was also found that step count can be predicted by demographic and anthropometric variables with reasonable predictive power⁽¹⁾. In a study performed on COPD patients, the number of steps on the 6MST was valid to verify exercise capacity and the cut-off point of 78 steps was able to identify patients with poor exercise tolerance. Values under this cut-off point are considered to identify patients with a poorer prognosis⁽²⁾. In a study on ILD patients it was concluded that A single-stage, self-paced 6-min step test provided reliable and reproducible estimates of exercise capacity and exercise-related oxyhaemoglobin desaturation in interstitial lung disease patients⁽⁵⁾. The 6MST was found to

accurately differentiate obese women with adequate cardiorespiratory fitness from women with poor fitness and to predict metabolic and cardiovascular maximal exercise values⁽⁶⁾. 6MST was also performed in patients after strokes, concluding that it is feasible and that physiological responses are the same during the 6MST and the 6MWT activity⁽⁷⁾. A study by Davi de Souza Franciso et al stated that the 6MST appeared to be a good tool due to its consistency with other functional variables, excellent test-retest reliability, and safety during its use in hospitalized elderly⁽⁸⁾. Another study in patients with COPD showed that the number of steps in the 6MST was significantly correlated with the 6MWT distance covered, maximum exercise capacity and oxygen consumption⁽¹⁰⁾. The ACSM stated that 6MST requires more energy than 6MWT and has a higher oxygen demand due to different body movements⁽⁹⁾. A study by Oliveira et al showed that a higher step height induced greater cardiovascular stress without exceeding the submaximal levels of the test, indicating that the 6MST can be used as an accurate tool to assess aerobic capacity in healthy individuals⁽¹³⁾. Albuquerque VS et al. predicted normative reference values and a reference equation for the 6-minute step test in the Brazilian population, which is not applicable in the present region due to anthropometric variability, and validated it only in the Brazilian region⁽¹⁸⁾. Therefore, the aim of this study was to predict normative reference values for the 6-minute step test and analyse age & gender differences in the step count.

MATERIALS & METHODS

Approval was obtained from the ethical committee. The inclusion criteria for the study were Normal Healthy participants of both genders of 20-80 years of age group. Participants with existing neuromuscular, cardiovascular, and orthopaedic diseases were excluded from the study. An informed written consent was obtained from all the participants. A total of 300 participants (150

males & 150 females) were recruited in the study.

6-minute step test- The test was performed on a 20 cm high wooden step where the participants were instructed to walk up and down the wooden step as fast as possible during 6-min period without any upper limb support ⁽⁵⁾. It was a self-paced test & the participants received instructions per minute similar to guidelines given by ATS for 6MWT ^(1,11). The number of steps climbed

by the participants were counted by the therapist. At the beginning & at the end of the test the vital parameters like heart rate & SPO₂ were noted.

The test was interrupted in cases of oxygen desaturation below 85% complaints of chest pain, intolerable dyspnoea, leg cramps, dizziness. The participant could interrupt the test to rest; however, the timer was not stopped during the interruption.



Figure 1: A Wooden Stepper of height of 20 cms used in the present study



Figure 2: Participant performing the test

STATISTICAL ANALYSIS:

Statistical analysis was done using IBM Statistical Package for Social Science (SPSS software- Version 26). The normality of the data was assessed using Shapiro-wilk test which found that the data is skewed to the left. Descriptive analysis for mean and standard deviation were studied for both genders. The normative reference values were expressed as Mean & Standard Deviation for age groups between 20-80 years of age for both genders. MANOVA was used to assess the difference in the number of steps performed by participants in all age groups. Mann Whitney-U test was

performed to analyse the difference in the number of steps according to the gender.

RESULT

300 healthy individuals of both genders with a BMI of 23.7±2.9 were recruited in this study. The included participants were divided by age range, in years: 20-29 (n=60), 30-39 (n=54), 40-49 (n=51), 50-59 (n=51), 60-69 (n=44), 70-80 (n=40). Normative values- The mean number of steps climbed during the 6MST for men and women in the age group of 20-80 years is as follows:- Table 1- Number of steps climbed in 6 minutes according to age & gender

Table 1- Number of steps climbed in 6 minutes according to age & gender

AGE GROUP	MALE (mean±SD)	FEMALE (mean±SD)
20-29	169±12	162±15
30-39	159±13	155±13
40-49	147±8	140±11
50-59	140±13	130±12
60-69	119±11	113±11
70-80	97±8	93±8

In our study we did not report any sudden drop of oxygen saturation throughout or after the completion of the test as mentioned

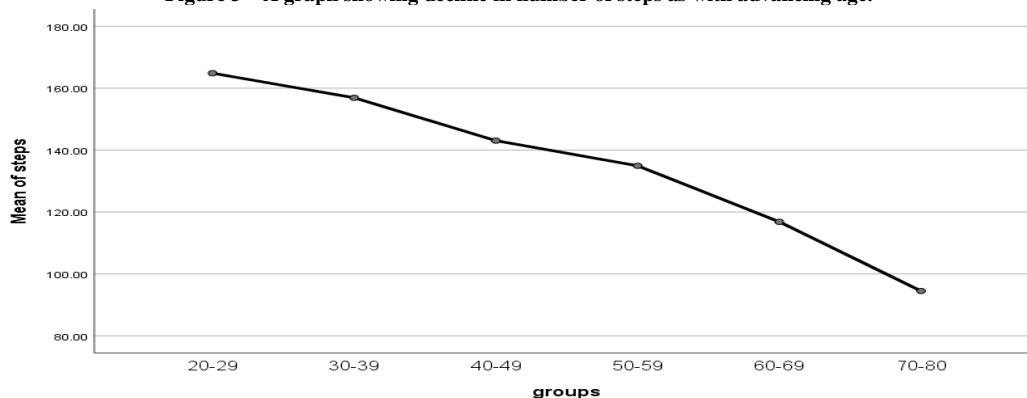
in Table 2. The Heart Rate response recorded at the beginning and after the 6-minute step is mentioned below in Table 2.

Table 2- Heart rate & oxygen saturation response pre & post 6MST

AGE GROUP	PRE HR	POST HR	PRE SPO2	POST SPO2
20-29	72.77± 8.7	121.1±16.4	99±1	99.05±1.1
30-39	73.13± 8.2	122.5 ± 8.8	99 ±1.1	99.04 ±1.0
40-49	76.8 ± 6.9	128.04 ± 12.2	98.47±1.1	98.7±0.85
50-59	72.4 ± 10.7	123.6 ±14.8	98.61±1.0	99.4±0.6
60-69	72.07± 8.3	124.7 ±10.3	98.7±1.08	99.01±0.9
70-80	66.35 ± 6.1	96.9 ± 10.2	98.3±1.5	98.5±1.6

The younger participants climbed more steps than the older participants which was found to be significant (p< 0.001) when assessed using MANOVA (figure3).

Figure 3 – A graph showing decline in number of steps as with advancing age.



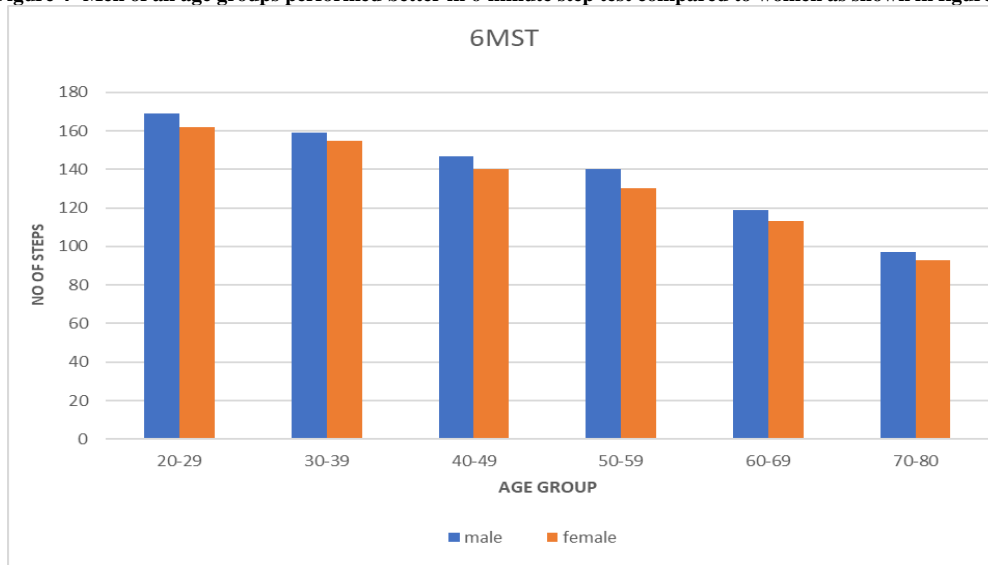
The study found that men had better performance than women in all age groups. This was analyzed using Mann Whitney-U test which was found to be statistically

significant ($p < 0.05$) for all age groups as mentioned in Table 3 & as shown in Figure 4.

Table 3: Men of all age groups performed better in 6MST compared to women which was found statistically significant ($p < 0.05$) age wise as mentioned in table below.

AGE GROUP	P value
20-29	0.033
30-39	0.031
40-49	0.016
50-59	0.017
60-69	0.032
70-80	0.023

Figure 4- Men of all age groups performed better in 6-minute step test compared to women as shown in figure 4.



DISCUSSION

This study analysed 300 healthy subject's males & females both from 20-80 years of age. The current study established normative reference values for the number of steps climbed during the 6MST in adult healthy individuals. These normative reference values will be beneficial to evaluate and compare the performance of an individual within a population, establish comparisons between different clinical conditions and also play a pivotal role to evaluate the effectiveness of a given intervention. Reference population indicates what is normal and this normative data will help to identify deviations from these norms.

6MST is an easy test which can be used in intervention & rehabilitation strategies like telerehabilitation and in home-based exercise as traditional functional tests like 6-

minute walk test & incremental shuttle walk test are not feasible for home based rehabilitative assessment because of need for physical space. 6MST does not require a long corridor of 30 meters like 6- minute walk test. In such conditions 6- minute step test can be utilized well. It is a self-paced test which allows the individuals to adjust pace during the exercise according to his or her limitations that would otherwise prevent early termination of test. 6MST has been found valid and reliable in patients with COPD, ILD, Heart Failure, stroke and coronary artery disease patients^(2,3,5,7,12). Previous studies reported that the Step Test involved working against gravity and the use of muscle groups that are not frequently used during activities of daily living. As such, then, the activities produce the physiological responses that are different from the walk test, which makes the

metabolic and ventilation responses more intense^(5,14).

Our study found out that Men climbed more steps than did women. This could possibly be due to some physiological variations between the genders, such as body composition, cardiovascular function, lung function, substrate metabolism, and thermoregulation, may influence exercise performance. In general, men have less body fat and greater aerobic capacity than do women⁽¹⁵⁾. Younger participants climbed more steps than older participants. The elderly population had a bad performance on 6-minute step test. The reason could be because, aging is associated with reduced aerobic and anaerobic capacity, reduced cardiovascular function, changes in oxidative capacity, changes in muscle fibre type, changes in skeletal muscle structure and function & degeneration of joints^(16,17). These factors might have affected the performance of 6MST in our study. Similar results were also reported in a study done by Vanessa Salles et al⁽¹⁸⁾. This decline can be both due to central & peripheral mechanisms^(1,21). The greater aerobic capacity by the younger adults is the result of many factors, including more muscle mass, muscle power, energy reserves, dominant muscle fibre type, and cardiopulmonary capacity⁽¹⁹⁾. Vanessa Salles et al. gave the reference equation for predicting the values of 6MST in healthy Brazilian population which was found valid, as there was no significant difference between the actual and predicted number of steps climbed by the independent sample⁽¹⁸⁾. As this equation was found valid in Brazilian population this 6MST can be used to assess exercise capacity which will be cost effective and easier for the physicians to administer. Their study also gave MDC of 21 steps⁽¹⁸⁾. A study by da Silva et al in-stroke patients suggested that all patients assessed in this study completed the test properly, without pausing during the six minutes, without sudden drops in Oxygen Saturation, and without need of supplemental oxygen which implies the test

does not have any adverse effects⁽⁹⁾. The results found were similar in our study where there were no drops in oxygen saturation. The reason of this could be that all individuals we tested were healthy without any respiratory illness. The step climbing test therefore also gives the clinician some insight into the gas transfer capacity of the lung, which could be useful in clinical setting which lacks full lung function tests which can also predict which candidates are likely to need long term supplemental oxygen therapy⁽²⁰⁾. A study by S. Dal Corso et al., in patients with ILD stated that 6MST may allow exercise capacity and exercise-related oxyhaemoglobin desaturation (ERD) to be determined during routine consultations to the physician with major advantages in terms of reducing costs and increasing the frequency of functional evaluations of ILD patients⁽⁵⁾. A study by Groisbois et al in their study on COPD patients depicted that their study shows that the number of steps on the 6MST was significantly correlated with the distance covered on the 6MWT, VO₂ max, and power at VT and at maximum effort, independent of the severity of COPD⁽¹⁰⁾. These results also show a significant correlation between improvements of performances on the 6MWT and 6MST after outpatient Pulmonary Rehabilitation⁽¹⁰⁾. Our study had only fewer participants experiencing leg fatigue immediately after the test which indicates that the test can be comfortably performed as it is similar to a step from a regular stair, leading to a better tolerability of 6MST when compared with other step tests. Hence the normative reference values for 6 MST found in our study will help determine & compare deviations from these norms. When performed in patients with cardiorespiratory illness the 6MST will play a vital role to assess exercise induced oxygen desaturation and will help evaluate patients in need of long-term supplemental oxygen therapy. This will also facilitate the quantification & interpretation of functional impairments with an easy to perform test for

use in clinical practice & research.

CONCLUSION

The mean number of steps climbed by males & females in the age group of 20-80 years was 139 ± 27 & 137 ± 24 respectively. The study found that number of steps decreased as the age advanced, younger adults performed better than older adults & men performed better than women. These normative reference values for 6 MST found in our study will help determine & compare deviations from these norms.

Declaration by Authors

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