

## 6 Minute Walk Test (6MWT) for Healthy Adult Volunteers

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<sup>1</sup> Conception of study

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## Abstract

**Objectives:** To determine the 6-minute walk test (6MWT) for healthy volunteers in our population and find out the factors affecting 6MWT. Furthermore, comparing our results with published National and International data.

**Materials and Methods:** This cross-sectional study was carried in the physiology department of Rawalpindi Medical College, from 1<sup>st</sup> July 2019 to 31<sup>st</sup> December 2019A total of 129 adult healthy volunteers between 18 and 60 years of age were included in this study after the application of inclusion and exclusion criteria. A 6-minute walk test (6MWT) was carried out in a standardized procedure. The height, weight, and BMI were recorded on predesigned Performa. Distance covered in 6-minute, heart rate, systolic BP, Diastolic BP, SPO<sub>2</sub>, Borg Scale Dyspnea score, Borg Scale Fatigue score were recorded before and after the 6-minute walk test. Correlation and its significance were calculated among anthropometric and physiological variables.

**Results:** Seventy (54%) men and Fifty-nine (46%) women participated in the study. The mean distance covered for all subjects was 430.412±63.0150. The distance covered by the female subject was 388.720±30.104 and 439.533±68.355 by male subjects. The mean age of the subjects was 31.64 ±12.36, while the mean BMI was 22.06 ±4.15. The mean heart rate value before the test is 77.72±1.48 and after the test is 92.84±1.12. The mean systolic BP value before the walk was 122.65±11.75 and after the walk, it was 106.5±9.83. Mean diastolic BP before the walk was 80.55±12.61 and after the walk, it was 76.5±9.83. SPO<sub>2</sub> mean value before the walk was 96.23±1.4 and after the walk is 98.2±1.17. Borg scale dyspnea score mean value before the test is 0 ± 0 and after the test it was 0.67±0.76 and Borg scale fatigue score mean value before the walk is 1.32±0.73 and after the walk is 1.62±0.92. A positive correlation was noted with height, while a negative correlation was noted with age and BMI. Gender also showed a significant relationship with the 6MWD.

**Conclusion:** The distance covered in 6-minute is shorter than the studies carried out in different parts of the world. Age, gender, height, and BMI showed a significant relationship with 6MWD. Those reference values for the 6MWD should not be used in our population, as it overestimates the distance and may interfere with the significance of the test.

**Keywords:** 6 Minute walk test (6MWT), Healthy Subjects, Fitness Criteria, Exercise.

## Introduction

For the evaluation of exercise capacity, different techniques and methods have been employed. Techniques requiring low tech provide basic information and are consequently simple to perform, while there are others for assessment of all systems providing a comprehensive picture. The method chosen depends on the clinical question to be answered and on resources availability. In order of ascending complexity, the conventional clinical exercises are stair climbing, a 6MWT, shuttle walk test, exercise-induced asthma detection, cardiac stress test (e.g., Bruce protocol), and cardio-pulmonary exercise test.<sup>1</sup> Balke and co in the early 1960s, for the evaluation of functional capacity, developed a simple test by measuring distance walked for a defined time period (6MWD).<sup>2</sup> For the physical fitness of healthy subjects, a longer more difficult 12-minute walk test was developed. But for patients suffering from respiratory distress for whom this test was too stressful, a 6-minute walk test was developed. Recently, a review regarding functional walk tests concluded, "6MWT is easy to conduct, well-tolerated, and more reflective of activities of daily living".<sup>3</sup>

Walking is a daily activity easily performed by everyone apart from the most severely impaired. The 6-minute walk test (6MWT) test focuses on the capacity of a patient to cover the amount of distance on a hard, flat surface for a time period of 6 minutes. The test measures the integrated and global responses of all physiological systems involved during exercise ranging from the systemic and peripheral circulation, pulmonary and cardiovascular systems, neuromuscular units, and muscle metabolism. Exertion levels of almost all daily activities are at submaximal but 6MWT may better reflect functional exercise level for daily physical activities. Decrease in the 6MWT parameters is multifunctional and they are affected by a varied set of physiological factors involved during exercise. The factors depend on a diverse and wide-ranging set of situations, assessing walking capacity useful. But the most valuable and clinically important indications are measuring pre-and post-treatment evaluation of functional status and comparing and predicting morbidity and mortality rates.<sup>5</sup>

A potential limitation for the 6MWT application is the diversity of race/ethnic groups regardless of age and gender. But overall this test could provide us valuable information for judging therapeutic interventions and evaluating prognosis and disability and overall help us

in conducting research. Previous research has shown marked variation among 6MWT values among different sub-populations specifically among racial/ethnic groups. Compared to Americans of Caucasian origins, mean values for healthy African-American are on average 40 m less (after correcting for gender, age, weight, and height).<sup>6</sup>

Differences in the covered distance by healthy subjects have been recorded in some studies.<sup>4-11</sup> Results may also be influenced by the variations in study populations and methodology. Furthermore, high variability in predictive power in most of the published predictive equations has been observed suggesting other factors (not considered in the performance test) potentially playing an important role in distance covered.<sup>7</sup> Guidelines for 6MWT were reported by the American Thoracic Society (ATS) but the reference equation from the healthy population base sample was not available.<sup>1</sup> 6-minute walk test has shown to be influenced by variables like gender, age, height, very few studies have been carried out in our country to generate the reference equation for healthy adult subjects.

Therefore, it is plausible for diversity to exist also amongst different Pakistani populations. As far as our knowledge is concerned, no published data on the normal 6MWT exist for the Northern population of Pakistan. So, our rationale to study and analyze the distance covered by healthy Pakistanis adults from central and northern regions in 6 minutes is well-founded providing us insight into the physiological determinants for 6MWT.

## Materials and Methods

129 healthy subjects were selected randomly ranging from 18 to 60 years of age to participate in this study. The study was conducted in Rawalpindi Medical University, Rawalpindi after getting approval from the college ethical review committee vide Ethical Review committee certificate no. 28/2020. The participants were mostly employees of the college and medical students. World Health Organization (WHO) sample size calculator was used for calculating the sample size with a level of significance of 5%, power of the test of 95%. The difference proportion anticipated is 9.73%.<sup>5</sup> Minimum sample size came out to be 129. Non-probability consecutive sampling technique was employed. A history of symptoms suggestive of a chronic medical condition, BMI>30, cigarette smoking, a professional athlete, or one exercising gym was considered as exclusion criteria. A structured

screening test before enrollment was conducted by specifically instructed physicians in training at the department of physiology in an attempt to investigate and confirm self-reported health status. Informed consent was taken from the participating subject.

**6-Minute Walk Test (6MWT):** For the conduct of 6MWT, a standardized protocol based on published guidelines were used.<sup>1</sup> Recordings were performed for age, gender, Body Mass Index (BMI), Blood pressure (BP), heart rate, in meter, kg and recorded for Borg scale for height, weight, SpO<sub>2</sub> dyspnea, and fatigue respectively. Standardized instructions were given to all subjects before the walk and underwent a 6-minute walk test in 50 meters indoor, hard floor, well-lit and marked corridor (in loose-fitting clothing or exercise attire, with comfortable ambient temperature and humidity) and turn around at clearly indicated markers at their own pace while attempting to cover as much distance as possible in the allotted 6 minutes. Subjects underwent 2 6MWT following a rest of at least 60 minutes and the best of 2 readings were recorded. Before the test and immediately after 6MWT, BP, heart rate, SpO<sub>2</sub>, and Borg value for dyspnea and fatigue were recorded. If any symptoms of chest pain, leg cramps, dyspnea were observed among the subject during the test, the test was discontinued but was then encouraged to continue the test as soon as they could. The formula  $mHR = 220 - \text{age}$  was used to calculate the maximum predicted heart rate. Statistical Package for Social Science (SPSS) version 17.0 was used for all the analyses and all p-values were two-sided and considered statistically significant if less than 0.05.

## Results

Out of the total 129 subjects who participated in this study, seventy (54%) were men, and fifty-nine (46%) were women. For our protocol, while some needed assistance, for others there were no interruptions. The mean distance covered by all subjects was 430.41±63.02. Table 1 covers the characteristics of our study population. While Table 2 shows the statistical significance whether present or not in the parameters under study, before and after the 6MWT. The distance covered by the female subject was 388.72±30.10 and 449.53±68.35 by male subjects. Compared to the first test, subjects of the second test walked on average 22 m more but it was longer in 60% of the subjects as

well. The 6MWD was approximately 60 m greater in males than in females (449.53 ±68.35 m versus 388.72±30 m; p-value=0.001). The mean age of the subjects was 31.64±12.36, while the mean BMI was 22.06±4.15.

The mean heart rate value before the test is 77.72±1.48 and after the test is 89.84±1.12. The mean systolic BP value before the walk was 122.65±11.75 and after the walk, it was 106.5±9.83. Mean diastolic BP before the walk was 80.55±12.61 and after the walk, it was 76.5±9.83. SPO<sub>2</sub> mean value before the walk was 96.23±1.4 and after the walk is 98.2±1.17. Borg scale dyspnea score mean value before the test is 0 ± 0 and after the test it was 0.67±0.25 and Borg scale fatigue score mean value before the walk is 1.20 ±0.73 and after the walk is 1.62 ±0.92. A significant independent association with 6MWT was seen in the Borg dyspnea score. A positive correlation was noted with height, while a negative correlation was noted with age and BMI and a significant relationship with gender was observed with 6MWT.

[Out of the total of 129 subjects who participated in this study, seventy (54%) were men and fifty-nine (46%) were women. The mean distance covered by all subjects was 430.41±63.02 m. The distance covered by the female subject was 388.72±30.10 m and 449.53±68.35 m by male subjects. The 6MWD was approximately 60 m greater in males than in females (449.53 ±68.35 m versus 388.72±30 m; p-value=0.001). The mean age and BMI of the subjects were 31.64±12.36 and 22.06±4.15 respectively. The mean heart rate value before the test was 77.72±1.48 and after the test was recorded to be around 92.84±1.12 while meaning systolic BP value before and after the walk was 122.65±11.75 m and 106.5±9.83 m respectively whereas the mean diastolic BP before and after was around 80.55±12.61 and 76.5±9.83 respectively. SPO<sub>2</sub> mean value before the walk was 96.23±1.4 and after the walk is 98.2±1.17.]

“On univariate linear regression analysis?? gender, weight, height, and age showed a significant relationship with the 6MWD. Further sub-analysis revealed a significant direct relationship between height (r=0.485, p=0.001) and weight (r=0.212, p<0.001) for the entire study cohort; however, this relationship was not present when the study population was segregated by gender.

Gender and age were identified as independent factors towards the 6MWD in multiple regression analysis.”

**Table 1: Anthropometric and physiological characteristics of the study population**

Characteristics	All subjects n=100 Mean± SD	Male n= 60 Mean± SD	Female n=40 Mean± SD
Age (years)	31.64 ± 12.36	36.86 ± 10.95	23.8 ± 10.07
Height(m)	1.64 ± 0.09	1.66 ± 0.10	1.60 ± 0.06
Weight(kg)	66.18 ± 15.2	70.93 ± 13.86	59.05 ± 14.44
BMI (kg/m <sup>2</sup> )	22.06 ± 4.15	21.23 ± 3.83	23.31 ± 4.04
Distance Covered (Meter)	430.41 ± 63.01	449.53 ± 68.35	388.72 ± 30.10
<b>Systolic BP (mm Hg)</b>			
Pre-walk	122.65 ± 11.75	121.25 ± 12.33	123.65 ± 11.21
Post-walk	106.5 ± 9.83	105.41 ± 11.15	107 ± 7.83
<b>Diastolic BP (mm Hg)</b>			
Pre-walk	80.55 ± 12.61	79.25 ± 9.28	81 ± 7.86
Post-walk	76.5 ± 9.83	75.33 ± 9.93	77.25 ± 8.08
<b>Heart rate</b>			
Pre-walk	77.72 ± 1.48	75.6 ± 1.44	80.02 ± 9.38
Post-walk	89.84 ± 1.12	91.8 ± 1.14	88.95 ± 9.47
<b>SPO<sub>2</sub></b>			
Pre-walk	96.23 ± 1.4	96.7 ± 1.67	95.42 ± 2.94
Post-walk	98.2 ± 1.17	98.03 ± 1.38	97.26 ± 2.59
<b>Borg Scale Dyspnea scores</b>			
Pre-walk	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Post-walk	1.1 ± 0.36	1 ± 0.4	1.52 ± 0.31
<b>Borg Scale Fatigue Scores</b>			
Pre-walk	0.52 ± 0.23	0.36 ± 0.80	0.74 ± 0.26
Post-walk	1.82 ± 0.92	1.76 ± 1.04	1.90 ± 3.30

**Table 2: T-Test results of study Characteristics vs 6MWD distance**

Characteristics	p-value
Age (years)	< 0.05
Height(m)	< 0.05
Weight(kg)	< 0.05
BMI (kg/m <sup>2</sup> )	< 0.05
<b>Systolic BP (mm Hg)</b>	
Pre-walk	< 0.05
Post-walk	< 0.05
<b>Diastolic BP (mm Hg)</b>	
Pre-walk	< 0.05
Post-walk	< 0.05
<b>Heart rate</b>	
Pre-walk	< 0.05
Post-walk	< 0.05
<b>SPO<sub>2</sub></b>	
Pre-walk	< 0.05
Post-walk	< 0.05
<b>Borg Scale Dyspnea scores</b>	
Pre-walk	< 0.05
Post-walk	< 0.05
<b>Borg Scale Fatigue Scores</b>	
Pre-walk	< 0.05
Post-walk	< 0.05

For distance covered, gender and age were significant independent factors. Considerable variations are seen between published references for 6MWT as evident from Table 3 in comparison with National and International studies for 6MWT.

**Table 3: Comparison of the 6MWDs with National and International Studies**

Study	6MWD	Difference (with our result)
Casanova C et al <sup>4</sup>	571±90 m	+ 141m
Rao NA et al <sup>5</sup>	469.88 ±101 m	+ 39m
Alameri H <sup>6</sup>	409 ±51 m	- 21m
Chetta A <sup>7</sup>	614 ±56 m	+ 184m
Hossain AM <sup>9</sup>	466.7 ±69m	+ 36m
Shrestha SK <sup>10</sup>	489 ±86	+ 59m
Ajiboye OA <sup>11</sup>	517.6 ±72 m	+ 87m
Kim AL <sup>12</sup>	598.5 ±57 m	+ 168m

## Discussion

Some studies have been conducted about a 6-minute walk distance test (6MWD) for healthy subjects in

Pakistan<sup>4</sup> but not among the population around Rawalpindi and Islamabad. Our study reflected on the statistical difference in an anthropometric variable as well as physiological variable. The significant independent association with 6MWT was seen with Borg dyspnea score. A positive correlation was noted with height, while a negative correlation was noted with age and BMI. In addition, gender had a significant correlation for the 6MWD, and a statistically significant inter-gender difference was also noted. Comparison between male and female subjects showed, increased distance covered by males, mean systolic and diastolic BP showed significant difference as well, in addition to the SPO<sub>2</sub> value that was lower in females. These variations were noted in the Borg scale dyspnea score and Borg scale fatigue score. A negative correlation was noted with age, weight, height, and BMI, and these results were aligned to the data studied from different countries.<sup>7-9</sup> The next step for our study was to derive the reference value for the local population that will be a barometer for comparing with other country's reference values.

Rao NA et al conducted a similar study demonstrating the mean 6MWD for healthy subjects was 469.88 m, which was 39 m more compared to our study mean.<sup>5</sup> Similarly, for a healthy adult cohort of the Arab population in a study conducted by Alameri H, was reported mean 6MWD value of 409±51 m.<sup>6</sup> It was the only study for regional and international literature in which a shorter 6MWD of 21 meters was shown specifically males (429±47 m) covered more distances than females (386±45 m) ( $p < 0.001$ ).

A study on 102 healthy Caucasians between the ages of 20-50 years and published a mean 6MWD of 614±56 m.<sup>7</sup> It was the biggest difference of approximately 184 m in terms of distance covered in 6 minutes. The mean 6MWD and DW values were 593±757 m and 638±744 m ( $P$ -value of 0.01) for females and males respectively. Another study focused on 6MWD reference values in healthy subjects ages 25 to 55 years having Bangladeshi origin.<sup>9</sup> The mean 6MWD for their study was 466.7 ±69 m with 36 meters more distance covered compared with our study.

Shrestha SK<sup>10</sup> conducted a similar study in Nepal showed mean 6MWT values 489±86 m and 509±82 m for males and 445±78 m for females. Compared to our study, their mean was approximately 60 m more. Gender, age, BMI, and weight had a significant contribution to the prediction of 6MWD and their findings were in line with our study. Gender played a vital role as being the single most important predictor of all factors. A study from Africa conducted by

Ajiboye OA titled showed a mean 6MWD of 517.6 ±72 m.<sup>11</sup>

Finally, focusing on South East Asia, Kim AL conducted a study where they evaluated reference equations for subjects aged 22 to 59 years. They showed mean 6MWD to be around 598.5±57.92 m, with males (628.9±59.51 m) covering significantly longer distances covered than females (580.9±47.80 m) ( $p < 0.001$ ). The difference was greater after Chatta A<sup>7</sup> in terms of 6MWD covered. A significant correlation of 6MWD was observed for height, weight, age, and BMI. Comparatively, there seems to be an overestimation in reference equations derived from Korean subjects than in North African and Caucasian populations while an underestimation is observed compared to other Asian sub-populations. For their study, the mean 6MWD came out to be around 600 m and height was revealed to be the most significant distance predictor through regression equation by a variance of 20.5%.

This wide range of variation in published literature can be explained by a number of factors ranging from testing methodologies and subject selection to differences in ethnicity of subjects studied. There is a significant error and moderate overestimation of 6MWD values among Pakistani populations analyzed comparatively through the 6MWT predictive equation with six widely accepted equations.<sup>4-12</sup> There could be several possible explanations for these discrepancies. For example, in terms of testing strategy, the length of the walking course i.e. 18 m, meant subjects had to turn more frequently and requiring more time in reversing directions leading to smaller 6MWT values.

Although ATS recommends a 30 m walking course<sup>1</sup>, different researchers have employed distances ranging from 15 m to 50 m.<sup>4-12</sup> A mean between 0-17 percent was observed from data published in the ATS review.<sup>1</sup> Our test subjects were naïve and practice sessions were not allowed, which could have impacted our 6MWT values. Other factors which could be considered are subject-related differences such as overall motivation, racial characteristics, exercise habits, coordination, and nutritional status.<sup>4-12</sup>

Similarly, to the previous studies<sup>4-12</sup>, age showed an inverse correlation while direct relation was observed for physiological determinants of weight and height with 6MWD values for our subjects. Physiological differences in systolic BP changes, VO<sub>2</sub> responses and heart rate, respiratory exchange ratio, plasma lactate levels, and shifts in plasma volume during exercise could be explained by the influence of gender on the distance covered. For heavier people additional energy would be required to support their body mass

(increase in adipose tissue rather than muscle mass), thus curtailing increased levels for effective work. Similarly, for taller people, taking longer strides should be considered as a plausible explanation resulting in shorter time periods due to less time spent in contact with the ground improving overall gait efficiency. In addition, an inverse correlation was observed between advancing age and 6MWD values likely caused by a combination of loss in skeletal muscle strength, quality and mass in older people. Among the study populations, this inconsistency is likely due to the dissimilarity in the age ranges and absence or presence of co-morbid conditions.<sup>8-11</sup>

Compared to previously published data, for our study, peak heart rate after walking was slightly lower. All these differences might be explained in broader terms by several interlinked factors i.e., genetic, physiological, and psycho-social in nature. In addition, another major contributor might be the low priority given to regular exercise in Pakistani society. This sedentary lifestyle could likely explain the peak heart rate and 6MWT values affecting overall physical fitness, motivation, self-efficacy (judgment of own capacity) and which in turn influences performance during physically demanding situations.

### Limitations

Several factors were involved in limiting this study such as sample size (conducted only on 129 subjects) and healthy volunteers were selected (not including individuals with age more than 60 years or patients with co-morbidities). Other potential variables such as peripheral muscle strength, daily physical activities, and other psychological factors were not assessed as they could have a limited physical function. The self-paced 6MWT is used to assess functional capacity at the submaximal level as mentioned above. For most of our subjects, maximal functional capacity was not achieved instead exercise intensity was chosen and they were provided with the possibility of stopping and taking rest during the test.

### Conclusion

In conclusion, 6MWT is a cheap, simple test that can be performed safely in any condition. Our study highlights the comparative differences between our local population with regards to National and International Studies in 6MWD values. In our study, mean values for 6MWD were considerably lower than

data published previously. The most significant independent physiological factors remain gender, age, and height depending on the predictive equation, the significant variance was seen. For establishing a new set of 6MWD values that will aid the development of diagnostic and prognostic markers, correlation with genetic factors, mood, and habits along with psychological and cognitive perspective need to be studied extensively.

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