Original Article

PREDICTION OF SIX MINUTE WALK DISTANCE IN HEALTHY PAKISTANI ADULTS AND ITS COMPARISON WITH OTHER ETHNIC GROUPS

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ABSRACT:

BACKGROUND AND OBJECTIVE: Six minute walk distance (6MWD) is used to assess severity and prognosis of different cardio-respiratory diseases but its predicted value varies in different geographic regions and with ethnicity in addition to the influence of anthropometric factors. This study was conducted to determine predicted value of 6MWD in Pakistani adults and to compare it with some other countries.

MATERIAL AND METHODS: The study was conducted in Lahore. Four hundred individuals of either gender participated in the study and age ranged from 18 to 80 years. Six minute walk test was administered to the participants according to guidelines of American Thoracic Society. Conditions that could affect walking were taken as exclusion criteria. Men and women were compared for the distance walked and effect of common anthropometric factors like height, weight, body mass index was studied. Eighty percent of the patients were randomly selected to find a predictive equation; remaining subjects were used as controls. Actual distance walked by the control group was compared with the predicted distance to validate the regression equation. The mean 6MWD of the study population was compared to the mean distance calculated using each of the five previously published equations.14-18

RESULTS:A total of 400 individuals participated in study; 344 (86.0%) were males and mean age of the patients was 32.42±10.33 years. Out of the study group (320 subjects), 279 (87.2%) were men and the mean age was 32.66+ 9.90 (range 19-72) years. Mean age of women was 38.0±13.79 years and that of men was 31.88± 8.96. Mean height and weight for men and women were 170.91±6.23 versus 156±6.92 cm (p=0.001) and 72.08±11.50 versus 59.59±21.68 Kg (p=0.001). Overall 6MWD of the study population was 855.78+ 107.01 m; 875.01±86.7 m for men and 724.95±137.41 m for women (P=0.001). Female gender, age and change in heart rate were negatively correlated whereas height and weight were positively correlated with 6MWD. Previously published equations mostly underestimated 6MWD in our study group.

CONCLUSION:Prediction of 6MWD for Pakistani population by previously published equations is not accurate and hence inappropriate. Major predictors of 6MWD remain age, sex, height and weight.

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INTRODUCTION:

The idea of measuring walk distance in a specified time interval is about 60 years old. Balke[1] described a test of physical fitness for air force personnel and Cooper[2] correlated a 12 min run fitness test with maximal-oxygen-consumption on treadmill testing.

McGavin et al[3] converted the 'run' test into 'walk' test maintaining the time interval at 12 minutes which was later felt too cumbersome for many patients; hence shorter time tests (two and six minutes) were employed. The 2-minute test became obsolete due to limited responsiveness; the six-minute walk test (6MWT), however, stood the test of time and became the standard time limited walk test. In 6MWT, the subject is asked to walk as fast as possible for 6 consecutive minutes.

Initially, this test was used only in patients with cardio-respiratory disorders, mainly for assessment of morbidity, prognosis and response to treatment[4]. Lately, it has been validated in a number of non cardio-respiratory situations namely; Cerebrovascular accidents[5], Alzheimer's disease[6], cerebral palsy[7], obesity, amputations[8], Down's syndrome[9] and fibromyalgia[10].

Although the gold standard for a clinical exercise testing is the comprehensive cardiopulmonary exercise testing, but it is not practical in day to day clinical work especially in the resource-limited

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countries like Pakistan. 6MWT has been advocated as a practical, cost-effective substitute. Some good correlations between the results of 6MWT and cardiopulmonary exercise testing have been reported[11]. The ever increasing scope and future role of 6MWT in the evaluation of patients can be judged from the elaborate guidelines issued by the American Thoracic Society (ATS) regarding the methodology and other aspects of this test[4].

An important practical issue about 6MWT is great variation in reported reference values of 6MWD for different populations[12]. Studies from different countries have reported normal values for the 6MWT for their population. Some of the earlier studies have used non-standardized variable protocols, therefore, the ATS in its guidelines has encouraged investigators to study and publish the reference values for 6MWT by using the standard protocol of the test as given in the ATS guidelines. The normal reference range of 6MWT cannot be applied universally on all populations as they are dependent on race, ethnic background along with height, weight, age and sex. As a result, it is imperative that normal reference values must be established for different populations. So far there has been little effort to find out the normal reference values for Pakistani population. There has been only one study from Karachi in this regard13. The objectives of this study were:

1.To establish the normal reference values for the 6MWT in healthy adult Pakistani population aged 20 to 60 years,

2.To study the influence of anthropometric & other variables on the normal values of 6MWD and thus formulate regression equations to predict reference value of this test,

3.To compare the values obtained from the Pakistani population with those obtained in other races mainly Caucasians.

METHODS:

Four hundred healthy volunteers between the ages of 18 and 80 years from either sex were enrolled in this descriptive, cross-sectional population based Study. The study was conducted in Lahore, a metropolitan city, the capital of Punjab province, Pakistan with an approximate population of 9 Millions. Participants were from different walks of life (teachers, office bearers, labourers, hospital employees etc). All subjects provided formal consent and were screened thoroughly by history and physical examination to ensure they are healthy. They were excluded from study if any one of the following was found: cardiovascular disease (CVD), respiratory disease / upper respiratory tract infection, Diabetes Mellitus (DM), smoking, spine disease, impaired cognition, neuromuscular disease, recent use of drugs affecting exercise capacity, claudication, lower extremity disease, participation in competitive sports, BP >140/90, HR > 100, Leg length difference >3cm, FEV1 < 80% predicted or FER < 70%. Demographic data, weight, height and leg length (both) were recorded for all individuals using standardized and calibrated scales and body mass index (BMI) for each subject was calculated. Subjects were asked to avoid caffeine, alcohol & consumption of a heavy meal for at least 2 h prior to testing and strenuous physical exercise in the previous 24 h.

They were further asked to wear light clothing & comfortable shoes during test. Tests were conducted between 3:00 p.m. and 8:00 p.m. Before starting test subjects were required to take rest for 15 minutes and resting heart rate, blood pressure and oxygen saturation (SaO2) were measured during this period using the 506N3 Vital Signs Monitor (Criticare Systems, WI, USA). Subjects were introduced to a 10 point Borg scale and were asked to indicate their level of breathlessness and fatigue on this scale wherein each score (i.e., ranging from 0 to 10) is illustrated by a printed figure.

6MWT

Each subject performed a single 6MWT. Test was conducted in corridor of an air conditioned building on a 100 feet hallway, a walking course of 30 m, marked every 3 m; start/end of 60 m lap was marked by a bright red tape. Turn- around points were marked by cones, at start and at 30 m.

Before starting, the protocol of the test was explained to every participant like this: "walk as far as possible for 6 minutes and exert yourself. If you get out of breath or become exhausted, you may slow down, stop & rest as necessary. You may lean against the wall and resume walking as soon as you feel you can walk again. You will walk back & forth around the cones pivoting briskly around the cones without hesitation. Do not jog or run." A trained technician demonstrated all this by walking one lap himself and stayed near the starting line throughout the test observing silence. The technician used standard phrases of encouragement in a uniform tone of voice and told remaining time after every minute.

At the end of the test, heart rate, blood pressure, oxygen saturation and Borg scale value was measured for every subject. A single technician conducted and supervised all tests.

STATISTICAL ANALYSIS:

Data was analyzed using the statistical package for social sciences (SPSS version 16). Categorical variables like age group and gender were given as frequencies and percentages. Continuous variables like age, height, weight, BMI, Leg length, systolic and diastolic blood pressure (BP), heart rate (HR), change in HR, 6MWD, FEV1 and FVC were expressed as mean + SD. Student's t-tests were used to compare female and male subjects with respect to these continuous variables. 6MWD was correlated with age, height, weight, BMI, heart rate, FVC and FEV1 values for all patients using the Spearman rank correlation coefficient. A stepwise linear regression model was used to see if any of the above variables was independent predictor of 6MWD. Approximately 80% of the patients were randomly selected to find a predictive equation, remaining subjects being used as controls. Actual distance walked by the control group was compared with the predicted distance calculated by the equation to validate the regression equation. The mean 6MWD of the study population was compared to the mean distance calculated using each of the five previously published equations. A paired sample t-test was used to compare two means. $P < 0.05$ was considered statistically significant.

RESULTS:

A total of 400 individuals participated in study; 344 (86.0%) were males and 56 (14.0%) were females. Mean age of the patients was 32.42±10.33. Eighty (20%) subjects were selected as controls by random selection. Out of the remaining 320 subjects (study group), 279 (87.2%) were males and 41(12.8%) were females with mean age 32.66+ 9.90 (range 19-72). Mean age of women was 38.0±13.79 years and that of men was 31.88± 8.96. Mean value of height for men was 170.91±6.23 cm and that for women was 156±6.92 (p=0.001). Mean value of weight for men was 72.08±11.50 Kg and the same for women was 59.59±21.68 (p=0.001). Other baseline characteristics of the study group, categorized on the basis of gender, are summarized in Table 1. Overall 6MWD of the study population was 855.78+ 107.01 m. Distance walked in 6 minutes for men was 875.01±86.7 m and that for women 724.95±137.41 m (P=0.001).

We observed significant positive correlations of the 6MWD of 320 cases with height (i.e., r= 0.381, p =0.001) and weight (i.e., r= 0.206, p =0.001) and with the 6MWD of 80 controls (i.e., r= 0.821, p= 0.001). Important negative cor-

Table 1: Comparison of Men and Women with respect to baseline characteristic and 6MWD

Variables	Male n=279	Female n=41	P-value
Age (years)	31.88± 8.96	38.0±13.79	0.001*
Height (Cm)	170.91±6.23	156±6.92	0.001*
Weight (Kg)	72.08±11.50	59.59±21.68	0.001*
BMI	24.49±3.2	24.42±5.14	0.900
Leg length (Cm)	82.59±8.1	70.03±6.2	0.001*
Systolic BP (mmHg)	122.61±5.8	123.61±7.2	0.473
Diastolic BP (mmHg)	80.28±3.8	81.21±4.3	0.301
Base line pulse (bpm)	73.89±8.2	72.0±8.5	0.262
End of test pulse (bpm)	130.97±15.4	134.57±12.9	0.224
Change in heart rate (end of test HR-baseline HR)	57.07±18.38	62.57±17.84	0.135
6MWD (m)	875.01±86.7	724.95±137.41	0.001*

Figure 1: Mean 6MWD of the Study population with respect to the age groups.

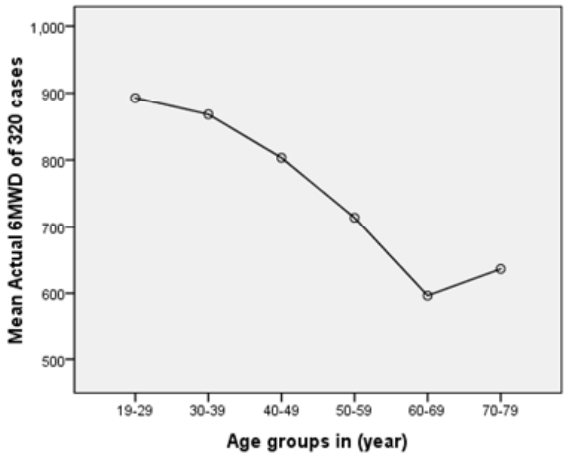


Figure 2: The difference between Actual 6MWD and predicted 6MWD of the control group.

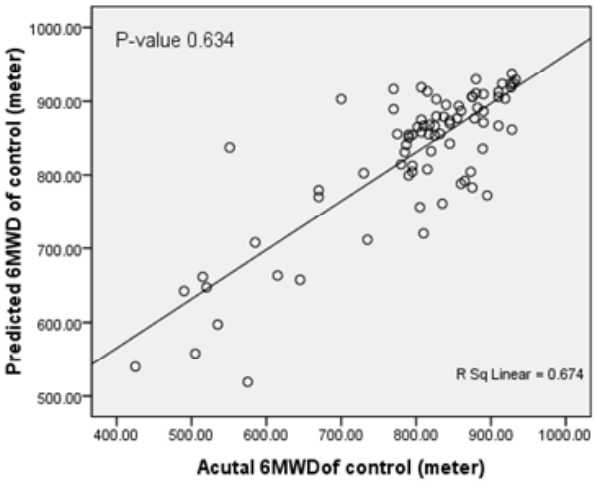
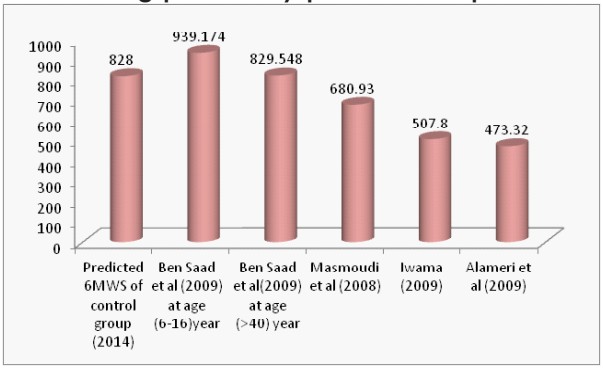


Figure 3: Comparison of predicted 6MWDs of the control group by our equation with those using previously published equations.



relations were female gender, age and change in heart rate (r = -0.469, p = 0.001; r = -0.549, p = 0.001; r =-0.369, p = 0.001 respectively) with the 6MWD of the 320 cases.

A reduction in mean 6MWD was observed with increasing age; 892.8 ±74.6 m in the age group 19-26 years versus 636.5±101in the age group 70-79 years (Figure 1).

Height (i.e., p= 0.001; 95% CI = 0.001 to 2.7), age (i.e., p= 0.001; 95% CI = -5.94 to -4.1) and sex of the subjects were used (i.e., p=0.001; 95% CI= -132.43 to -64.5) in a multiple linear stepwise regression analysis model to predict 6MWD. Approximately 66.7% of the variability in 6MWD was explained by these variables (i.e., r2= 0.667).

Based on the results of correlation and regression analyses, following equation was derived to predict 6MWD for both males and females:

6MWD = 895.69 – {5.03 x age (years)} – {98.48 x gender (male=1, female=2)} + {1.39 x height (cm)}.

This equation accurately predicted the distances walked by the control group i.e., measured 6MWD = 805.24±112.06 m and predicted 6MWD = 828.50±95.13 m; mean difference between measured and predicted distances being 23.26±56.0 m (P value = 0.634 , 95% CI = 10.46-36.06) (Figure 2).

Figure 3 compares the predicted 6MWD of our control group using our derived equation with the predicted 6MWD of the same group using five previously published equations. Predicted 6MWD appears to be underestimated for Pakistani population by most of the previously published equations; Masmoudi K et al.(2009) by 320.2±86.04, Al R.M et al.(2009) by 354±22.12 m (P-value < 0.001), IWAMA et al.(2009) by148.0 ±39.74 m (P-value < 0.001) Equations by Ben saad et al.(2009) overestimated this distance by 1.548± 20.0 m (P-value >0.05) in older subjects and by 111.17±143.3 m (P-value < 0.05) in younger subjects.

DISCUSSION:

This single centre observational study revealed that 6 MWD for Pakistani population cannot be accurately predicted by the currently available equations[14-18]. We used five such equations derived for different geographic and ethnic regions, namely North Africa[14,15] Tunisia[16] Brazil[17] and Saudi Arabia[18].

We found that most of the previous[16-18] equations under-estimate 6 MWD for Pakistani subjects (Fig.3); difference ranging from 147 to 355 meters.

One equation[15] (subjects' age > 40 years) gave similar results when applied to our control group. The other equation[14] by the same investigators (subjects' age < 40 years) over estimated 6 MWD in our control group. Our subjects were also relatively young (mean age 32.66 + 9.99). This is well explained by our observation that age is negatively correlated with 6 MWD (Fig.1).

We found men walked longer distance than women which is in accordance with the finding in published literature.[19] This can be explained by the fact that men had all the characteristics associated with longer walked distance i.e., young age, tall height, longer legs and less change in heart rate.

Some investigators have used average or maximum of the 2 or >2 walks while performing this test[17] while others used single walk distance.[18] Our subjects performed the test once and we used single reading for analysis and that is closer to the day to day clinical practice.

Another study on Pakistani population conducted in Karachi reported much lower values of 6 MWD: mean 6MWD 469.88 ± 101.24 m; 502.35 ± 92.21 m for men and 389.28 ± 74.29 m for women.[13]

This is surprising to have grossly different values of 6MWD from two areas of the same country. Casanova et al [19] have reported a similar observation. They administered 6MWT to 444 subjects from 10 geographic regions in seven countries (America and Europe) and found differences in 6MWD values not only between countries but also among different cities of the same country (Spain). They further noted that factors predicting 6MWD were different for different population groups and hence they could not derive a predictive equation uniformly applicable to all groups. Instead, they resorted to generate age-specific charts for men

and women. In this study, anthropometric factors alone could not explain geographic variations in 6MWD even after adjusting for the effect of effort using HRmax/HRmax % pred.

For the purpose of determining effect of different anthropomorphic characteristics on 6MWD, we used grading of correlation coefficient (r) proposed by Lacasse et al[20] whereby r = 0 - 0.20 is considered non-significant; r = 0.21-0.35 is weak; r = 0.36-0.50 moderate and r > 0.50 is strong correlation.

We found that age had the strongest correlation with 6MWD (r = - 0.549); 6MWD decreased with increasing age. This also explains the longer distance walked by our study participants (most of them being young) as compared to the distance reported by another study from our country.[13]

Age has bimodal relationship with 6MWD; for adult and elderly individuals, the correlation is negative[18,21,22] and for children and adolescents, it is positive. [14,23-26] Some studies have shown a strong correlation [22,24,25] like ours, while others have shown a moderate correlation[15,17,18,26-28] ; still others have reported significant correlation without giving strength of correlation.[21,29] As one grows older after adulthood, muscle mass and muscle power generally decreases with a consequent negative impact on 6MWD.[30,31] During first 2 -3 decades of life, one gains muscle mass and power with advancing age and hence a positive impact of age on 6MWD.

The second important factor was gender that correlated moderately with 6MWD (r = - 0.469); women walked less distance than men. This finding is in agreement with many published studies on adult population. [15,17,18,21,26,27,32,33] In one study on elderly subjects,34 men and women walked similar distance in 6 minutes when corrected by height. The difference in 6MWD of men and women appears to be due mainly to relatively higher muscle mass and strength in men.

The third determinant of 6MWD in our study was height having a moderate positive correlation (r = 0.381). Similar results have been consistently reported by other investigators; some studies report moderate correlation[17,18,24,26-28,32] just like our study, while others reported strong correlation. [14,15,22,25,33] Long steps with tall height can well explain this correlation.

A wide range of 6 MWD values has been reported in different ethnic populations. Almost every new study addressing this question has shown unreliability of previous equations for that specific population and derived a new regression equation. A multicenter study revealed that there was a statistically significant difference in 6MWD values among individuals from different geographic regions; minimum distance was 510+ 39 m (Venezuela) and maximum was 638+ 95 m (Brazil), p <0.001.[19] This difference could not be fully explained on the basis of anthropometric factors alone. Both countries are from Latin America and have minor differences in their ethnic origins. It is in accordance with our observation.

We conclude that 6 MWD for Pakistani population cannot be predicted by previously published equations and it may be different in different in different areas of the country. We feel that main value of 6 MWD is to follow the progression of disease or efficacy of some therapeutic intervention in a given individual by measuring it serially. We recommend that similar studies should be performed in different regions of Pakistan to validate the proposed equation for prediction of 6MWD.

Author's Contribution

KH: Conducted the study and wrote the article. AMA: Helped in conducting the study and was research coordinator.SM: Re-analyzed data, reviewed and corrected the article.AK,SAA and SQ data collction and helping in study.

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