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Six-Minute Walk Test Performance in Healthy Adult Pakistani Volunteers

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ORIGINAL ARTICLE

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ABSTRACT

Objective: To determine the six-minute walking distance (6MWD) for healthy Pakistanis, identify factors affecting 6MWD, compare published equations with the local data and derive an equation.

Study Design: Cross-sectional study.

Place and Duration of Study: Two medical institutes of Karachi, from January to May 2011.

Methodology: Subjects between 15 and 65 years were prospectively enrolled after screening. A standardized 6MWT was administered. SpO_2, HR, BP and dyspnoea scores were determined pre- and post-test.

Results: Two hundred and eleven (71%) men and 85 (29%) women participated. Mean 6MWD was 469.88 ± 101.24 m: men walked 502.35 ± 92.21 m and women walked 389.28 ± 74.29 m. On univariate analysis, gender, height, weight and age showed a significant relationship with the 6MWD. Gender and age were identified as independent factors in multiple regression analysis, and together explained 33% of the variance. The gender-specific prediction equations were: 6MWD (m) for men = 164.08 + (78.06*1) - (1.90*age in years) + (1.95*height in cms) 6MWD (m) for women = 164.08 - (1.90*age in years) + (1.95*height in cms).

Conclusion: 6MWDs among the volunteer subjects were shorter than predicted by reference equations in literature. Height, gender and weight combined explained 33% of the variance. The moderate over-estimation of the 6MWD in Pakistani subject. The proposed equation gives predicted (mean) 6MWDs for adult Pakistani naïve to the test when employing standardized protocol.

Key Words: *Healthy subjects. Pakistani. Six-minute walking distance.*

INTRODUCTION

Exercise testing is increasingly utilized in clinical practice to optimize patient management and acquire valuable functional and prognostic information not obtainable through static cardiopulmonary measurements. A range of exercise testing protocols are available for this purpose; among them walking distance is an economical and expeditious gauge of functional ability.[1] It provides a comprehensive assessment of all the mechanisms involved during exercise including the cardiovascular, respiratory, neurolocomotor and the metabolic systems.

Walking is the natural advancement of a subject through space with minimal mechanical and physiological expenditure. Six-minute walk test (6MWT) in this respect is a simple, low tech, easy to perform reproducible test.[1,2] It entails measuring the maximal distance that a subject can travel during a self-paced walk on a flat hard surface over a 6 minutes period. It has shown to reflect the capacity to undertake day-to-day activities and correlates well with health related quality of life scores.[3] Additionally, among patients with moderate to severe COPD,[4] and congestive heart failure,[5] the total distances covered during the 6MWT has shown a moderately strong correlation with the peak oxygen uptake measured during an incremental cycle ergometry test.

A reduction in walking distance is frequently multi-factorial and may result from a varied set of disorders that afflict a series of physiological variables engaged during exercise.[6] It is the enormity of these factors that make the assessment of walking capacity useful in such a wide-ranging and diverse set of situations. However, the most valuable clinically important indications remain; measuring and comparing outcomes pre- and post-treatment, evaluation of functional status and predicting morbidity and mortality.[2]

A potential limitation in the application of 6MWT is the dearth of reference values for a variety of race/ethnic groups in both genders and across a wide range of ages,[7] which could prove useful in evaluating disability, prognosis, conducting research and judging therapeutic interventions. Moreover, there is evidence supporting a variation in 6MWD among different population groups and within ethnic/racial groups. For example, healthy African-Americans have shown to walk on average 40 m less than white Americans after correcting for age,

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gender, height and weight.[9] It is, therefore, plausible that such diversity also exist among different South East Asian populations.

As far as we are aware, there is no published data on the normal 6MWD for South East Asian community. The purpose of this study was to: (a) measure the distance covered by a healthy Pakistanis adult in six minutes; (b) provide insight into physiological determinants of the 6MWD; and (c) derive and compare (with published literature) a predictive equation.

METHODOLOGY

This twin-centre study was conducted at The Ojha Institute of Chest Diseases (OICD) and The Aga Khan University Hospital (AKUH), Karachi, from January to May 2011.

The study was conducted in compliance with the 'Ethical Principles for Medical Research involving Human Subjects' of Helsinki Declaration.[9] Written, informed consent was obtained prior to participation. The Hospital Ethics Committee approved the research protocol.

This prospective study randomly enrolled volunteering healthy Pakistani individuals aged between 15 – 65 years. The subjects included staff members at the two hospitals, attendants of patients and personnel undergoing routine employment and health screening at various hospital clinics.

The exclusion criteria were a history or symptoms suggestive of a chronic medical condition; > 10 pack years of smoking; BMI > 30 and any 6MWT contraindications.

Physicians in training, who were specifically instructed, conducted a structured screening interview immediately prior to enrollment in an attempt to investigate and confirm self-reported health status. Standing height was measured bare foot using a calibrated stadiometer. Weight was obtained without shoes and in light clothing. BMI was calculated. Pulse rate, sitting BP, pulse oximetry and dyspnea scores employing modified Borg dyspnea scale,[10] were measured pre- and post-6MWT.

A standardized protocol based on published guidelines was used in the conduct of the 6MWT.[2] In summary, subjects were instructed to walk along an 18-meter flat straight well lit marked hard 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. All participants performed the test alone, were naive to the 6MWT and were given identical instructions before and during the test.

All analyses were conducted by using the Statistical Package for Social Science (SPSS) version 17.0. All p-values were two sided and considered as statistically significant if < 0.05.

A descriptive analysis was done for demographic features and results are presented as mean ± standard deviation for quantitative variables and number (percentage) for qualitative variables. The difference of means amongst the gender was assessed by two-tailed t-test and differences of 6-minute walk test among different age groups were assessed by using one-way analysis of variance (ANOVA). Univariate associations of 6MWD with continuous measures of age, gender, weight, height, BMI, heart rate, BP were assessed by univariate regression analysis. Variables significantly associated with 6-minute walk test in univariate analysis were further included together in multiple linear regression model. The impact of individual factors, was expressed as a β-coefficient, Standard error of β-coefficient and associated p-value. To determine the association between 6-minute walk test with weight and height were assessed by Pearson correlation coefficient (r).

The mean or gender specific mean (where applicable) 6MWD in this study was compared with 6MWD predicted from six published equations.[11-16] Difference between actual 6MWD and predicted 6MWD for each equation was calculated. Regression and correlational analyses were used to calculate the slope, intercept, t-ratio and resulting standard errors when actual values for 6MWD were regressed on predicted 6MWD values. Scores (ε) for each equation were calculated by:

$$\varepsilon = \sqrt{\gamma — \check{y} / \acute{\eta}} \quad [24]$$

Where "γ" is the actual 6MWD, "ў" is the predicted 6MWD and "ή" the sample size. All p-values were two sided and considered as statistically significant if < 0.05.

Table I: Anthropometric and physiological characteristics of the study population.

Characteristic	All subjects (n = 296) Mean ± SD	Men (n = 211) Mean ± SD	Women (n = 85) Mean ± SD	p-value
Age (years)	37.38 ± 12.77	36.86 ± 12.34	38.67 ± 13.77	0.27
Height (cm)	164.09 ± 10	168.72 ± 6.53	152.60 ± 6.62	< 0.001
Weight (kg)	61 ± 11	63.67 ± 9.45	54.35 ± 10.85	< 0.001
Body Mass Index (kg/m^2)	23.29 ± 4.33	23.21 ± 4.45	23.50 ± 4.05	0.60
Resting systolic BP (mm Hg)	117 ± 11.14	117.97± 10.49	114.32 ± 12.34	0.02
Resting diastolic BP (mm Hg)	75.45 ± 7.71	75.81 ± 7.07	74.53 ± 9.13	0.26
Heart rate (beats/min)				
Pre-walk	81.84 ± 9.95	80.69 ± 9.82	84.71 ± 9.76	0.002
Peak post-walk	89.43 ± 13	87.79 ± 12.87	93.50 ± 12.33	0.001
SpO_2 (%)				
Pre-walk	97.51 ± 1.26	97.52 ± 1.30	97.49 ± 1.18	0.89
Post-walk	97.57 ± 1.39	97.39 ± 1.47	98.02 ± 1.04	< 0.001
Modified Borg dyspnea scores				
Pre-walk	0	0	0	0
Post-walk	0.21 ± 0.57	0.22 ± 0.51	0.19 ± 0.69	0.70

Student t-test

Table II: 6MWDs for the study participants .

Variable	Number	Mean* ± SD	Range*	p-value**
All subjects	296	469.88 ± 101.24	756 – 180	
Men				
All	211	502.35 ± 92.21	756 – 252	< 0.001
15 – 25 years	41	515.85 ± 92.80	684 – 288	
26 – 35 years	71	527.94 ± 81.43	756 – 360	
36 – 45 years	49	510.61 ± 83.72	720 – 360	
46 – 55 years	28	463.82 ± 104.68	702 – 288	
56 – 65 years	22	425.18 ± 73.98	540 – 252	
Women				
All	85	389.28 ± 74.29	612 – 180	0.08
15 – 25 years	20	419.40 ± 73.43	612 – 306	
26 – 35 years	14	413.07 ± 61.12		
36 – 45 years	24	369.75 ± 73.73	576 – 270	
46 – 55 years	18	376.50 ± 75.12	504 – 270	
56 – 65 years	9	363 ± 76.89	180 – 432	

** meters; **one-way analysis of variance (ANOVA).*

Table III: Univariate analysis of participant variables and 6MWD.

Variable	Coefficient (SE)	p-value
Gender		
Women	Reference	
Men	113.06	< 0.001
Weight (kg)	(11.23)	< 0.001
Height (cm)	2.0 (0.53)	< 0.001
Age	5.0 (0.52)	< 0.001
BMI	-2.30 (0.44)	0.30
Resting systolic BP	-1.39 (1.35)	0.92
Resting diastolic BP	0.05 (0.54)	0.52
Pre-walk heart rate	-0.50 (0.79)	0.27
Post-walk heart rate	-0.64 (0.59)	0.34
Pre-walk SpO_2	-0.42 (0.45)	0.34
Post-walk SpO_2	-4.36 (4.65)	0.01
Post-walk modified Borg dyspnea scores	-10.04 (4.19)	0.07
	-19.07 (10.58)	

RESULTS

Three hundred and seventeen subjects underwent the pre-enrolment screening assessment. Twenty one were excluded (undiagnosed hypertension, BMI > 30, > 10 pack years of smoking, declined consent). Two hundred and ninety six individuals completed the study protocol. Two hundred and eleven (71%) were men and 85 (29%) women. Table I summarizes the anthropometric characteristics of the study population. When compared to women, men were significantly taller and heavier (Table I), and had a lower pre- and post-walk heart rate (Table I). There were no statistically significant gender differences in BMI, pre-walk SpO_2 and dyspnea scores (Table I).

The mean 6MWD for all participants was 469.88 ± 101.24 m (ranging from 180 m - 756 m). In men, it was 502.35 ± 92.21 m and in women 389.28 ± 74.29 m (Table II). Men aged > 45 years in the study cohort walked a significantly shorter distance than their younger counterparts ($p < 0.001$) and similarly, women aged > 35 years walked shorter distances compared ($p=0.005$) to their younger contemporaries (Table II).

Twenty four subjects reported minimal leg fatigue (score = 1) on conclusion of the 6MWT. However, no participant required a rest period.

On univariate linear regression analysis gender, weight, height and age showed a significant relationship with the 6MWD (Table III). 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 (Figure 1).

Gender and age were identified as independent factors towards the 6MWD in multiple regression analysis, and together explained 33% of the variance.

Table IV: Comparison of the 6MWDs predicted from six equations to actual values.

Equation	Predicted (m)	Difference^ (m)	t-ratio analysis	Regression analysis		
				Intercept	Slope	Error (m)
Poh[12]	775.49	-305.61	11.41*	236	0.30	467.25
Enright[11]			12.74*	214.83	0.38	467.64
Male	671.12	-168.77				
Female	641	-251.72				
Cheetta[13]			37.66*	-210.28	1.11	467.82
Female	561.31	-172.03				
Male	625.63	-123.28				
Troosters[14]			33.24*	63	0.51	467.21
Male	826.25	-323.9				
Female	699.15	-309.87				
Gibbons[15]			40.72*	-289.20	1.03	467.39
Male	758.59	-256.24				
Female	678.47	-289.19				
Camarri[16]			58.10*	-272.77	0.99	467.35
Male	774.30	-271.95				
Female	681.39	-292.11				

*^ Difference between the actual 6MWD (mean 469.88 m, men 502.35 m, women 389.28 m) and predicted 6MWD; * Significantly different p < 0.05*

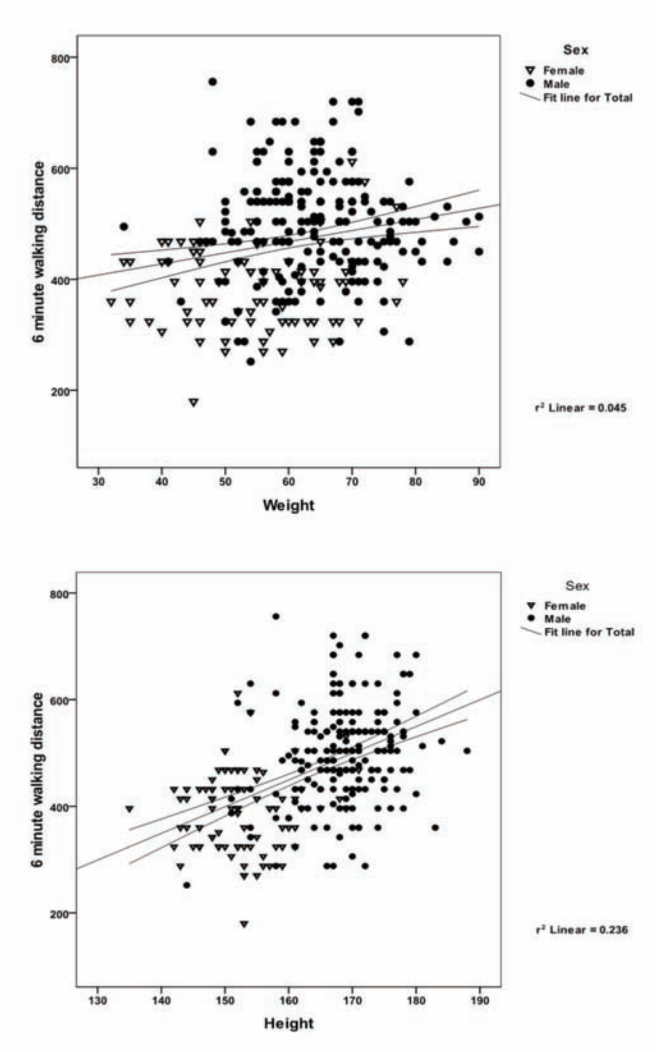

Figure 1: Individual data showing the relationship between the 6MWD, weight and height in males and females (r^2 = coefficient of determination).

The regression equation predicting 6MWD in the local population is:

$$y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \varepsilon$$

With an intercept term (β_0), slope parameters (β_1, β_2, β_3), one dichotomized variable of gender (X_1, X_1= '0' if the subject is female, and '1' if male).

The sex-specific prediction equations are: 6MWD(m) for men = 164.08 + (78.06*1) - (1.90*age) + (1.95*height in cms) 6MWD(m) for women = 164.08 - (1.90*age) + (1.95*height in cms).

DISCUSSION

To the authors' knowledge, this is the first reported data from a Southeast Asian country in literature on reference values and factors influencing 6MWD among healthy local adults. In the present study the mean 6MWD was 469.88 ± 101.24 m. For men it was 502.35 ± 92.21 m and for women 389.28 ± 74.29 m. Age and gender were the significant independent predictors of 6MWD and together accounted for 33% of the variance in the distance walked.

There is considerable variation between published references for 6MWD. Among Asian population studies, Poh demonstrated that the mean 6MWD for healthy Singaporean men and women (mean age 61 years) was 580 m and 538 m respectively.[12] Similarly, for a healthy cohort of Japanese men and women (mean age 65 years) Takishima, reported a mean 6MWD of 572 m and 504 m.[17] Teramoto, a mean value of 624 m and 541 m respectively.[18] For Caucasian based studies, Troosters (mean age 65 years),[14] and Enright (mean age 67 years)[18] published a mean 6MWD for a healthy cohort of 673 m and 400 m for men and 589 m and 367 m for women respectively. A study from Tucson, USA on 290 healthy adults (mean age 60 years) demonstrated a 6MWD of 466 m for men and 544 m for women.[11] Similarly, Rikli in 7183 senior men and women reported values of 689 m and 624 m respectively.[19] Several factors that have been put forward in explaining this wide variation in the published data include difference in race and ethnicity, subject selection and testing methodologies.

A comparison of the authors' 6MWT predictive equation with six widely accepted equations in Pakistani population,[11-16] generally showed that they were prone to significant errors and moderately overestimated the 6MWT distance. This missinterpretation ranged from a maximum of -341 m to a minimum of -124 m for men and a maximum of -331 m and a minimum of -181 m for women (Table IV).

There are several potential explanations for these discrepancies. First in terms of testing strategy, the length of the walking course i.e. 18 m, meant that subjects had to turn more frequently and thereby also consume more time in reversing directions, leading to a shorter 6MWD. Although, American Thoracic Society (ATS) recommends 30 m walking course,[2] investigators have employed corridors ranging from 15 m to 50 m in published studies.[14,20] Second, a learning effect of repeat testing or a practice session has been demonstrated to significantly impact the 6MWD in previous studies.[14,15] An ATS review of published data reported this to be from a mean of zero to 17%.[6] Since these subjects were naive to the walk test and were not allowed a practice session, this impacted the distance covered in six minutes by our cohort. A third factor would be subject-related differences in terms of racial characteristics, motivation and psychological factors, exercise habits, coordination and nutritional status.

Analogous to previously published data,[11,12,14,15] the physiological determinants of height and weight showed a direct, whereas age, an inverse correlation with 6MWD in our subjects. A plausible explanation for a taller person would be the taking of longer length strides resulting in less time spent in contact with the ground plus shorter periods supported by two legs, thereby improving gait efficiency. Similarly, a heavier individual would require additional energy while ambulating to support an enlarged body mass (increase in adipose tissue rather than muscle mass) and thereby curtailing the maximal level of effective work.[21] Moreover, an inverse relation between advancing age and 6MWD most likely represents a combination of loss in the skeletal muscle strength, mass and quality in the elderly.[22]

In contrast to Enright and Poh who failed to show a significant gender difference in 6MWD in Singaporean and Caucasian populations,[8,12] the authors found a statistically significant difference in 6MWD between males and females (Table III). This inconsistency is most likely due to the dissimilarity in the age ranges and presence or absence of co-morbid conditions among the study populations. Additionally, the influence of gender on the walked distance could be explained in physiological terms by the differences in heart rate and VO_2 response, systolic BP changes, plasma lactate levels, respiratory exchange ratio and shifts in plasma volume during exercise.[23,24]

The post-walk peak heart rate in our cohort was relatively lower compared to previous reports. Although, in broader terms, several interlinked factors such as psycho-social, physiological and genetic variations may explain these differences and the ultimate levels of exercise, a major contributor is likely to be the low priority given to regular exercise in Pakistani society. This sedentary life style is likely to have the impact on peak heart rate and 6MWT of the studied subjects by affecting their perceptions of physical fitness, self-efficacy (judgment of own capacity), motivation and the familiarity with and performance during physically demanding situations.

Some of the strengths of this study are that randomly selected healthy individuals were enrolled who underwent medical screening by trained physicians and included a wide age range from a geographically-related population group not studied previously. Additionally, these subjects were chosen from an ethnically diverse community of Karachi, representing a range of socioeconomic and occupational status. These findings should, however, be interpreted with the certain cautions, as the subjects were volunteering adults, which may have ascertained a group who was well motivated and healthier, thus resulting in a recruitment bias. Moreover, carbon monoxide levels in these volunteers were not determined, as low level exposure has shown to curtail exercise ability in healthy individuals.[25] Furthermore, information on physical activity level of the individuals was not collected in this study which has shown to effect exercise capacity.

CONCLUSION

6MWT is a simple, inexpensive test that can be safely performed in the outpatient setting. The mean 6MWD in the studied cohort was considerably shorter than previously published references. Gender, age and height were the most significant independent physiological determinants of 6MWD, and a predictive equation based on these variables explained 33% of the total variance. Future studies with larger numbers incorporating models to unravel the 6MWD relationship with habits, mood, genetic factors in addition to cognitive and psychological perspectives are warranted.

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