Six-Minute Walk Test: Reference Values For Healthy Young Adults In Malaysia

Padmavathy K.M*, Rohith Sharan Sankaran, Tujuba Jergefa Oncho***, Gurmessa Enkossa Ayana****, Varun Roshan Sankaran*******

*Professor , School Of Medicine, Wollega University, Nekemte, Ethiopia, ** MD General Medicine V[th] Course, Yerevan State Medical University, Armenia,***Assistant Professor, School Of Veterinary Medicine, Wollega University, Nekemte, Ethiopia, ****Dean, School Of Medicine, Wollega University, Nekemte, Ethiopia, *****MD General Medicine Iii[rd] Course, Yerevan State Medical University, Armenia

Abstracts: Background: The six-minute walk test (6MWT) is a submaximal exercise test used to assess functional capacity of cardiorespiratory status in clinical practice and research. Objectives: The six-minute walk distance (6MWD) and six-minute walk work (6MWw) were compared among both genders of second year medical students and derived regression equation separately. Methods: The 6MWT was administered to 164 healthy subjects (83 male) aged between 19-21 years. Their anthropometric measurements and BMI were compared between genders. Predicted equation for 6MWD was derived using independent predictors by multiple linear regressions. Results: Among the genders the height, weight, chest expansion and 6MWw were significantly ($p<0.0001$) different but 6MWD was not significantly different ($p>0.05$). The 6 MWD and 6MWw were greater in males than in females (605.5 ±119.8m, 39845.3±1315.0kg.m vs 574.2±117.4m, 32868.2±8923.4kg.m). The 6MWD was significantly correlated with height (r2=7.65%; p=0.01), weight (r2 =5.66%; p<0.05) and chest expansion (r2 =5.9%, p<0.05) in males. The reference equation for 6 MWD in healthy young adults of Malaysian population is 441.08+0.529xheight(cm)+0.646xweight(kg)+2.601xchest expansion(cm) for females and 60.058+2.367xheight(cm)+0.780xweight(kg)+18.035xchest expansion(cm) for males. Interpretation & Conclusion: The significant correlation of height, weight and chest expansion explains the increase in 6MWD in males. Reference values explaining a high proportion of the variance were derived by multiple regressions among healthy young adults in Malaysia. [Padmavathy M, Natl J Integr Res Med, 2018; 9(3):66-70]

Key Words: Exercise test, Reference values, Six minute walk distance, Anthropometry, Regression analysis.

Author for correspondence: K. M. Padmavathy, 171/69 N.M. K. STREET, Ayanavaram, Chennai -600023, Tamilnadu E-Mail: kmpadmavathy@gmail.com M: 7338972787

Introduction: The six-minute walk test (6MWT) is a simple tool for the evaluation of functional capacity of the individual to perform daily activities. The demographic, anthropometric, clinical, and physiological characteristics can affect the test performance in healthy subjects and in patients with cardiopulmonary diseases [1,2]. Since the 6MWT is a self-paced test, the results are influenced by external factors such as energy expenditure, verbal encouragement and subject motivation, accordingly the six-minute walk distance (6MWD) varies widely even among healthy subjects [3,4]. Therefore, the instructions and the level of verbal encouragement given must be carefully standardized [1]. The American Thoracic Society (ATS) recommends that researchers to establish specific reference values for each population [1]. Recent studies have defined 6MWT reference values for various populations [5,6,7,8,9]. It has been suggested that six-minute walk work (6MWw), which is the product of 6MWD and body weight, can be used as an alternative means of measuring functional walking capacity[10]. In patients with chronic obstructive pulmonary disease, the 6MWw has demonstrated better sensitivity and specificity in identifying exercise intolerance than has 6MWD [11]. Hill et al.[12] described 6MWw as an appropriate variable for estimating maximal exercise capacity in chronic obstructive pulmonary disease patients during an incremental cycle ergometer test.

However, no previous studies shown regression equations for predicting 6MWD among Malaysian young adults, it is imperative to establish such equations for both genders. In the present study, we assessed 6MWD and 6MWw in a population-based sample of healthy young adults and established a reference equation to predict 6MWD based on anthropometric measures and BMI.

Methods: We studied 164 healthy subjects of second year medical students (83 males) of AIMST University, Malaysia aged between 19-21 years. After obtaining permission from Institutional Ethics committee and the written informed consent, the personal details of participants were collected in a questionnaire. The total body mass (kg) and body height (cm) were measured according to standard techniques with the subjects wearing light clothing and no shoes [13]. The body mass index (BMI) was calculated; underweight (<18.5 kg/m2), normal weight (18.5-24.9 kg/m2), overweight (25-29.9 kg/m2), and obese (>30 kg/m2) [14]. Chest measured at the level of nipple (IV[th]intercosal space) using measuring tape at the end of maximal deep inspiration and at the end of maximum forced expiration to derive chest expansion by their difference[15]. The subjects with normal spirometry values were included, FEV1>80% predicted, FVC>80% predicted and FEV1/FVC > 70% [16]. Inclusion criteria included healthy subjects defined as absence of any cardiopulmonary diseases and absence of any acute illness in the preceding six weeks. We excluded smokers and individuals with abnormal lung function on spirometry.

6MWT was performed according to the standardized protocol of American Thoracic Society between 09:00 to 13.00 hours in order to avoid intra-day variability [1]. After an adequate rest of 15 minutes subjects were instructed to walk as far as possible at their own pace for six minutes undisturbed in a 30 meter straight corridor which was marked at every 3 meter interval. Standardized encouragement was provided e.g., “You are doing well”, “Keep up the good work”. They were informed that they could stop if they developed symptoms of dyspnoea, dizziness, leg cramps or chest pain, but resume to walk as soon as they could[1]. All subjects performed the test for the first time without any practice or warm up. At the end of the test the 6MWD covered during the test was recorded. The number of laps and any additional distance covered were recorded. The best value out of three performances with 15 minutes interval between the walk was considered for this study. 6MWw (product of 6MWD and body weight) was calculated.

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 20. Variables are described as mean and standard deviation (Mean ± SD) for normally distributed continuous variables. Independent t-test was used to study differences between the genders. Using Pearson’s correlation coefficient to evaluate the correlation of age, height, weight, chest expansion, BMI and gender as independent variable; and six - minute walk distance (6MWD) as dependent variable. Stepwise multiple regression analysis was used to evaluate independent variables explaining the variance in 6MWD and generated the prediction equation for 6MWD. A p-value of <0.05 was considered as being statistically significant.

Result: Of the 164 subjects, 83(51%) were males aged between 19-21 years. The mean±SD of variables: height, weight, BMI, chest expansion, six-minute walk work (6MWw) and six-minute walk distance (6MWD) of both genders were shown in Table 1. The height, weight, chest expansion and 6MWw were statistically (p<0.001) different in both genders. The 6 MWD did not show significant difference between genders.

The 6MWD and 6MWw were greater in males than in females (605.5±119.8m, 39845.3±1315.0kg.m vs 574.2±117.4m, 32868.2±8923.4kg.m). The 6MWw correlated significantly (p<0.0001) with height, weight and BMI in both genders, but chest expansion had significant correlation (r2 =10.12%; p<0.01) only in males (Table 2).

Table:1 Mean and standard deviation ofcharacteristics of the study subjects

Variable	Females (n = 81) Mean±SD	Males (n = 83) Mean±SD	Total (n-164) Mean ± SD
Height (cm)	162.0±5.29	171.4±8.07	166.7±6.68*
Weight (kg)	57 .1±9.81	65.2±13.87	61.2±11.84*
BMI(kg/m2)	21.7±3.19	22.0 ± 3.52	22.0±3.36
Chest Expansion (cm)	4.0±0.74	4.9±1.07	4.45±0.91*
Six minute walk Distance(m)	574.2± 117. 4	605.5 ± 119.8	589.9±118.6
Six minute walk work (kg.m)	32868.2 ± 8923.4	39845.3 ± 1315.0	36356.8± 11037.2#

p values: # = very highly significant (p<0.001); * = very very highly significant (p < 0.0001)

Table:2 Univariate correlation coefficient for six minute walk work of both genders

Variables		Female (n = 81)		Males (n=84)	
		r2 (%)	p	r2 (%)	p
Six minute walk work (6MWw)	Height (cm)	13.21	< 0.001	34.19	<0.0001
	Weight (kg)	46.45	<0.0001	66.39	<0.0001
	BMI (kg/m2)	38.72	<0.0001	51.04	<0.0001
	Chest Expansion (cm)	NS	NS	10.12	<0.01

(NS = not statistically significant; p<0.01, p<0.001, p<0.0001 statistically significant)

The 6MWD significantly correlated with height ($r2 = 7.65\%$; $p=0.01$), weight ($r2 = 5.66\%$; $p<0.05$) and chest expansion ($r2 = 5.9\%$; $p<0.05$) in males. The 6MWD significantly correlated with 6MWw in both females and males ($r2=59.07\%$; $p<0.001$ vs $r2=54.3\%$; $p<0.0001$). The variables of height, weight and chest expansion to be the independent predictors, the predictive equation of 6MWD was derived for both genders separately. The multiple regression equation derived from this study was: 6MWD=441.08+0.529xheight(cm)+0.646xweight(kg)+ 2.601xchest expansion(cm) for females; 6MWD=60.058+2.367xheight(cm)+0.780xweight+18.035xchest expansion(cm) for males.

Discussion: The present study is to investigate predicted values and potential demographic and anthropometric determinants of 6MWD in Malaysian young adults and to propose a predictive equation. Reference equations would permit a more appropriate evaluation of Malaysian patients with chronic diseases that affect exercise capacity. Since we adhered to the guidelines for the 6MWT established in 2002 [1], we believe that the results of the present study contribute to facilitating the international comparison of 6MWD values.

In our study, the height, weight and chest expansion significantly influenced the 6MWD of male subjects and these variables were significantly different from females. In previous studies, mostly the age and the gender were selected as determinants of 6MWD after multiple regression analysis [17,18]. The negative influence of increasing age on the 6MWD might be explained by the gradual reduction in muscle mass, muscle strength and maximal oxygen uptake. The influence of gender on 6MWD might be attributable to the greater absolute muscle strength, muscle mass and height of males as compared to females. In our study, on univariate analysis, height ($r2= 7.65\%$; $p=0.01$), weight ($r2=5.66\%$; $p<0.05$) and chest expansion ($r2= 5.90\%$; $p<0.05$) showed a significant relationship with the 6MWD among males. Our finding showed that influence of height to 6MWD, agrees with the correlations between height and 6MWD reported by others[3,4,6,18]. The height can be attributed to the greater walk length of taller individuals, being a major predictor of gait speed [19]. The potential sources of 6MWD variance other than age, gender or height include psychological status related to exercise capacity in patients with pulmonary disease [1], peripheral muscle conditioning[2,20] and in pulmonary function[21]. The chest expansion explains the muscle strength and maximum oxygen uptake indicating pulmonary function that influenced 6MWD in our study.

In our study the mean 6MWD was 574.2±117.4 meters; males walked 605.5±119.8 meters and females 589.9±118.6 meters and was not significantly different between genders. In contrast, another Asian study with healthy Western India population the 6MWD was significantly different in both genders ($p=0.001$) and correlated with age, height and weight in univariate analysis and the reference equation was derived with age and gender [22]. Similarly in another study by Vaish et al among Indian young adults, the males walking 76.50±10.87meters ($p<0.0001$) farther than females and observed significant correlations with age and height, but not weight, leg length, BMI [23]. Similarly 6MWD differs significantly among Pakistani subjects in both genders (men walked 502.35 ± 92.21 m and women walked 389.28 ± 74.29 m), the separate predictive equation was derived from age and height for each gender separately [24].

We found only a weak correlation between BMI and 6MWD. But BMI showed significant correlation with 6MWw in females and males ($r2 = 38.72\%$; $p<0.001$ and $r2=51.04\%$; $p<0.0001$ respectively) (Table 2). This correlation has been previously shown to be nonlinear, as obesity increases 6MWw, 6MWD being shorter in subjects with greater body weight or higher BMI [2]. In contrast, the study among Nepal subjects above 18 years showed contribution of body mass index for prediction of 6MWD in addition to age, gender, weight but height had the least significance [25]. Among Singaporean Chinese adults, 6MWD was not significantly different between men and women, similar to our study. In addition to age, height, weight, the % predicted heart rate maximum was the independent contributor to 6MWD[6]. In contrast, the 2MWD conducted among adults of 40-75 years in Malaysia showed significant difference among genders ($p < 0.001$) and regression equations were derived using age, gender and change in heart rate [26]. Similar to Asian studies, the study among Arab population showed that males walked longer distances than by females ($p<0.001$) and equation was derived from age and height[27]. Our study subjects were within the normal range of BMI and both genders did not differ significantly. Among Brazilian adults, the equation derived from height, age and BMI valid for both genders but the 6MWD values were not significantly different in both genders [28,29]. Similar findings showed in Korean adults but height to be the single independent predictor of 6MWD[30].

In this study, the variables of height, weight and chest expansion to be the independent predictors, equation derived for 6MWD in both genders separately as follows: 6 MWD = 441.08 +0.529 x height(cm)+ 0.646 x weight(Kg) + 2.601 x chest expansion(cm) for females; 6 MWD = 60.058 +2.367 x height(cm)+ 0.780 x weight(Kg) + 18.035 x chest expansion(cm) for males. The estimated 6MWD using this formula was 605 meters and 580 meters in males and females respectively. In our study, the height, weight, BMI influenced the 6MWw (Table 2). In fact, 6MWw has been shown to correlate with changes in oxyhemoglobin desaturation during walking, with the anaerobic threshold and with maximal oxygen uptake [10]. Our results suggest that 6MWw is important for evaluating walking performance.

The limitation of our study was that we used convenience sample rather than a random sample and this can be validated in future studies. Moreover most studies have used convenience samples [2,7,9,28,29]. Other potent variables which have demonstrated their influence on exercise performance and may improve the variance of 6MWD like lean body mass, peripheral muscle strength, psychological factors and life style factors (Physical activity level). But the inclusion of such factors in an equation is time consuming as well as appears unpractical for routine clinical use especially in developing countries.

Conclusion: The specific reference values for 6MWD and6MWw will have the advantage of providing a benchmark for functional capacity assessment. We developed a reference equation for 6MWD for Malaysian young adult population. When compared to studies of reference equation from other Asian, Arab and Brazilian population we found that equations developed were using age, gender, height, weight, change in heart rate and BMI. Our study utilised chest expansion as one of the independent variable to derive the equation. Our reference equation may be used to evaluate exercise capacity in patients with chronic cardiopulmonary diseases in Malaysian young adult population.

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