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Research Article

Six Minute Walk Distance and Six Minute Walk Work in Young Adults Aged 18-25 Years

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ABSTRACT

Background: Previous studies have demonstrated that reference equation for six minute walk test (6MWT) derived from one population did not appropriately predict the six minute walk distance (6MWD) in another population. The outcome of 6MWT can also be stated in terms of six minute walk work (6MWw). Objective: The present study aimed to: study the normal values, to investigate the factors influencing the 6MWD and 6MWw; to develop prediction equation for 6MWD in young Indian adults aged 18-25years. Method: After initial screening and physical examination 6MWT was conducted in subjects aged 18–25years. 6MWw was calculated by the formula: 6MWw (Kgm) = Body weight (Kg) X 6MWD(m). Analyses and Result: Relationships between anthropometric data with 6MWD and 6MWw were examined by using Pearson's coefficient of correlation. 6MWDs and 6MWw were compared between males and females using unpaired t-tests. Stepwise multiple regression analysis was performed to develop prediction equations. A probability (p) value < 0.05 was regarded as significant. Mean 6MWD and 6MWw were 564.75±81.2 m and 29557.99 ± 6457.24 Kgm respectively. Predicted 6MWD (m) [males] = 681.97 -19.99 x age (years) + 2.06 x height (cm). Predicted 6MWD (m) [females] = 856.55-16.08 x age (years). Anthropometric characteristics had significant correlation with 6MWw. Conclusion: Specific reference values for 6MWD and 6MWw will provide realistic benchmark for functional capacity assessment. The prediction equations for the 6MWD in young Indian adults can facilitate the assessment of patients with diseases influencing their exercise capacity. 6MWw can be considered for evaluation of walking ability.

1. INTRODUCTION

Field walking tests play an important role in evaluation of functional exercise capacity**[1]**. The six minute walk test (6MWT) is a self paced functional walk test that assesses the sub-maximal level of functional capacity and requires only the ability to walk**[2]**. The test measures the distance that a participant can quickly walk on a flat, hard surface in a period of six minutes known as the six minute walk distance (6MWD)**[3]**.

Numerous studies have been conducted globally for establishing reference values and prediction equations to interpret the test results in healthy subjects**[4-13]**. Certain studies have demonstrated that the equation derived from one population did not correctly predict the 6MWD in another population**[9-13]**. Ethnic and geographic dissimilarities have been reported as some of the factors responsible for the discrepancies in 6MWD**[13]**.

Body weight directly affects the work/energy required to perform the 6MWT. The outcome of the 6MWT can also be stated in terms of work**[1]**.Six minute walk work (6MWw) is the product of 6MWD and body weight**[7]**.It has been suggested that 6MWw can be used as a substitute means of measuring functional walking capacity**[14]**. Limited literature is available on the 6MWT reference equation for Indian subjects**[13,15,16]**. In the studies conducted in India and involving adult individuals, the predicted 6MWD was determined considering only age greater than 25 years**[13,15,16]**. As per our knowledge literature is scarce regarding normal values for 6MWw and factors affecting it worldwide. The present study aimed to study the normal values of 6MWD and 6MWw in subjects aged 18 - 25 years; to investigate the influence of age, anthropometric variables on 6MWD and 6MWw; to develop gender specific prediction equations for 6MWD in young Indian adults aged 18-25 years.

2. Materials and Method

The study was approved by the research and ethical committee of the institute. All subjects gave written informed consent to participate in the study.

Three hundred and eighty four (205 males and 179 females) asymptomatic normal young adult volunteers in the age range of 18-25 years were recruited from randomly selected six educational groups of institutions running professional courses located in Kanpur, India.

To calculate the minimum sample size needed in order to give the study sufficient statistical power, we used the following formula: N > 50 + 8m where m is the number of variables**[17]**. Given that there should be a separate equation for each gender and that height and age were independent

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variables, N > 50 + 16 for males, and N > 50 + 16 for females (i.e. total of 132 subjects were required for the study). A total of 1023 individuals were screened and out of that 384 individuals were selected for the study.

After initial screening and physical examination, the height and weight were measured and used to calculate BMI (Body Mass Index was calculated using the formula Weight/Height^2). Height was recorded using a height scale (Avery Healthcare, Northampton, UK); leg length was measured while standing and was taken from the greater trochanter of femur to the lateral border of the calcaneum; body weight was recorded using a beam balance scale (Equinox, New Delhi, India) that was calibrated every month. Subject's systolic and diastolic blood pressure (Digital Sphygmomanometer, HEM7111, Omron, Tokyo, Japan) were also recorded. History of orthopedic, cardiac or neurological disorder, or any surgical history, physical activities, smoking habits, and use of medication were self-reported.

The subjects were included if they met the following criteria: age 18-25 years; asymptomatic with stable vital signs; lifetime non smokers; BMI = 18.5 - 24.9 kg/m^2; absence of any disease in the 6 weeks preceding the study.

Criteria for exclusion from the study included resting heart rate (HR) ⩾100 beats per minute; systolic blood pressure >139 mmHg and diastolic blood pressure > 89 mmHg; individuals with any answer as yes in PAR Q and YOU questionnaire; having undergone thoracic surgery; use of medication or any health problem that might interfere with the normal ability of walking (such as impaired cognition or sensation, neurologic, metabolic, cardiac, or orthopedic disease, use of walking aids); having history of physician diagnosed cardiac or respiratory disease; having stayed, for one year or more, in environments in which the concentration of dust was high and there was a risk of developing respiratory disease; having a history of exposure to cigarette smoke in sleeping quarters; having a history of exposure to smoke from wood-burning stoves, having history of tobacco use or present use of tobacco in any form, past or present consumption of alcohol in any form. None of the subjects were involved in any kind of competitive sports activities.

2.1 6MWT procedure

6MWT was performed following standard guidelines**[1]**.The subjects were given orientation to the 6MWT on the day of the test. The entire tests were conducted on a single marked corridor by the same person. All subjects received the same standardized instructions and encouragement**[1]**.Also, all the tests were conducted between 9 am and 12 noon to avoid intra-day variability. All participants performed the test alone. The examiner did not walk alongside the participants. Each subject underwent the 6MWT in a flat, straight course with hard surface, undisturbed 30m level corridor. The course was identified by two cones indicating the turnaround points. The course was marked at every 3m interval. Ten minutes before the test the subjects were made to sit in a chair located near the starting position. During this time baseline values were recorded. The subjects were asked to walk as far down the length of the corridor as they could at their own pace for six minutes. Encouragement was given every minute during the test with the following phrases: 'You're doing well' and 'Keep up the good work' in the local language. Subjects were allowed to stop during the test if they developed symptoms of leg cramps, dizziness, dyspnoea, or chest pain but were encouraged to continue walking as soon as they could. The examiner clearly informed the participants when the test was over by saying to stop where you are in local language. 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. Then 6MWw was calculated from the formula: 6MWw (kgm) = 6MWD (m) X Body Weight (kg). If the participant stops walking during the test, the timer was not stopped. All subject completed the test and no subject stopped during the test.

Before and immediately after each test the following data were recorded: heart rate and oxy-hemoglobin saturation (Finger Pulse-oxymeter, MD300C2, Beijing, China), systolic and diastolic blood pressure and rate of perceived exertion (Modified Borg Rating of Perceived Exertion). Prior to the test before administering the modified Borg Rating of Perceived Exertion to the individuals, the examiner explained the meaning of the score.

2.2 Statistical Analyses

Analyses were performed using SPSS for windows statistical software (version16.0; SPSS, Inc., Chicago, IL). All data are presented as mean ± standard deviation (SD) unless otherwise stated. 6MWDs and 6MWw were compared between males and females using unpaired t-tests. Relationships between age and anthropometric data with 6MWD and 6MWw were examined by using Pearson's correlation coefficients (r). Stepwise multiple regression analysis was performed on the variables that significantly correlated with 6MWD to develop prediction regression equations. A probability (p) value < 0.05 was regarded as significant.

3. Results

Of the 384 subjects evaluated, 205 were males and 179 were females. All the subjects completed the entire 6MWT according to the protocol. In no case it was necessary to stop the test prematurely. The characteristics of the study population are summarized in Table 1.

Table No. 1: Characteristics of subjects

Characteristics	**Total Sample (n=384)**	**Males (n=205)**	**Females (n=179)**
Mean Age (years)	20.81±2.13	20.83±2.06	20.78±2.20
Mean Height (cm)	158.48±8.45	163.73±6.25	152.47±6.38
Mean Weight (kg)	52.02±6.60	55.12±6.03	48.48±5.33
Mean BMI (kg/m^2)	20.69±1.76	20.53±1.63	20.87±1.88
Mean Leg-length(cm)	85.44±5.46	87.82±4.69	82.71±4.99
Resting Heart Rate (bpm)	79.11±5.57	78.12±5.61	80.25±5.31
Resting Systolic BP (mmHg)	122.19±6.49	123.40±5.73	120.81±7.02
Resting Diastolic BP(mmHg)	79.24±4.53	79.58±4.38	78.84±4.67

BMI=Body mass index, BP=blood pressure, n=Total no. of subjects.

Mean 6MWD covered by the subjects was 564.75 ± 81.2 m The 6MWD for the males and females was 602.24 ± 73.09 m and 521.83 ± 67.80 m, respectively, with males walking 76.50 ±10.87 m ($p < 0.0001$) farther than females. Pre and post six minute walk test results are summarized in table 2.

Table No. 2: Pre and post six minute walk test results

Characteristics	Males (n=205)	Females (n=179)
	Mean ± SD	**Mean ± SD**
Resting Heart Rate (bpm)	78.12±5.61	80.25±5.31
Resting RPE	0.06±.07	1.16±0.32
Resting SpO2 (%)	97.33±1.43	97.24±1.48
Post Test Heart Rate (bpm)	97.64±8.03	95.35±6.22
Post Test RPE	1.62±0.59	1.66±0.56
Post Test SpO2 (%)	95.53±1.70	95.03±1.89

SD= Standard deviation, RPE = Rate of perceived exertion, SpO2 = Oxy-hemoglobin saturation, n = number of subjects, $p < 0.05$ is considered significant

Significant correlations were observed between 6MWD and age (r = -0.57 [males], r = -0.52[females]), height (r = 0.19 [males], r = 0.20 [females]). There was no significant association between weight, leg length, BMI and 6MWD in either male or female subjects. Correlations of 6MWD in male and female subjects are summarized in table 3.

Table No. 3: Correlations of six minute walk distance

		Males(n = 205)		Females (n = 179)	
		R	**P**	**R**	**P**
6MWD (m)	Age (years)	-0.57	0.0001	-0.52	0.0001
	Height (cm)	0.19	0.007	0.20	0.005
	Weight (kg)	0.04	0.54	0.13	0.76
	BMI(kg/ m^2)	-0.13	0.62	-0.04	0.55
	Leg Length (cm)	0.17	0.18	0.19	0.10

6MWD = Six minute walk distance, BMI = Body Mass Index, r = correlation coefficient, p = probability value, n= number of subjects, $p < 0.05$ is considered significant

Mean six minute walk work was 29557.99± 6457.24 kgm. The difference in 6MWw of males and females was also significant (33212.12 ± 5554.73 kgm [males], 25373.09 ± 4622.21 kgm [females], p = 0.0001). Age, height weight, BMI and leg length were found to have significant correlation with 6MWw. Correlations of 6MWw in male and female subjects are summarized in table 4.

Table No. 4: Correlations of Six minute walk work

Variables		Males (n = 205)		Females (n=179)	
		R	**P**	**R**	**P**
6MWw (kgm)	Age (years)	-0.27	0.0001	-0.44	0.0001
	Height (cm)	0.57	0.0001	0.51	0.0001
	Weight (kg)	0.69	0.0001	0.76	0.0001
	BMI (kg/m^2)	0.38	0.0001	0.55	0.0001
	Leg Length (cm)	0.48	0.0001	0.42	0.0001

6MWw = Six minute walk work, BMI = body mass index, r = correlation coefficient, p = probability value, n = number of subjects $p < 0.05$ is considered significant

Height, weight, BMI and leg length demonstrated better correlations with 6MWw than 6MWD in both males and females subjects.

We developed gender specific regression equations for six minute walk distance in young Indian adults. The prediction regression equations explained 35% and 27%of the variance in 6MWD in males and females, respectively. Regression analyses are summarized in table 5. The equations were as follows:

Predicted 6MWD (m) males = 681.97 -19.99 x age (years) +2.06 x height (cm) ($r^2 = 0.35$)

Predicted 6MWD (m) females= 856.55-16.08 x age (years) ($r^2 = 0.27$)

Table No. 5: Predictors of Six minute walk distance

Predictors of 6MWD in males (n=205)			**Predictors of 6MWD in females (n=179)**		
Model	Coef	P	Model	Coef	P
Cons	681.97	0.0001	Cons	856.55	0.0001
Age	-19.99	0.0001	Age	-16.08	0.0001
Height	2.057	0.002			
Dependent Variable: 6MWD					

6MWD = Six minute walk distance, cons= constant, coef = coefficient,p= probability value, n = number of subjects, $p < 0.05$ is considered significant

4. Discussion

To our knowledge, the present study is the first to investigate reference values of 6MWD, and 6MWw; factors influencing 6MWD and 6MWw; propose gender specific prediction equations for 6MWD in the young Indian adults (18 - 25 years). Prediction equations would permit a more appropriate evaluation of patients with chronic diseases that affect exercise capacity.

In a group of young adult subjects with ages ranging from 18 - 25 years, we found the mean 6MWD was 564.75±81.2 m. The 6MWw measured in subjects between 18 - 25 years in the present study was 29557.99±6457.24 kgm.

There was significant difference in the 6MWD between male and female subjects (76.51±10.87m, p=0.0001).The influence of gender on 6MWD might be attributable to the greater absolute muscle strength, muscle mass and height of males compared to females.[11]There was significant difference in the 6MWw between male and female subjects (7634.18±7194.34, p=0.0001). We propose that 6MWw is higher in males than in females, since males were heavier and covered a longer 6MWD than females.

Consistent with the previous studies age correlated significantly with 6MWD in males**[9,13,18]** and in females**[9,18]**. Also age correlated significantly with 6MWw in males and females as in previous studies**[7,11]**.Previous

reports have hypothesize that the shorter distance walked as age increased can be explained by decreases in muscle mass and strength and the maximum oxygen consumption, inherent to the aging process**[11]**.In the present study age was more strongly correlated with 6MWD in males than females, is consistent with the finding of previous studies, as age has a stronger relationship with maximal oxygen uptake in males than females[9].

The correlation between height and 6MWD was positive in males[4,9,10,13,18,19] and female subjects[9,18,19]. In the present study there was positive correlation of height with 6MWw in males and in females, in line with findings of previous study[11]. We found to have significant positive correlation between 6MWw and leg length. Previous studies have attributed these relationships to increase leg length, which generates a longer stride which makes walking more efficient[5, 20]. Stride length being a major predictor of the gait speed, probably resulting in a longer distance walked by the taller men[11].

In the present study, weight was found to have a positive significant correlation with 6MWw in male and female subjects. Weight did not correlated significantly with 6MWD neither in our male subjects nor in the female subjects as in the previous study[9].Previous reports of relationship between weight and 6MWD have been inconsistent[9,12].

In the present study BMI did not influence the 6MWD. Previous reports state that inclusion of individuals with wider range of BMI is required to evaluate an effect on distance walked[21].Significant and positive relations were found between 6MWw and BMI in males and females. The probable reason for such association of BMI with 6MWw is due to the fact that 6MWw is dependent on 6MWD and body weight. Previous reports suggest that 6MWw is more in individuals with higher body weight[11].

Previous studies report that 6MWw is superior to 6MWD when associated with changes in oxy-hemoglobin saturation during walking, maximum oxygen uptake and anaerobic threshold[22]. It has been demonstrated that 6MWw reflects the work of walking and hence better correlates with functional capacity than the 6MWD[7]. In the present study height, leg length, weight, and BMI were found to have better correlations with 6MWw than with the 6MWD in both male and female subjects.

In our male subjects age and height turned out to be as the independent predictor of 6MWD as in the previous studies[5,9,10]. In our female subject's only age was the independent predictor of 6MWD. Camarri *et al.* [21].developed a common equation for both genders and the independent predictor apart from gender was age.

We developed gender specific reference equations for 6MWD. The equation of 6MWD in male subjects explained around 0.35 of the variance in the 6MWD and the equation of 6MWD in female subjects explained around 0.27 of the variance in the 6MWD. The findings of the present study are consistent with previous studies which explained relatively low variance in the 6MWD (20-50%)[4,21,23,24].We studied only anthropometric variables in present study as they are objectively obtained in routine clinical settings and require less time of the participant.

The present study has some strength. As per our knowledge we were not able to locate any literature in India assessing the normal values of 6MWD and 6MWw as well as the factors influencing 6MWD and 6MWw particularly in young adults aged 18 - 25years. No specific reference equation is available in India for young adults in this age range. Literature on 6MWw in normal subjects in scarce. The previous studies have documented that 6MWw assesses the functional capacity better than the 6MWD and also reflects the work energy expenditure. It has also been reported that normal values are used as standard and are required for quantification of magnitude of data. We were able to study the normal values, factors influencing 6MWD and 6MWw and develop gender specific prediction equations for 6MWD in young Indian adult subjects aged 18 - 25 years. We were also able to see the anthropometric factors that influenced 6MWw more than the 6MWD.

The limitations of the study were: Prospective validity of the developed reference equation has not been checked. This study did not investigate 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 (particularly gastrocnemius, quadriceps and hamstring), psychological factors (anxiety, level of motivation), and life style factors (Physical activity level, efficiency of walking). But the inclusion of such factors in an equation is time consuming on the part of participant as well as the investigator and thus appears unpractical for routine clinical use especially in developing countries.

6. Conclusion

In conclusion, specific reference values for 6MWD and 6MWw will have the advantage of providing a benchmark for functional capacity assessment. 6MWD can be predicted adequately using variables that are obtained simply in routine clinical settings in normal young Indian adults. This study resulted in reference equations for the prediction of 6MWD in normal young adult subjects, and these equations can facilitate the assessment of patients with ailments that affect their exercise capacity. Anthropometric characteristics affect 6MWw in young Indian adults. Also, 6MWw can be considered for estimation of walking capacity.

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