



RESEARCH REPORT

Prediction equations for 6-minute walk distance in apparently healthy Nigerians



Olufunke A. Ajiboye, MSc ^{a,*}, Chikodi N. Anigbogu, PhD ^b,
Jane N. Ajuluchukwu, MMed ^c, Smith I. Jaja, PhD ^b

^a Department of Physiotherapy, Lagos University Teaching Hospital/College of Medicine, University of Lagos, Lagos, Nigeria

^b Department of Physiology, College of Medicine, University of Lagos, Lagos, Nigeria

^c Department of Medicine, College of Medicine, University of Lagos, Lagos, Nigeria

KEYWORDS

6-minute walk distance;
6-minute walk test;
predicted equations

Abstract The aims of this study were to determine the 6-minute walk distance (6MWD), establish prediction equations for the 6MWD in apparently healthy Nigerians, evaluate any effects regarding participant sex, and compare measured 6MWDs with the predicted 6MWD from reference equations derived from other populations. Four hundred and twenty two (422) apparently healthy Nigerians participated in the study. The 6-minute walk test was carried out according to the American Thoracic Standard-standardized protocol. The 6MWD obtained from the study was compared with reference values from other foreign populations. There were no significant differences between the mean age and mean weight of the male and female participants. However, significant difference existed in the mean height and mean body mass index (BMI; $p < 0.001$) of these participants. Male participants covered a statistically significant longer distance than female participants ($p < 0.001$). The mean 6MWD measured in Nigerian participants (517.6 ± 72.2 m) was statistically lower than 6MWD in Americans, Brazilians, and Tunisians and was higher than in Arabians ($p \leq 0.002$), respectively. The 6-MWD in healthy Nigerians cannot be predicted by established reference equations from other populations. The regression equations established in this study may better predict the distance for Nigerians.

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* Corresponding author. Department of Physiotherapy, Lagos University Teaching Hospital/College of Medicine, University of Lagos, Lagos, Nigeria.

E-mail address: oaajiboye@yahoo.com (O.A. Ajiboye).

Introduction

The use of field-walk tests in patients with cardiorespiratory diseases results from the adaptation of the 12-minute run fitness test developed by Cooper [1]. This test was developed with the objective of verifying the level of physical fitness of the United States of America Armed Forces personnel. The test involved running the longest possible distance in 12 minutes. In the 1970s, McGavin et al [2] adapted Cooper's run fitness test into a 12-minute walk test (12MWT) with the objective of evaluating the exercise tolerance of patients with chronic bronchitis. In most patients with chronic illnesses, the 12MWT was adapted to shorter distances (e.g., 2, 4, and 6 minutes), mainly because it was strenuous for patients [3]. By contrast, the 2- or 4-minute tests presented limited responsiveness, especially in less debilitated patients [3]. In this sense, the 6-minute walk test (6MWT) became the most popular among the tests with controlled duration, and it consists of walking as fast as possible for 6 minutes. The 6MWT was first introduced as a functional exercise test by Lipkin et al [4]. The 6MWT is a useful assessment instrument for exercise capacity and it has been shown to provide a clinically useful index of functional capacity in chronic heart failure (CHF) [5] and other chronic illnesses. Its results highly correlate with those of the 12MWT from which it was derived and with those of cycle ergometer- or treadmill-based exercise tests [3,6,7]. Because exercise is a physiological form of stress, dynamic exercise testing has become a valuable noninvasive method for diagnosis and evaluation of heart diseases in children and adults [8]. In clinical practice, an objective estimate of performance and fitness can be obtained through standardized exercise tests [9]. Such tests provide objective and reliable estimate of physical working capacity and maximum oxygen uptake and provide clues to the mechanism that limit physical working capacity [9].

The 6MWT was originally developed to evaluate the functional capacity, monitor the effectiveness of several treatments, and establish the prognosis of patients with cardiorespiratory diseases [10]. Patients with such dysfunctions presented with exercise intolerance due to malfunctioning respiratory and/or cardiovascular systems and peripheral and respiratory skeletal muscle dysfunction [3]. However, more recently, the test has been used to assess functional exercise capacity in several disease conditions such as CHF, chronic cardiopulmonary conditions, and stroke [11–13] even in sub-Saharan African populations. In patients with cardiorespiratory diseases, oxygen consumption during the 6MWT does not significantly differ from the maximum oxygen consumption (VO_{2max}) obtained during incremental laboratory tests performed using cycle ergometer [14]. Therefore, it is possible to adequately estimate the VO_{2max} by the distance walked using the 6-MWT or 6-minute walk distance (6MWD). Thus, the 6MWT is a simple and less expensive tool to assess the cardiorespiratory fitness [10]. The 6MWT is well-tolerated by patients and is more representative of the activities of daily living in comparison with other walk tests [15]. It is frequently used as an outcome measure in cardiopulmonary and cardiovascular rehabilitation and as an assessment tool in the selection of patients for lung and heart surgery [16,17]. The

6MWT is a popular and widely accepted modality of objective evaluation of functional exercise capacity as it is inexpensive and simple to perform [18].

Several demographic, anthropometric, and physiological factors can influence the 6MWD in healthy individuals and in patients with chronic diseases. Shorter individuals and women present a shorter step length and, consequently, a shorter 6MWD [19]. Elderly and obese individuals commonly have reduced lean body mass and, consequently, a shorter 6MWD. The 6MWT has been found to be influenced by external complicating factors, such as effort spent and motivation [20]. Thus, the instructions and the encouragement given to the participants must be carefully standardized and the demographic, anthropometric, and nutritional differences observed among the different ethnicities evaluated must be considered [10]. Greater height and higher amount of lean mass observed in whites have a significant impact on the 6MWD [21]. Therefore, the American Thoracic Society (ATS) encourages the scientific community to use the standardisation of the 6MWT suggested in its consensus and to develop reference values of the 6MWD for several ethnicities.

Despite the popularity of the 6MWT in the clinical setting, there is a paucity of 6MWD reference values obtained from healthy participants [10,22]. This limits the interpretation of 6MWD in patients and poses problems for clinicians wishing to provide patients with a measure of their expected 6MWD in the absence of disease [23]. Recent studies have established regression equations to predict the 6MWD in healthy Asians [22,24], Americans [25], Brazilians [26], North Africans [27], and Arabians [28]. However, regression equations have not been established for the Nigerian population. This study was therefore aimed at determining the 6MWD in a healthy sample of Nigerians aged between 21 and 67 years, identify factors contributing to distance covered in 6 minutes (6MWD), establish regression equations for a Nigerian population, and to compare measured 6MWD with predicted 6MWD from existing reference equations derived from American, Asian, North African, and Arabian participants.

Materials and methods

Participants

A total of 422 apparently healthy Nigerian participants (224 males, 198 females) with no history of cardiovascular, pulmonary, or musculoskeletal disorders participated in the study. Those who were involved in sports and vigorous exercises were excluded from participating in the study. The participants were volunteers from staff and relatives of patients in Lagos University Teaching Hospital (LUTH), Lagos, Nigeria.

A 'rule of thumb' was adapted to calculate the sample size for this study [29,30].

$$(N > 104 + m) [30]$$

The sample size to number of predictor ratio was calculated from the following formula:

Sample size to number of predictor ratio = N/m where N is the sample size, m is the number of independent variables, which was four in this study (age, height, weight, and body mass index)

Sample size to number of predictor ratio = $422/4 = 105.5 = 106$

Ethical considerations

The research protocol was approved by the Ethical and Protocol Review Committee of the LUTH. Informed consent was obtained from the participants before they were enrolled in the study.

Procedure

The test procedures were explained to the participants before the commencement of exercise testing. The ATS-standardized 6MWT protocol was used.

Protocol

The 6MWT was carried out using a 30-m straight walk course marked out on the flat surface of the medical gymnasium, with chair placed at both ends of the course. Participants were instructed to stand at the zero mark of the walk course, and then walk at his/her own pace, to cover as much ground as possible in a period of 6 minutes. Timing with a stopwatch began when the participant was instructed to "go" and ended when the stopwatch read 6 minutes. Every minute, participant was encouraged with standardized statements "You are doing well" or "Keep up the good work." They were allowed to stop and rest during the test when tired, but were instructed to resume walking as soon as they were able to do so. The total walking distance covered during this period was measured and recorded in metres. The 6MWT was conducted only once on all the participants to eliminate any learning effect. Immediately after the test, participants were told to remain in standing position and the cardiovascular parameters were measured again and recorded as post-test measurements. Height and weight were measured using Seca weight–height scale; the age, in years, was recorded as at the last birthday. The distance walked during the test was recorded to the nearest meters as 6MWD.

Assessment of cardiorespiratory functions

Resting arterial blood pressure (systolic and diastolic in mmHg) was measured with Omron automatic blood pressure monitor (model HEM-712 CLCN2; Bannockburn, IL, USA). This instrument was validated using the Accoson Mercury sphygmomanometer. Regular checks for consistency were routinely done every week. Participants were required to be seated for at least 20 minutes before measurements were taken following standardized methods recommended by the American Heart Association [8]. The average of two systolic and two diastolic measurements was recorded, respectively. Resting heart rate (beats per minute or bpm) was measured using an Omron automatic blood pressure monitor while a polar heart rate monitor

was used to monitor the heart rate during the exercise. The unit of measurement was bpm. Resting respiratory rate (cycles per minute) was determined by observing the chest excursions.

Data analysis

Independent t tests were used to compare characteristics (age, height weight, and BMI) and 6MWD between male and female participants. The relationships between 6MWD and participant characteristics were examined using Pearson's correlation coefficients (r). Stepwise regression analysis was performed on the following variables: age, height, weight, and BMI to determine their contribution to distance covered in 6 minutes and to determine tolerance to detect multicollinearity. The 6MWD measured in this study was compared with predicted 6MWD derived from other foreign studies [25–28]. All data were analyzed using SPSS package (version 17.0; SPSS Inc., Chicago, IL, USA). Data were reported as mean $\pm$ standard deviation. The level of significance was set at $p < 0.05$.

Results

A summary of the physical characteristics of the participants is shown in Table 1. The mean height was higher in males than in females, whereas mean BMI was higher in females than in males ($p < 0.001$), respectively. There were no significant differences in age and weight between male and female participants.

The 6MWD correlated negatively with the age ($r = -0.375$, $p < 0.001$), weight ($r = -0.108$, $p < 0.026$), and BMI ($r = -0.356$, $p < 0.001$), while it correlated positively with height ($r = +0.470$, $p < 0.001$) in the overall analysis of the participants. In male participants, 6MWD correlated negatively with age ($r = -0.410$, $p < 0.001$) and positively correlated with height ($r = 0.250$). There was no significant correlation between 6MWD and weight ($r = -0.018$, $p = 0.789$) and BMI ($r = -0.100$, $p = 0.170$) in the male participants. In female participants, 6MWD negatively correlated with age ($r = -0.419$, $p < 0.001$), weight ($r = -0.267$, $p < 0.001$), and BMI ($r = -0.391$, $p < 0.001$), whereas it positively correlated with height ($r = 0.298$, $p < 0.001$). Results are shown in Table 2. The strongest correlate of 6MWD in the overall analysis was height with correlation coefficient of $+0.470$ followed by age with correlation coefficient of -0.375 and BMI ($r = -0.356$). The least important correlate of 6MWD was weight ($r = -0.108$) as shown in Table 2.

Table 3 shows stepwise regression analysis of the predictors of 6MWD in combined participants. Three models are represented in the table; the model with the highest regression coefficient (0.550), highest R^2 (0.303), and least standard error of estimate (SEE = 58.1) was considered appropriate to predict 6MWD in the overall analysis and presented as Eq. (1). The prediction equation [Eq. (1)] showed that age, height, and weight were the determinants of 6MWD. Height had the most significant contribution to 6MWD with a standardized regression coefficient of 0.479 followed by weight with standardized coefficient of -0.210 and age with standardized coefficient of -0.118

Table 1 Physical characteristics of participants.

Characteristics	Combined participants (<i>n</i> = 422), mean $\pm$ SD	Male participants (<i>n</i> = 224), mean $\pm$ SD	Female participants (<i>n</i> = 198), mean $\pm$ SD	<i>t</i> value	<i>p</i>
Age (y)	36.4 $\pm$ 12.7	35.9 $\pm$ 12.4	36.7 $\pm$ 13.1	0.702	0.483
Height (m)	1.67 $\pm$ 0.08	1.72 $\pm$ 0.07	1.62 $\pm$ 0.06	−15.602	<0.001*
Weight (kg)	70.7 $\pm$ 13.7	70.8 $\pm$ 12.0	70.6 $\pm$ 15.4	−0.138	0.891
BMI (kg/m ²)	25.3 $\pm$ 4.8	20.7 $\pm$ 6.9	26.9 $\pm$ 5.6	9.149	<0.001*

*Significant at < 0.001.

BMI = body mass index; SD = standard deviation.

Table 2 Correlation of 6MWD with age, height, weight, and BMI in combined, male, and female participants.

Variables	Combined participants (<i>n</i> = 422), mean $\pm$ SD	Correlation coefficient (<i>r</i>)	<i>p</i>	Male participants (<i>n</i> = 224), mean $\pm$ SD	Correlation coefficient (<i>r</i>)	<i>p</i>	Female participants (<i>n</i> = 198), mean $\pm$ SD	Correlation coefficient (<i>r</i>)	<i>p</i>
6MWD (m)	517.6 $\pm$ 72.2	—	—	548.9 $\pm$ 67.9	—	—	482.5 $\pm$ 59.9	—	—
Age (y)	36.4 $\pm$ 12.7	−0.375	<0.001*	35.9 $\pm$ 12.4	−0.410	<0.001*	36.7 $\pm$ 13.1	−0.419	<0.001*
Height (m)	1.67 $\pm$ 0.08	+0.470	<0.001*	1.72 $\pm$ 0.07	+0.250	<0.001*	1.62 $\pm$ 0.06	+0.298	<0.001*
Weight (kg)	70.7 $\pm$ 13.7	−0.108	0.026**	70.8 $\pm$ 12.0	−0.018	0.789	70.6 $\pm$ 15.4	−0.267	<0.001*
BMI (kg/m ²)	25.3 $\pm$ 4.8	−0.356	<0.001*	20.9 $\pm$ 6.9	−0.100	0.170	26.9 $\pm$ 5.6	−0.391	<0.001*

High and significant negative correlations were seen between 6MWD and age and significant positive correlations between 6MWD and height in both sexes. However, significant correlations were seen between 6MWD and BMI and weight in female participants only.

p* < 0.001.*p* < 0.05.

6MWD = 6-minute walk distance; BMI = body mass index; SD = standard deviation.

(*p* = 0.001) as shown in Table 3. Collinearity/tolerance of excluding BMI from the equation was 0.430 (*p* = 0.794). Body mass index did not have a significant contribution to 6MWD in the overall data analysis. Model 3 with these features was considered as the most appropriate equation for the study.

Table 4 shows stepwise regression analysis of the predictors of 6MWD in male participants. Two models were represented in the table; the model with the higher regression coefficient (0.367), higher *R*² (0.135), and least SEE (61.7) was considered appropriate to predict 6MWD in the male participants and represented as Eq. (2). The prediction equation [Eq. (2)] showed that age and height

were major determinants of 6MWD. Age was a better predictor between the two with standardized coefficient of −0.288 (*p* = 0.001), followed by height with standardized coefficient of 0.158 (*p* = 0.028) as shown in Table 4. The collinearity/tolerance of excluding weight was 0.589 (*p* = 0.700) and tolerance of excluding BMI was 0.902 (*p* = 0.171). Weight and BMI did not have significant contribution to 6MWD in Nigerian male participants.

Table 5 shows stepwise regression analysis of the predictors of 6MWD in female participants. Five models were represented in the table; model 4 with the highest regression coefficient (0.542), highest *R*² (0.294), and least SEE (50.9) was considered the most appropriate to predict

Table 3 Stepwise regression analysis of the predictors of 6MWD in combined participants.

Model	Unstandardized coefficients		Standardized coefficients	<i>t</i>	Significance	<i>R</i>	<i>R</i> ²	Adjusted <i>R</i> ²	Standard error of estimate
	B	Standard error	β						
1 (Constant)	−141.775	66.890		−2.120	0.035	0.446	0.199	0.197	62.1
Height	391.364	40.071	0.446	9.767	<0.000				
2 (Constant)	−169.242	63.859		−2.650	0.008				
Height	467.874	40.028	0.533	11.689	0.001	0.525	0.275	0.271	59.1
Weight	−1.422	0.224	−0.289	−6.344	0.001				
3 (Constant)	−79.023	66.897		−1.181	0.238				
Height	419.834	41.220	0.479	10.185	<0.001	0.550	0.303	0.297	58.1
Weight	−1.031	0.242	−0.210	−4.256	0.001				
Age	−1.021	0.263	−0.185	−3.878	0.001				

6MWD = 6-minute walk distance.

Table 4 Stepwise regression analysis of the predictors of 6MWD in male participants.

Model	Unstandardized coefficients		Standardized coefficients β	t	Significance	R	R^2	Adjusted R^2	Standard error of estimate
	B	Standard error							
1 (Constant)	609.106	14.890		40.906	<0.001	0.334	0.112	0.107	62.4
Age	-1.850	0.383	-0.334	-4.834	<0.001				
2 (Constant)	336.858	123.871		2.719	0.007	0.367	0.135	0.125	61.7
Age	-1.595	0.396	-0.288	-4.031	0.001				
Height	153.142	69.184	0.158	2.214	0.028				

6MWD = 6-minute walk distance.

6MWD in female participants and represented as Eq. (3). Eq. (3) shows that age, height, weight, and BMI were determinants of 6MWD. These four predictors gave an equation with the least SEE, as shown in Table 5. The strongest predictor of 6MWD in female participants was age with standardized coefficient of -0.211 ($p = 0.003$) followed by BMI with β of -2.196 ($p = 0.008$), then by weight with a standardized coefficient of $+2.025$ ($p = 0.018$), which was then followed by height with standardized coefficient of -0.392 ($p = 0.158$) with SEE of 50.9 (Table 5). The 6MWD had negative correlation with height, age, BMI, and had positive correlation with weight of female participants.

Stepwise multiple regression equations to predict 6MWD in a Nigerian population:

$$6MWD_{\text{Combined}} = [419.834 \times \text{Height}_{(m)}] - [1.021 \times \text{Age}_{(\text{years})}] - [1.031 \times \text{Weight}_{(\text{kg})}] - 79.023$$

(SEE = 58.050, $R = 0.550$) (1)

$$6MWD_{\text{Male}} = [153.142 \times \text{Height}_{(m)}] - [1.595 \times \text{Age}_{(\text{years})}] + 336.585$$

(SEE = 61.713, $R = 0.367$) (2)

$$6MWD_{\text{Female}} = 1253.862 - [406.447 \times \text{Height}_{(m)}] - [1.010 \times \text{Age}_{(\text{years})}] - [7.890 \times \text{Weight}_{(\text{kg})}] - (23.551 \times \text{BMI})$$

(SEE = 50.856, $R = 0.542$) (3)

Comparison of the measured 6MWD with estimated 6MWD from foreign prediction equations is shown in Table 6. The table shows that the mean 6MWD covered by Nigerians was 517.6 ± 72 m (male, 548.9 ± 67.9 m vs. female, 482.5 ± 59.9 m). The 6MWD measured in Nigerian participants (517.6 ± 72.0 m) was statistically lower than predicted values from Americans ($647.3 \pm 91.0.4$ m; $p < 0.001$), Brazilians (616.6 ± 23.1 m, $p < 0.001$), Tunisians (830.3 ± 84.1 m, $p < 0.001$), and significantly higher than Arabian population (472.3 ± 21.1 , $p < 0.001$).

When the comparison was made based on the sex, male participants covered significantly longer distance than their female counterparts (Table 2).

Discussion

The aims of this study were to determine 6MWD, establish prediction equations for 6MWD in apparently healthy Nigerians, evaluate effects of sex on distance covered, and compare measured 6MWD with predicted 6MWD from existing reference equations derived from other populations. It is noteworthy that this is the first study to establish prediction equations for 6MWD using 6MWT in apparently healthy Nigerians. The sample size in this study was comparable to those used in the previous studies [22,25–28]. The mean 6MWD in apparently healthy Nigerians between 21 and 67 years (male, 21–67 years; female, 25–57 years) was 517.6 ± 72.2 m (male, 548.9 ± 67.9 m; female, 482.5 ± 59.9 m). This age range is a representative of individuals undergoing cardiovascular/cardiopulmonary rehabilitation in Nigeria [11]. Male participants were taller than their female counterparts while the female participants had higher body mass index, though the weights were comparable (Table 1). The higher BMI in female participants observed may be attributed to the shorter height observed in the female participants. This study shows that apparently healthy Nigerian male covered significantly longer distance during 6MWT than their female counterparts. The age range of participants involved in this study is consistent with the study of Tsang [24] (21–67 years vs. 21–70 years). He equally reported that male participants covered longer distance in 6 minutes than their female counterparts in a Chinese population with mean difference of 62.0 m (635.0 m vs. 573.0 m), whereas in our study, the mean difference between male and female participants was 66.4 m (548.9 m vs. 482.5 m). Chinese participants in Tsang's study covered longer distance than Nigerian participants; this difference may be attributed to the higher BMI reported in our study.

The result of this study showed negative correlation between the 6MWD and age, weight, and BMI and positive correlation with height. These results are consistent with the previous studies [25–28]. Most studies emphasized the correlations between the 6MWD and age, height, weight, and BMI in their various study populations because they are very easy to obtain and cost effective. The data can be easily obtained without depending on sophisticated equipment. The negative correlation of age with 6MWD (Table 2) agreed with the results of the previous studies [31,32]. They reported reductions in 6MWD with increasing age in the adults and elderly population studied. The shorter distance walked with advanced age can be attributed to

Table 5 Stepwise regression analysis of the predictors of 6MWD in female participants.

Model	Unstandardized coefficients		Standardized coefficients β	t	Significance	R	R^2	Adjusted R^2	Standard error of estimate
	B	Standard error							
1 (Constant)	552.835	11.542		47.896	<0.001	0.419	0.176	0.172	54.5
Age	-1.913	0.296	-0.419	-6.467	<0.001				
2 (Constant)	141.963	108.763		1.305	0.193				
Age	-1.751	0.289	-0.384	-6.050	<0.001	0.482	0.233	0.225	52.7
Height	249.765	65.766	0.241	3.798	<0.001				
3 (Constant)	171.013	106.500		1.606	0.110				
Age	-1.122	0.341	-0.246	-3.287	0.001				
Body mass index	-2.607	0.794	-0.243	-3.284	0.001	0.523	0.273	0.262	51.5
4 ^a (Constant)	1253.862	465.812		2.692	0.008				
Age	-1.010	0.340	-0.221	-2.967	0.003				
Height	-406.447	286.726	-0.392	-1.418	0.158	0.542	0.294	0.279	50.9
Body mass index	-23.551	8.811	-2.196	-2.673	0.008				
Weight	7.890	3.306	2.025	2.386	0.018				
5 (Constant)	594.036	17.861		33.259	<0.001				
Age	-1.059	0.340	-0.232	-3.118	0.002				
Body mass index	-11.431	2.138	-1.066	-5.346	<0.001	0.535	0.287	0.275	51.0
Weight	3.319	0.734	0.852	-4.522	<0.001				

6MWD = 6-minute walk distance.

^a Model chosen to establish the prediction equation for female participants.

decreases in muscle mass and strength and the reduced maximum oxygen consumption, inherent to the ageing process [31,32]. Conversely, Priesnitz et al [33] and Ben Saad et al [34] reported increases in 6MWD with increasing age in children and adolescents, respectively. They associated their results with higher degree of maturation among adolescents when compared with children.

The significant positive correlation between height and the distance walked during the 6MWT as observed in the participants may be attributed to the longer length of steps in taller individuals. The length of the step is one of the main determinants in gait velocity [35]. The correlation observed between the 6MWD and height in this study was consistent with previous studies [26–28,36]. Only the study

Table 6 Comparison of measured distance in Nigerian participants with predicted distance from foreign regression equations.

Participants	6MWD in this study, mean $\pm$ SD	6MWD (m) predicted from foreign equations, mean $\pm$ SD	6MWD mean difference (m)	t value	p
Combined participants (m) $n = 422$	517.6 $\pm$ 72.0 (364–741 m)	647.3 $\pm$ 91.0 ^a	-129.7 $\pm$ 88.9	-29.9	<0.001*
		648.2 $\pm$ 90.4 ^b	-130.6 $\pm$ 90.1	-29.9	<0.001*
		616.6 $\pm$ 23.1 ^c	-99.0 $\pm$ 67.0	-30.3	<0.001*
		830.4 $\pm$ 84.2 ^d	-312.8 $\pm$ 82.6	77.6	<0.001*
		472.3 $\pm$ 21.1 ^e	45.3 $\pm$ 62.7	-6.6	<0.001*
Male participants $n = 224$	548.9 $\pm$ 67.9 (403–741 m)	658.4 $\pm$ 82.2 ^a	-109.5 $\pm$ 83.8	-18.5	<0.001*
		655.8 $\pm$ 79.5 ^b	-106.9 $\pm$ 85.4	-16.4	<0.001*
		617.1 $\pm$ 23.1 ^c	-68.2 $\pm$ 62.1	-55.6	<0.001*
		844.1 $\pm$ 75.5 ^d	-295.2 $\pm$ 79.1	-8.2	<0.001*
		483.3 $\pm$ 18.8 ^e	65.6 $\pm$ 61.6	1.6	0.106
Female participants $n = 198$	482.5 $\pm$ 59.9 (364–608 m)	582.4 $\pm$ 91.5 ^a	-99.9 $\pm$ 82.3	-15.5	<0.001*
		641.0 $\pm$ 99.4 ^b	-158.5 $\pm$ 89.7	-24.9	<0.001*
		554.6 $\pm$ 24.3 ^c	-72.1 $\pm$ 54.4	-19.7	<0.001*
		625.5 $\pm$ 84.0 ^d	-143.0 $\pm$ 81.4	-21.4	<0.001*
		459.6 $\pm$ 15.7 ^e	23.3 $\pm$ 57.8	-1.0	0.118

* $p < 0.001$.^{a,b} Enright and Sherrill (1998) [25].^c Iwama et al (2009) [26].^d Ben Saad et al (2009) [27].^e Alameri et al (2009) [28].

by Enright and Sherrill [25] showed no significant correlation between the 6MWD and height.

The major determinants of 6MWD in male participants were age and height (Table 4). No significant contribution was observed between the 6MWD and weight and BMI of male participants while these contributed significantly in female participants (Table 5). This explains further why weight and BMI were not selected as determinants of 6MWD in male participants. In Nigerian adults' population, prevalence of obesity among women and men in an urban centre was reported to be 17.27% and 2.25%, respectively, by Olatunbosun et al [37]. Their reports showed that obesity is more prevalent among Nigerian females than their male counterpart.

The major determinants of 6MWD in the overall analysis are height with standardized coefficient of 0.479, $p < 0.001$, weight with standardized coefficient of -0.210 , $p = 0.001$, and age with standardized coefficient of -0.185 , $p = 0.001$ ($R = 0.550$, $SEE = 58.1$). In the male participants, age was found to be a better predictor of 6MWD with standardized coefficient of -0.228 ($p = 0.001$) followed by height with standardized coefficient of 0.158 ($p = 0.028$), whereas in the female participants, age was found to be the most significant predictor of 6MWD with standardized coefficient of -0.221 ($p = 0.003$) followed by BMI and weight. Height was not found to be a significant predictor of 6MWD in female participants. The results of this study corroborate the findings of previous researchers on the necessity for sex-specific prediction equations to be established.

Among Nigerian adults, male participants walked an average of 66.4 m more than their female counterparts. This result is consistent with previous studies [22,24–28]. The difference in the distance covered during the 6MWT between the male and female participants may be attributed to higher muscular strength and mass seen in men compared with women. More so, higher height in male participants observed might contribute to this difference. By contrast, some studies among the adolescents [28,33] did not show that participant sex affected 6MWD. They attributed their results to similar musculoskeletal behaviour between males and females before adolescence [33].

The 6MWD measured in this study was significantly less than the predicted 6MWD from regression equations derived in American and Asian populations. This result is consistent with previous studies [22,38,39]. The implications of this for patients with chronic obstructive pulmonary diseases or CHF and other chronic diseases may be considerable, and include an overestimation or underestimation of the level of a patient's ability or disability as well as the potential for setting unrealistic outcomes from interventions aimed at improving the walking capacity of these patients. The prediction equations for 6MWD derived from this study should therefore be used in the Nigerian population.

Conclusion

This study shows that regression equations derived for other populations may not be appropriate to predict 6MWD in Nigerian individuals. The prediction equations presented in this study should be used for estimating 6MWD in Nigeria.

Conflicts of interest

All contributing authors declare no conflicts of interest.

References

- [1] Cooper KH. A means of assessing maximal oxygen intake: correlation between field and treadmill testing. *JAMA* 1968; 203:201–4.
- [2] McGavin CR, Gupta SP, McHandy GT. Twelve-minute walking test for COPD patients. *Br Med J* 1976;1:822–33.
- [3] Butland RJ, Pang J, Gross ER, Woodcock AA, Geddes DM. Two-, six-, and 12-minute walking tests in respiratory disease. *Br Med J (Clin Res Ed)* 1982;284:1607–8.
- [4] Lipkin DP, Scriven AJ, Crake T, Poole-Wilson PA. Six minute walking test for assessing exercise capacity in chronic heart failure. *Br Med J* 1986;292:653–5.
- [5] Nogueira PAMS, Leal ACM, Pulz C, Nogueira IDB, Filho JAO. Clinical reliability of the 6-minute corridor walk test performed within a week of a myocardial infarction. *Int Heart J* 2006;47:533–40.
- [6] Peeters P, Mets T. The six minute walk as an appropriate exercise test in elderly patients with chronic heart failure. *J Gerontol A Biol Sci Med Sci* 1996;51A:M147–57.
- [7] Stevens D, Elperin E, Sharma K, Szidon P, Ankin M, Kesten S. Comparison of hallway and treadmill six-minute walk tests. *Am J Respir Crit Care Med* 1999;160:1540–1.
- [8] ACC/AHA guidelines for the evaluation and management of chronic heart failure in adult: executive summary. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to revise the 1995 Guidelines for the Evaluation and Management of Heart Failure). *J Am Coll Cardiol* 2001;38:2101–13.
- [9] Fletcher GF, Balady G, Froelicher VF, Hartley LH, Haskell WL, Pollock M. Exercise standards: a statement for healthcare professionals from the American Heart Association: writing group. *Circulation* 1995;91:580–615.
- [10] ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: guidelines for the six-minute walk test. *Am J Respir Crit Care Med* 2002;166:111–7.
- [11] Anigbogu CN, Ajiboye OA. Changes in cardiovascular response to six minute walk test of Nigerians with chronic heart failure. *FASEB J* 2010;24:806–21.
- [12] Olawale OA, Jaja SI, Anigbogu CN, Appiah-Kubi KO, Jones-Okai D. Exercise training improves walking function in an African group of stroke survivors: a randomized controlled trial. *Clin Rehabil* 2011;25:442–50.
- [13] Anigbogu CN, Isichei CV, Ajuluchukwu JN. Blood pressure, heart rate, cardiovascular reflexes and electrocardiographic changes in some hypertensive Nigerians. *Niger J Physiol Sci* 2012;27:23–7.
- [14] Troosters T, Gosselink R, Decramer M. Six minute walking distance in healthy elderly subjects. *Eur Respir J* 1999;14:270–4.
- [15] Solway S, Brooks D, Lacasce Y. A qualitative systemic overview of measurement of properties of functional walk test used in cardiorespiratory domain. *Chest* 2001;119:256–70.
- [16] Cahalin L, Pappagianopoulos P, Prevost S, Wain J, Ginns L. The relationship of the 6-min walk test to maximal oxygen consumption in transplant candidates with end-stage lung disease. *Chest* 1995;108:452–9.
- [17] Kadikar A, Maurer J, Kesten S. The six-minute walk test: a guide to assessment for lung transplantation. *J Heart Lung Transplant* 1997;16:313–9.
- [18] Olsson LG, Swedberg K, Clark AL, Witte KK, Cleland JG. Six minute corridor walk test as an outcome measure for the assessment of treatment in randomized, blinded intervention

- trials of chronic heart failure: a systematic review. *Eur Heart J* 2005;26:778–93.
- [19] Dourado VZ, Vidotto MC, Guerra RL. Reference equations for the performance of healthy adults on field walking tests. *J Bras Pneumol* 2011;37:607–14 [Article in English, Portuguese].
- [20] Araujo CO, Makdisse MR, Peres PA, Tebexreni AS, Ramos LR, Matsushita AM, et al. Different patterns for the 6-minute walk test as a test to measure exercise ability in elderly with and without clinically evident cardiopathy. *Arq Bras Cardiol* 2006; 86:198–205.
- [21] Britto RR, Probst VS, de Andrade AF, Samora GA, Hernandez NA, Marinho PE, et al. Reference equations for the six-minute walk distance based on a Brazilian multicenter study. *Braz J Phys Ther* 2013;17:556–63.
- [22] Poh H, Eastwood PR, Cecins NM, Ho KT, Jenkins SC. Six-minute walk distance in healthy Singaporean adults cannot be predicted using reference equations derived from Caucasian populations. *Respirology* 2006;11:211–6.
- [23] Roul G, Germain P, Bareiss P. Does the 6-minute walk test predict the prognosis in patients with NYHA class II or III chronic heart failure? *Am Heart J* 1998;136:449–56.
- [24] Tsang RCC. Reference values for 6-minute walk test and hand-grip strength in healthy Hong Kong Chinese adults. *Hong Kong Physiother J* 2005;23:6–12.
- [25] Enright PL, Sherrill DL. Reference equations for the six-minute walk in healthy adults. *Am J Respir Crit Care Med* 1998;158: 1384–7.
- [26] Iwama AM, Andrade GN, Shima P, Tanni SE, Godoy I, Dourado VZ. The six-minute walk test and body weight-walk distance product in healthy Brazilian subjects. *Braz J Med Biol Res* 2009;42:1080–5.
- [27] Ben Saad H, Prefaut C, Tabka Z, Mtir AH, Chemit M, Hassaoune R, et al. 6-Minute walk distance in healthy North Africans older than 40 years: influence of parity. *Respir Med* 2009;103:74–84.
- [28] Alameri H, Al-Majed S, Al-Howaikan A. Six-min walk test in a healthy adult Arab population. *Respir Med* 2009;103:1041–6.
- [29] Harris RJ. A primer of multivariate statistics. 2nd ed. New York: Academic Press; 1985.
- [30] Green SB. How many subjects does it take to do a regression analysis? *Multivariate Behav Res* 1991;26:499–510.
- [31] Fleg JL, Lakatta EG. Role of muscle loss in the age-associated reduction in $\text{VO}_{2\text{max}}$. *J Appl Physiol* 1988;65:1147–51.
- [32] Evans WJ, Campbell WW. Sarcopenia and age-related changes in body composition and functional capacity. *J Nutr* 1993;123: 465–8.
- [33] Priesnitz CV, Rodrigues GH, Stumpf Cda S, Viapiana G, Cabral CP, Stein RT, et al. Reference values for the 6-min walk test in healthy children aged 6-12years. *Pediatr Pulmonol* 2009;44:1174–9.
- [34] Ben Saad H, Prefaut C, Missaoui R, Mohamed IH, Tabka Z, Hayot M. Reference equation for 6-min walk distance in healthy North African children 6-16 years old. *Pediatr Pulmonol* 2009;44:316–24.
- [35] Callisaya ML, Blizzard L, Schmidt MD, McGinley JL, Srikanth VK. Sex modifies the relationship between age and gait: a population-based study of older adults. *J Gerontol A Biol Sci Med Sci* 2008;63:165–70.
- [36] Spence DPS, Hay JG, Carter J, Pearson MG, Calverley PMA. Oxygen desaturation and breathlessness during corridor walking in COPD: effect of oxitropium bromide. *Thorax* 1993;48:1145–50.
- [37] Olatunbosun ST, Kaufman JS, Bella AF. Prevalence of obesity and overweight in urban adult Nigerians. *Obes Rev* 2011;12: 233–41.
- [38] Camarri B, Eastwood PR, Cecins NM, Thompson PJ, Jenkins S. Six minute walk distance in healthy subjects aged 55-75 years. *Respir Med* 2006;100:658–65.
- [39] Chetta A, Zanini A, Pisi G, Aiello M, Tzani P, Neri M, et al. Reference values for the 6-min walk test in healthy subjects 20-50 years old. *Respir Med* 2006;100:1573–8.