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Reference Values for 3-Meter Backward Walk Test among Apparently Healthy Adults

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Highlights of the Study

- The lack of reference values for the 3-meter backward walk test limits its use in rehabilitation.
- This study provided a gender- and age-reference value of the 3-meter backward walk test in healthy adults.
- The findings indicate that males have shorter 3-meter backward walk than females.
- The time taken to accomplish 3-meter backward walk increases with age in apparently healthy individuals.

Keywords
Anthropometrics · Fall · Mobility · Normative values

Abstract
Objective: The 3-meter backward walk (3MBW) test is an outcome performance measure to assess backward walking mobility, balance, and risk of fall. However, the lack of baseline values is a potential limitation for its use as a rehabilitation target value or predictor of outcomes. This study aimed at ascertaining a gender- and age-reference value of 3MBW and determining its correlation with sociodemographic and anthropometric variables. ***Methods:*** A total of 1,601 Nigerian healthy adults participated in this cross-sectional study. 3MBW was measured following standardized procedure on a marked 3-m floor. Anthropometric and sociodemographic parameters were taken. Data were summarized using the descriptive statistics of mean, standard deviation, and percentile (less than the 25th, between the 25th and 75th, and above the 75th percentiles were regarded as low, average, and high 3MBW, respectively). ***Results:*** From this study, less than 2.23 s and 2.60 s were regarded as low risk of fall for males and females, respectively; 2.23–3.00 s and 2.60–3.50 s were regarded as average risk of fall for males and females, respectively, while greater than 3.00–3.9 s and 3.50–3.90 s were regarded as

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high risk of fall for males and females, respectively. 3MBWT was significantly associated with age ($r = 0.51$, $p = 0.001$), sex ($r = 0.315$, $p = 0.001$), weight ($r = 0.14$, $p = 0.001$), BMI ($r = 0.28$, $p = 0.001$), but not height ($r = -0.03$; $p = 0.250$). ***Conclusion:*** This study provided a reference set of values according to age and gender for 3MBW in healthy individuals. Males have shorter 3MBW than females, and the time taken to accomplish 3MBW increases with age.

Introduction

Physical performance tests are the traditional assessment methods employed by physiotherapists to evaluate physical impairment/deficiencies, monitor improvement during rehabilitation, and document outcomes [1]. Some of these physical performance measures include the Berg Balance Scale [2], Dynamic Gait Index [3], the Timed Up and Go Test [4], and Short Physical Performance Battery [5]. These traditional physical performance measures have been reported to be valid predictors of health outcomes and prognosis [6], as well as proxy indicators of other health indices/indexes. Examples of these include Simmonds Physical Performance-Based Tests Battery in the prediction of disability risks among patients with chronic low-back pain [7], Physical Performance Test (PPT) in the prediction `of aerobic capacity sufficient for independence in early-stage Alzheimer disease [8], fitness testing to predict injury risk [9], and as a predictor of several health outcomes [10].

Meanwhile, several measures of risk of fall in adults have been developed; these include forward walking, turning, and stepping motions [11]. Research shows that backward walking is more sensitive to identifying health-related changes in mobility and balance compared to forward walking [12]. The 3-meter backward walk test (3MBWT) is one of the outcome measures to assess backward walking mobility, balance, and risk of fall [11]. Backward walking is necessary to perform such tasks as walking backward towards a chair, opening a door, or getting out of the way of a sudden obstacle [13]. Backward walking might be quite challenging, especially for elderly people with neurological deficits [11]. It has been shown that mechanical measurements of back support specifically the speed, step length, and double support surface are mostly reduced in the elderly. According to a study by Carter et al. [13], the 3MBWT showed similar or better diagnostic accuracy for falls in the past year than most commonly used measures. Also, a previous study by Carter et al. [11] proposed that 3MBWT was a better predictor of retrospective falls in the elderly than other popular fall predictive tests such as five times "Seat to Stand" and "Timed Up and Go," and as such, it may be a valuable addition to the current battery of clinical tools.

Based on the time taken to cover a marked 3-meter backward walk (3MBW), researchers classified people as having a low, moderate, and high risk of falls [11]. In a study aimed to determine diagnostic accuracy and an appropriate fall cut-off score of the 3MBWT in a person with Parkinson's (PwP), the cut-off of 4.2 s was identified to be the most optimal for identifying falls in PwP within the past 6 months [13]. The 3MBWT is gaining increased use as a valid and reliable functional outcome tool for measuring dynamic balance and falls in individuals with stroke [14], multiple sclerosis [15], Parkinson's disease [16], spinal cord injury [17], cerebral palsy [18], dementia [19], fibromyalgia [20], arthroplasty [21], and among wide range of older adults [12]. However, the lack of baseline or reference values for 3MBWT is still a potential limitation in its use as an outcome performance measure to assess backward walking mobility, balance, and risk of fall risk. Thus, reference normative database is necessary to identify alterations in balance and gait mechanics, as well as any mobility impairments, and in turn inform appropriate intervention plan.

Normative or reference values for the 3MBWT will help identify normal and abnormal backward walk scores. Therefore, to identify departures of the backward walk score from "normal," a normative database is needed. Comparing 3MBWT results to reference data of healthy subjects may help identify individuals who are prone to fall and may also serve as objective quantitative benchmarks for setting specific goals to improve balance and stability and provide outcome measures for evaluating the success of an intervention. This study aimed to provide gender- and age-reference values of the 3MBWT in healthy Nigerian adults using the 3MBWT.

Materials and Methods

This cross-sectional study recruited healthy adults who were 18 years and older, without known musculoskeletal and neurological disorders, and who were not elite athletes or professional sportsmen and women. However, individuals with obvious physical or cognitive impairments were excluded from this study. The participants were volunteers and residents in Ondo town, Ondo State, Nigeria, including students, public and private sector workers who responded to a research advertisement. Ethical approval for the study was obtained from the Ethics and Research Committee of University of Medical Sciences, Ondo, Nigeria (NHREC/TR/UNIMED/HREC-Ondo

Table 1. General characteristics of the participants (n = 1,601)

Variable	≤20 years (n = 268)	21–30 years (n = 261)	31–40 years (n = 259)	41–50 years (n = 250)	51–60 years (n = 250)	>60 year old	All participants (n = 1,601)
	mean±SD	mean±SD	mean±SD	mean±SD	mean ± SD	mean±SD	mean ± SD
Age, years	18.8±1.02	24.1±2.93	34.7±2.86	45.3±3.13	54.9±4.60	63.6±3.36	40.8±16.7
Height, m	2.85±13.85	1.66±0.09	1.64±0.06	1.64±0.07	1.65±0.08	1.60±0.08	1.84±5.68
Weight, kg	58.8±9.05	64.2±7.99	64.4±7.56	65.7±8.18	64.6±9.46	65.6±9.89	64.1±9.08
BMI, kg/m^2	21.5±3.79	23.4±3.47	24.5±3.47	24.6±3.66	23.8±4.11	25.6±4.56	23.9±4.10

BMI, body mass index; SD, standard deviation.

St/22/06/21/PHT/16/0650). Written informed consent was also obtained from each participant. Data on anthropometric and sociodemographic parameters were obtained. The sample size for this study was based on the formula $n_0 = z^2\delta^2/e^2$ [22], where z = 1.96, δ = 1, e = 0.05; $1.96^2 \times 1^2/0.05^2 = 1{,}536$. A total of 1,601 responded and were included in the study.

3-Meter Backward Walk Test

Participants were asked to walk 3 m on a tiled floor measured and marked with black tape. Participants were asked to align their heels to follow the black band. Following the "start" command, participants were asked to walk backwards as quickly but as safely as possible. The researcher walked backward with the participant to ensure safety. When the distance of 3 m was completed, the time taken was assessed by a stopwatch. Participants were not allowed to run during the test but could look behind themselves if they desired. The test was repeated three times and the average values were recorded. A demonstration was done by the researcher before participants were instructed to go through the procedure [11].

Data Analysis

The Shapiro-Wilk test was used to examine the normality of the data. Data were summarized using the descriptive statistics of mean, standard deviation, and percentile. To construct gender- and age-reference value tables for the 3MBWT, the participants were classified into six age groups: less than 20, 21–30, 31–40, 41–50, 51–60, and older than 60 years, respectively. Typically, 25th and 75th percentiles are the lower and upper bounds in a dataset. In addition, studies on normative or reference values have utilized values between 25th and 75th percentiles to represent "normal" or "average" for the construct being investigated [23]. Thus, poor 3MBWT was defined as a walk test time less than the 25th percentile, medium 3MBWT as a walk test time that ranged between the 25th percentile and 75th percentile, and good 3MBWT as a walk test time that is greater than 75th percentile. Pearson product-moment correlation analysis was also used to investigate the association of 3MBWT with sociodemographic and anthropometric variables. Independent t test was used to assess sex differences in anthropometric variables. The alpha level was set at $p < 0.05$. Data analysis was done using IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp., Armonk, NY, USA).

Results

Participants' ages ranged between 18 and 65 years; 905 (56.5%) were females and 696 (43.5%) were males. The mean and standard age, weight, height, and body mass index (BMI) of the participants were 40.8 ± 16.7 years, 64.1 ± 9.08 kg, 1.84 ± 5.68 m, 23.9 ± 4.10 kg/m^2, respectively. Presented in Table 1 are the general characteristics of participants. Table 2 shows the age- and sex-reference values for a 3MBW.

Using the 25th, 25th–75th, and >75th percentiles as low, average, and high 3MBWT, respectively, for male and female participants, less than 2.23 s and 2.60 s were regarded as a low risk of fall for males and females, respectively; 2.23–3.00 s and 2.60–3.50 s as the average risk of fall for males and females, respectively, while greater than 3.00–3.9 s and 3.50–3.90 s were regarded as high risk of fall for male and female, respectively (Table 2). Presented in Table 3 are the results on the correlation between 3MBW and sociodemographic parameters and anthropometric parameters. Result showed that a significant correlation exists between 3MBW and each of age (r = 0.51; p = 0.001), sex (r = 0.315; p = 0.001), weight (r = 0.140; p = 0.001), and BMI (r = 0.281; p = 0.001). The results of sex comparison of anthropometric parameters showed significantly higher values in height (t = 10.564, p < 0.001) and weight (t = 2.962, p = 0.003) among male participants but higher BMI among female participants (t = 3.696, p < 0.001). However, there was no significant sex difference in age (Table 4).

Discussion

The purpose of this study was to provide a reference value for 3MBWT in apparently healthy individuals. 3MBWT is considered an outcome performance measures to assess backward walking mobility, balance, and risk of fall risks. Reference values for a 3MBWT can be used as rehabilitation target values or predictor of

Table 2. Age- and sex-reference values for 3-meters backward walk test

	Minimum	25th percentile	50th percentile	Mean	SD	Median	75th percentile	95th percentile	Maximum
18–20 years									
Male	1.2	1.80	2.10	2.10	0.40	2.10	2.40	2.80	3.00
Female	1.7	2.80	3.00	2.43	0.32	3.00	3.10	3.30	3.90
Total (male & female)	1.2	2.10	2.30	2.31	0.39	2.30	2.60	2.90	3.90
21–30 years									
Male	1.2	2.20	2.40	2.06	0.41	2.40	2.63	2.90	3.30
Female	1.7	3.10	2.49	3.36	0.26	3.30	3.42	3.70	3.20
Total (male & female)	1.2	2.00	2.30	2.27	0.46	2.30	2.60	3.00	3.30
31–40 years									
Male	1.5	1.80	2.10	2.81	0.35	2.10	2.30	2.83	3.50
Female	1.9	2.90	3.00	2.98	0.39	3.00	3.10	3.70	3.90
Total (male & female)	1.5	3.20	3.00	3.09	1.30	3.00	3.30	3.60	3.60
41–50 years									
Male	2.3	2.30	2.50	2.49	0.24	2.50	2.80	3.10	3.80
Female	2.5	3.10	3.40	3.28	0.26	3.40	3.60	3.90	3.80
Total (male & female)	2.3	2.90	3.10	3.14	0.30	3.66	3.40	3.60	3.80
51–60 years									
Male	1.9	2.70	2.90	2.97	0.39	2.90	3.00	3.20	3.90
Female	1.7	2.90	3.00	3.30	0.40	3.00	3.20	3.98	4.80
Total (male & female)	1.7	2.90	3.15	3.16	0.43	3.15	3.50	3.80	4.80
>60 years									
Male	2.1	3.00	3.20	3.13	0.42	3.20	3.40	3.60	4.70
Female	2.2	3.30	3.60	3.57	0.51	3.57	3.90	4.50	5.10
Total (male & female)	2.1	3.00	3.40	3.40	0.52	3.40	3.70	4.40	5.10
All									
Male	1.2	2.23	2.90	2.67	0.57	2.90	3.00	3.50	4.70
Female	1.7	2.60	3.10	3.08	0.80	3.10	3.50	3.90	3.90
Total (male & female)	1.2	2.50	3.00	2.90	0.79	3.00	3.30	3.80	3.80

Table 3. Correlation between the 3-meters backward walk test and sociodemographic and anthropometric parameters

Variables	Correlation (*r*)	*p* value
Age, years	0.510	0.001*
Sex	0.315	0.001*
Height, m	–0.030	0.250
Weight, kg	0.140	0.001*
BMI, kg/m^2	0.281	0.001*

*Indicates significant correlation, *r*-Pearson's correlation coefficient.

outcomes. A study among residents of a retirement community without a history of neurological deficits by Carter et al. [11] found that people walking faster than 3.0 s on the 3MBW were unlikely to have reported falling, whereas people slower than 4.5 s were highly likely to have reported falling. In another study [12], more than 75% of people who were faster than 3.0 s did not report any falls, while 94% of people who did not report falling were faster than 4.5 s. For people who were slower than 4.5 s, 81% reported falling. In other words, persons walking faster than 3.0 s on the 3MBWT were relatively unlikely to have reported falling, whereas people walking slower than 4.5 s were very likely to have reported falling [12]. The values obtained from the reference norms in this study are somewhat comparable with walk speed reckoned to risk of fall during a 3MBWT in the study by Carter et al. [11]. While speeds of 3.13 ± 0.42 s and 3.57 ± 0.51 s were found in this study for male and female, respectively, who were in the >60 years of age category, 3.8 ± 1.8 s and 4.2 ± 2.2 s were reported among male and female, respectively, in the study by Carter et al. [11] among community-dwelling older adult (aged 60–89 years) without a history of neurological deficit who were residents of a retirement community in the USA.

In disease conditions, 3MBWT scores are expected to take longer to accomplish. In a study among patients with stroke, Abit Kocaman et al. [14] recorded the first and second walking durations for 3MBWT as 15.45 ± 8.91 s and 15.55 ± 9.39 s, respectively. Thus, patients with

Table 4. Sex differences in the anthropometric parameters (n =1, 601)

Variable	Male, mean±SD	Female, mean±SD	t	p value
Age, years	39.91±15.88	39.62±16.25	0.343	0.731
Height, m	1.66±0.07	1.62±0.07	10.564	<0.001*
Weight, kg	64.86±7.63	63.59±8.84	2.962	0.003*
BMI, kg/m^2	23.57±3.45	24.28±3.93	3.696	<0.001*

SD, standard deviation. *Indicates significant difference.

stroke are at a higher fall risk compared to healthy older individuals. In another study among persons with multiple sclerosis, the average of the first and second measurements of the 3MBWT was reported as 6.17 ± 3.98 sec and 6.19 ± 3.89 s [15].

In another study by Carter et al. [13], the 3MBWT was recommended to be considered as part of a battery of tests among persons with Parkinson's disease, as it had the highest overall accuracy for retrospective falls compared with other tests. While the 3MBWT was found to be reliable in healthy elderly individuals [11], it has been recommended for validation among other patient populations [13], as it has the potential to assess neuromuscular control, proprioception, protective reflexes, fall risk, and balance. Accordingly, a recent study by Ayşe et al. [24] reported that the 3MBWT was valid and reliable in individuals with stroke as an effective and reliable tool for measuring dynamic balance and falls in stroke.

Differences in 3MBW between male and female participants were observed in this study. Males had shorter 3MBW than females; Laufer [25] reported that male subjects demonstrate a higher gait velocity than females only in the backward walking condition, whereas the stride length of female subjects was shorter than that of male subjects in both forward and backward walking conditions. It was also reported that cadence and the swing and double support phases of ambulation were not affected by gender, but an interaction effect in cadence between walking condition and gender may indicate that the cadence of male subjects is more stable across walking conditions [25].

The current showed that 3MBWT was significantly associated with age, sex, weight, and body mass index but not height. Similar to the findings of Carter et al. [11], 3MBWT was significantly associated with age but not gender. Tabue-Teguo et al. [26] observed that underweight and overweight/obese individuals are significantly slower in gait speed compared to persons with normal body mass index. High and low body mass indices are here shown to constitute a risk factor for being a slow walker, thus more vulnerability to stressors and exposure to negative outcomes. Being overweight and obese has been previously linked to sarcopenia (i.e., age-related continuing loss of muscle mass and strength) [27]. Thus, individuals with obesity may spontaneously become slow walkers due to impairment of balance and physical fatigue. The excess of adipose tissue may alter the optimal ratio with lean mass and affect the quality and function of the skeletal muscle. Consistently, malnourished individuals may reduce their gait speed because of quantitative and qualitative deficits of the skeletal muscle [28].

With respect to height, taller individuals walk faster than their shorter counterparts [29], and there are multiple mechanisms underlying this association. Taller persons tend to have lower body mass index, better cardiovascular risk profiles, and have higher cognitive function, all of which have been associated with faster gait speed [30]. While a study by Elbaz et al. [30] posited that there is little association between height and gait speed; however, a study by Samson et al. [31] implied that mechanical factors, such as greater stride length of taller persons, play an important role. The higher stride frequency of shorter persons does not compensate for shorter strides, leading to slower gait speed compared to their taller counterparts [32]. We observed that male adults were significantly taller than the female counterparts, while female adults had a higher body mass index. However, mentioned above, females walked faster backward than males in this study. These findings suggest more intricate mechanisms, other than physical and anthropometric parameters, may be responsible for backward walk speed.

From this study, the time taken to accomplish 3MBW increases with older age in apparently healthy individuals. Several measures of fall risk have been previously developed and include forward walking, turning, and stepping motions. However, recent research has demonstrated that backward walking is more sensitive to identify age-related changes in mobility and balance compared with forward walking [11]. Age-related changes in gait negatively impact function, as indicated by an increase in falls and the use of assistive devices in old age. Older adults have less cadence in walking, shorter stride distance, more variable kinematic parameters, and increased double support time compared to younger individuals because of this reason, walking backward slows down more than walking forward [33]. In a study by Fritz et al. [12], backward and forward walking performance declined significantly in the elderly compared to young and middle-aged adults, with spatiotemporal measures of backward walking declining more precipitously than forward walking [12]. Increased time taken to accomplish the 3MBW in the elderly is linked to different changes that occur in various systems in the body. It has been found that with aging, motor weakness is due in part to neuromuscular degeneration, but also to degenerative changes in the central nervous system. Thus, reduction in gray matter volume, number of motor cortical and spinal motor neurons and synaptic density, white matter integrity, and descending commands for motor activation are some of the factors that may contribute to age-related motor impairment [34].

The age- and sex-reference values for 3MBWT could be used in rehabilitation to estimate backward walking mobility, balance, and risk of fall risk in a patient at intake, as well as serve as rehabilitation targets, and as an outcome measure of improvement. There is an apparent dearth of normative database among healthy individuals. The study by Carter et al. [11] was conducted among community-dwelling older adults. Other studies have been carried out among different patient populations. The current study, to the best of our knowledge, seems to be the first study to generate age- and sex-reference values for 3MBWT. Thus, there are no data to compare the percentile values obtained in this study directly. However, the data for participants older than 60 years in this study were compared with previous results [11]. It is speculated that ethnic and racial differences may significantly influence the pattern of 3MBWT. Currently, there seems to be no empirical data on this. Thus, there is a need for more studies on normative values for 3MBWT from other climes.

This study has a few limitations. Sample bias may be associated with voluntarily participation. Furthermore, the health status of the participants was based on self-report; thus, it is possible that the participants might have given vague or incorrect answers about their health statuses. The average of three consecutive measurements of 3MBWT was used in this study, as recommended and like most other physical performance test. Using the average value may help to control for within-subject performance bias, and random intra-rater errors. No motivation or encouragement was given to the participants during the walk test to avoid performance bias; however, full information about the nature of the test was provided. Finally, the age categorization employed in this study may serve as another potential limitation. However, while no rule of thumb is referred to in this study, many studies with participants having a wide age range construct reference value tables on the classification by age categories in 10-year intervals [23].

Conclusions

This study provides a reference set of values according to age and gender for 3MBW in apparently healthy individuals. Males have shorter 3MBW than females and the time taken to accomplish 3MBW increases with age.

Statement of Ethics

The Ethics and Research Committee of University of Medical Sciences Ondo, Nigeria, gave ethical approval for the study (NHREC/TR/UNIMED/HREC-Ondo St/22/06/21/PHT/16/0650). In addition, written informed consent was obtained from all participants.

Conflict of Interest Statement

The authors have no conflict of interest to declare.

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Author Contributions

Chidozie E. Mbada: study conceptualization and design. Aanuoluwapo D. Afolabi, Augusta Akinkuoye, and Taofik O. Afolabi: data collection. Chidozie E. Mbada, Aanuoluwapo D. Afolabi, Augusta Akinkuoye, Taofik O. Afolabi, Adekola B. Ademoyegun, Faatihah Niyi-Odumosu, and Francis Fatoye: data analysis and interpretation and manuscript drafting. All authors read and approved the final draft of the manuscript.

Data Availability Statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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