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Research Article

Psychometric Testing of Three-and Six-Minute Walk Tests among Stroke Survivors -

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ABSTRACT

Background: Easy walk-related fatigability in stroke resulting from high energy expenditure demands calls to question the suitability of six-Minute Walk Test (6-MWT) in functional capacity testing in stoke. This study was aimed to investigate the concurrent validity, test-retest reliability and completion rate of three-Minute Walk Test (3-MWT), as well as, its physiological variables.

Methods: Thirty-two consenting stroke survivors who were ambulant with or without walking aid performed 6-MWT following the American Thoracic Society (ATS) guidelines, and the 3-MWT, which was a replica of the 6-MWT but shorter in duration. The order of performance of the walk tests was random. The participants performed the 3-MWT and 6-MWT separately on the same day once, and were repeated within a week for reliability testing. Data was collected on total distance walked, blood pressure and heart rate. Descriptive and inferential statistics were used to analyze data. Alpha level was set at $p < 0.05$.

Results: There was 100% completion rate for the 3-MWT without having to rest during the test, while there was 21.8% resting rates during the 6-MWT. The mean walk distance for 6-MWT and 3-MWT were 264.2m and 124.8m.3-MWT was strongly correlated with each of 6-MWT Distance ($r = 0.96$; $p = 0.000$) and 6-MWT gait speed ($r = 0.96$; $p = 0.000$).The Intra-class correlation coefficients for walk distance for - was 0.878. There were no significant differences in the cardiovascular variables between the two tests except in the pre-test systolic blood pressure ($p = 0.02$).

Conclusion: The 3-MWT has a high completion rate and good psychometric properties as a measure of functional capacity in stroke survivors. In addition, it evokes comparable physiological responses with 6-MWT.

Keywords: Six-minute walk test; Three-minute walk test; Stroke; Concurrent validity; Cardiovascular response

INTRODUCTION

Stroke is one of the main chronic illnesses around the globe [1-4] and a cause of majority of functional independence in many populations [5]. Inadequate aerobic conditioning [6] coupled with increased energy expenditure during walking compromise their locomotor ability in daily activities in stroke [7]. Thus, stroke affect functional locomotion [8], and limit survivors' independence and social participation [9,10]. Typically, the 6- Minute Walk Test (6-MWT) has been used to describe and evaluate changes in walking capacity following stroke. The 6-MWT, which was primarily developed to evaluate cardio respiratory endurance, measures the maximum distance an individual can walk in 6 minutes [11]. The test is used mainly as a tool for evaluating functional endurance and is a significant predictor of community ambulation and integration in stroke survivors [12]. However, easy walk-related fatigability that is a component of most many chronic illnesses such as stroke is significant shortcoming of the use of 6-MWT.

Fatigue is a commonly reported issue after stroke [13,14]. Congruent with evidence for increased fatigue and impaired gait after stroke, walking speed in individuals with stroke can decrease in as little as six minutes of continuous effortful walking. In stroke survivors, the distance walked during 6-minute walk test have been discovered to be hamstrung by fatigue even while walking at their comfortable speed [15]. Sibley, et al. [16] reported that about 29% of the participants rested during a 6-minute walk test in a study which evaluated spatiotemporal parameters of stroke patients while performing functional capacity test. Although rest is permitted in the American Thoracic Society Guidelines on 6-MWT administration [17], it has been documented that some individuals are not willing or unable to complete the 6-MWT leading to null values [18]. Sibley, et al. [16] found that resting during the 6-MWT influences the amount of distance completed per unit time among stroke survivors and quantification of rest times has implications for interpretation of 6-MWT scores as well as for treatment planning.

Individuals in the sub-acute phase (< 3 months) after stroke covered less distance in the latter phases of the 6-MWTcompared to the initial minutes of the test [19]. Eng, et al. [20] reported similar changes of smaller magnitude in participants in the chronic stroke phase (> 3 months) who walked even shorter distances overall. The authors concluded that the changes in walking speed reflected the impact of cardiorespiratory challenge and fatigue. Sibley, et al. [16] in their study suggested that an additional measure of shorter continuous walking distance (i.e. until a rest is taken) may be a valuable supplement or alternative to the traditionally used measure of total distance walked in six minutes. There was an attempt to validate two-Minute Walk Test (2-MWT), which is a shorter version of 6-MWT, by Kosak and Smith, [15] in patients with stroke. However, in that study, 2-MWT was not assessed independently as a test but concurrently as part of 6-MWT, and they reported 2-MWT to be useful in assessing patients' self-selected walking speed more than their functional capacity. Consequent to the foregoing, the three-Minute Walk Test (3-MWT) may provide a valid alternative measure of functional capacity with higher completion rate and tolerability among stroke survivors.

The 3-MWT is a sub maximal walk test which is simple, non-incremental and easy to carry out both in the hospital and community. The distances covered in three-minute walk test has been compared with the six-minute walk test in patients with Chronic Obstructive Pulmonary Disease (COPD) [21], and apparently healthy individuals [22]. Also, 3-MWT has been found to be feasible for patients presenting to the emergency department with acute dyspnea [23], and it has been proven to be a good tool for evaluation and exercise prescription in the aquatic environment [24]. To the knowledge of the authors there has not been any study that characterizes functional capacity of stroke survivors using 3-minute walk test. The purpose of this study was to determine the completion rate, concurrent validity and test-retest reliability of 3-MWT among stroke survivors, and also to compare their cardiovascular variables during the 3MWT and 6-MWT.

MATERIALS AND METHODS

Thirty-two (32) consenting patients with stroke who were actively undergoing rehabilitation at the Physiotherapy Unit of Ladoke Akintola University of Technology Teaching Hospital (LAUTECH), Osogbo, Nigeria, were purposively recruited in this cross-sectional study. The sample size used in this study was mirrored on the study conducted by Iriberri, et al. [21]. They found

a correlation of 0.98 between the 3MWT and 6MWT in patients with COPD. With an alpha of 0.05 and power of 80% including 20% loss rate. The BioEstat(r) 5.0 software indicates six participants would be enough to detect a statically significant correlation. In all, thirty-two participants were recruited in this study. Inclusion criteria included: (1) a history of cerebrovascular accident, (2) independent ambulation with or without assistive device, and (3) score of ≥ 16 in Mini-Mental State Examination. Participants were excluded if they had: (1) comprehensive aphasia, (2) unstable medical conditions like uncontrolled hypertension, arrhythmia, unstable cardiovascular status etc., (3) major musculoskeletal problems from other than stroke, or (4) other neurological problems other than stroke. Informed consent was obtained from each participant, and ethical approval was given by Research Ethics Committee of LAUTECH Teaching Hospital, Osogbo, Nigeria.

PROCEDURE

Assessment of six- and three-minute walk tests

The walk tests were undertaken with participants wearing their normal footwear and usual walking aid (eg, cane, orthosis). Participants were instructed to walk with their self-selected gait while attempting to cover as much ground as possible around a 30-m rectangular path provided inside Physiotherapy Unit in six or three minutes as the case may be and not to stop unless they needed to. The walk tests were allocated to the participants randomly using simple ballot system. The 3-MWT and 6-MWT was administered separately on the same day once and was repeated within a week. Participants who performed the 3-MWT first was allowed to rest for 30 minutes before being engaged in the 6-MWT and vice versa. Encouragement was provided every 30 seconds or more in a standardized manner by saying: "you are doing well" or "keep up the good work". Participants were reminded of the time remaining for the completion of each test. The walk distance during the six and three minute was recorded to the nearest whole number in meters. The pre- and post- test cardiovascular parameters (Blood pressure and heart rate) were measured for each test using Auto-inflated electronic sphygmomanometer (Omron Healthcare Inc., Vernon Hills, Illinois, USA). Rate Pressure Product (RPP), a measure of myocardial oxygen consumption, was calculated as the product of HR and systolic BP while the average speed of each participant was calculated using the distance achieved in each test divided by the duration of the same. Maximal heart rate was calculated using the formula, HR_{max} = 208-Age for each participant.

Socio-demographic characteristics including age and sex was recorded while the anthropometric characteristics including body weight and height was assessed and body mass index calculated. Duration since the onset of stroke, the type of stroke, side of injury, type of walking aid and the medications and dosage prescribed by the attending physician were recorded.

DATA ANALYSIS

Descriptive statistics of frequency, percentage, mean, standard deviation and range was used to summarize the data. Pearson Product Moment Correlation was used to determine the validity of the 3-MWT while the reliability of the two tests was determined by the Intra-class Correlation Coefficient (ICC > 2,1). Paired t test was used to compare the cardiovascular changes between the 6-MWT and 3-MWT. A level of $p < 0.05$ was considered significant. IBM SPSS Statistics version 21 was used for the analysis.

RESULTS

The mean age, height, weight and body mass index of the participants were 61 years, 1.64 meters, 70.4 kilograms and 26.2 kgm^{-2} respectively. The average time since stroke was 18 months (see table 1) with 62.5% of participants on ACE inhibitors, n = 20. 78.2% of the participants walked without any assistive device or orthosis while 21.8% of the participants rested during the 6-MWT. However, there was a 100% completion rate by the participant during 3-MWT. The mean walk distances for three- and six- minute walk test were 124.8m and 246.2m (table 2). The walk speed for 3-MWT and 6-MWT were 0.69m/s and 0.68m/s. Table 3 shows the Pearson product moment correlation coefficient between the 3-MWT walk distance and the

Table 1: General characteristics of the participants (N = 32).

Variable	Frequency	Percentage	Mean ± SD	Range†
Sex (M/F)	20/12	62.5/37.5		
Type of stroke (I/H)	18/14	56.3/43.8		
Paretic side (left/right)	6/26	18.8/81.2		
Medication Prescribed‡ ACE inhibitors Peripheral	20	62.5		
vasodilators	13	40.6		
diuretics	17			
antidepressants	3	9.4		
antiarrhythmic	1	3.1		
Age (y)			61.1 ± 12.4	31-81
Height (m)			1.64 ± 0.07	1.5-1.8
Weight (Kg)			70.4 ± 8.99	48-90
BMI (kg / m2)			26.2 ± 2.87	18.3-32.0
Time since stroke (month)			18 ± 15	1-48

Key: I-Ischaemic; H-Haemorrhagic; SD-Standard Deviation; † - Full range; ‡- The percentage of drug prescribed sum more than 100% due to the combination of medications.

Table 2: Average walk distances for six- and three-minute walk test and their functional measures (n = 32).

Variable	Mean	S.D	Range†
Walk Distance			
3MWD (m)	124.84	45.11	51.6-201.6
6MWD (m)	246.2	93.87	100.2-396.0
Estimated RPP‡			
3MWT (mmHg*bpm)	11828	2301	7728-17273
6MWT (mmHg*bpm)	12042	2390	2390
Gait speed			
3MWT (m/s)	0.69	0.25	0.29-1.12
6MWT (m/s)	0.68	0.26	0.28-1.10
%HR_{max}§			
3MWT	54.3	10.8	31.6-80.9
6MWT	54.7	10.1	32.2-79.1

Key: 3MWD: 3-Minute Walk Distance; 3-MWT: 3-Minute Walk Test; 6MWD: 6-Minute Walk Distance; 6-MWT: 6-Minute Walk Test; RPP: Rate Pressure Product; % HR_{max}: Percentage of maximum heart rate; † : Full range; ‡: Estimation based on systolic blood pressure and heart rates post- test; §: calculation based on heart rates post- test

Table 3: Correlation between 3-Minute Walk Test and different measures of functional capacity derived from 6-MinuteWalk Test.

3-MWT			
Distance (m)			
Variable		*r*	*p* - value
6MWT			
Distance walked (m)		0.96	0.000
RPP (mmHg*bpm)		0.04	0.810
Gait speed (m/s)		0.96	0.000

Significant at $p < 0.01$
Key: 6-MWT: 6-Minute Walk Test; 3-MWT: 3-Minute Walk Test; RPP: Rate Pressure Product; r: Pearson correlation coefficient.

different measures of functional capacity derived from 6-MWT (i.e. 6-MWT walk distance, gait speed and rate pressure product). A strong significant correlation was found between the 3-MWTwalk distance and 6-MWTwalk distance ($r = 0.96$; $p = 0.000$) and 6-MWT gait speed ($r = 0.96$; $p = 0.000$). The relationship between distances covered in both tests is depicted in the scatter plot (figure 1).

Table 4 shows the test-retest reliability of the three- and six-minute walk test obtained in the first and second sessions at a week interval. Good reliability was obtained for both tests (ICC ≥ 0.8; $p = 0.001$) with adequate internal consistency. There was no significant difference ($p > 0.05$) in the cardiovascular responses (blood pressure, heart rate and rate pressure product) between three- and six- minute walk test except in pre-test systolic blood pressure as shown in table 6. Furthermore, there was no significant increase in cardiovascular variables within each test, except in diastolic blood pressure for 3-MWT.

DISCUSSION

This study was conducted to validate the use of the 3-MWT, examine its test-retest reliability, and compare the cardiovascular response between the 3- and 6- minute walk test among stroke survivors. The average walk distance for 6-MWT in this study was 246.2 ± 93.8m. Although there is no standard for distance walked for stroke survivors as in healthy individuals [10], the distance obtained in this study is more than the walk distance in patients with stroke of about 28days duration (215m) [10], and (150m) [15], but the value is comparable to those obtained by Eng, et al. [20] among stroke patients of more than one-year duration, where 6-MWT walk distance was 268m. This may suggest that time since onset of stroke influences distance walked by stroke survivors in 6-MWT. The 6-MWT walk distance covered by stroke survivors in this study was low and about 50% of the distance covered by patients with chronic respiratory disease [25], and only about 40% obtained in healthy individuals [26]. This evidence indicates that caution is needed when comparing distance covered in stroke survivors with apparently healthy adults and in other disease state as pathology mechanism is bound to be different and may have varying effect on walk performance. Reduction in mobility post stroke is mediated by primary motor impairment, muscle tone alteration, poor selective motor control, abnormal reflexes, and balance impairment [27].

The average distance covered by the participants in this study during 3-MWT was 124.8 ± 45, which is about 51% of the distance walked during the 6-MWT. There is no available data to compare this value in stroke population as this is the first study to our knowledge, to test 3-MWT among stroke survivors. Nevertheless, the 3-MWT distance walked in this study is about 50% of the average distance reported for patients with COPD undergoing 3-MWT (243 ± 28m) [21], and 91% (135 ± 13) of the distance walked by apparently healthy young subjects who undertook 3-MWT inside water [24].

The findings of this study showed that the 3-MWT demonstrated good and acceptable evidence of validity when compared with 6-MWT. The correlation coefficient obtained for stroke survivors participating in this study is significantly strong ($r = 0.96$; $p = 0.000$). This value supports the concurrent validity of 3-MWT as a measure of functional capacity post stroke. Equally, the 3-MWT correlated strongly with the 6-MWT gait speed ($r = 0.96$), but has poor correlation with 6-MWT rate pressure product ($r = 0.04$). The results from this study regarding test-retest reliability of 3-MWT and

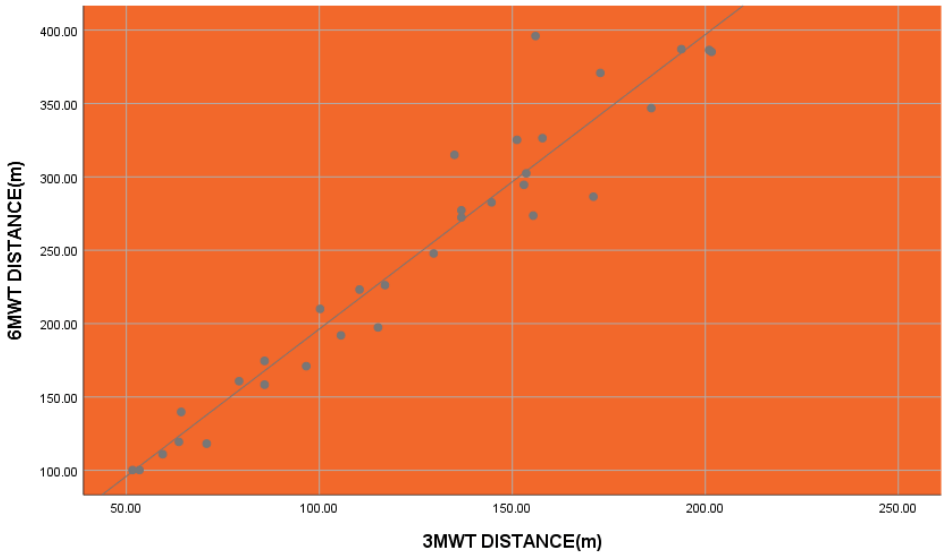

Figure 1: Scatter plot depicting positive, strong relationship between 6-MWT Distance and 3-MWT Distance ($r = 0.96$).
Key: 6MWT: 6-minute walk test; 3MWT: 3-minute walk test; m: meters.

Table 4: Test-retest reliability for 3-Minute and 6-Minute Walk Test at one-week interval.

			95% CI	
Variable	Cronbach's α	ICC	Lower - Upper	*p* - value
3-MWT				
Distance (m)	0.935	0.878	0.766 - 0.939	0.000
6-MWT				
Distance (m)	0.951	0.906	0.817 - 0.953	0.000

Significant at $p < 0.05$
Key: LB: Lower Bound; UB: Upper Bound; CI: Confidence Interval; 6MWT: 6-Minute Walk Test; 3MWT: 3-Minute Walk Test; m: meters.

Table 5: Comparison of cardiovascular variables at pre- and post test 6-MWT and 3-MWT

Variable	Pre-test Mean	Post-test Mean	t	*p* - value
6MWT				
SBP (mmHg)	132.09	139.44	-4.417	0.000
DBP (mmHg)	82.23	85.86	-3.352	0.002
HR (bpm)	82.2	86.25	-6.297	0.000
RPP (mmHg*bpm)	10871	12042	-7.349	0.000
3MWT				
SBP (mmHg)	127.92	138.45	-5.828	0.000
DBP (mmHg)	82.64	83.66	-1.429	0.163
HR (bpm)	83.02	85.53	-4.95	0.000
RPP (mmHg*bpm)	10589	11828	-7.331	0.000

Significant at $p < 0.05$ (2-tailed)
Key: 6MWT: 6-Minute Walk Test; 3MWT: 3-Minute Walk Test; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; HR: Heart Rate; RPP: Rate Pressure Product.

Table 6: Comparison of cardiovascular responses between 6-MWT and 3-MWT.

Variable	6MWT		3MWT	t	*p* - value
SBP pr (mmHg)	132.09		138.45	2.444	0.020
SBP po (mmHg)	139.44		138.45	0.67	0.508
DBP pr (mmHg)	82.23		82.64	-0.49	0.628
DBP po (mmHg)	85.86		83.66	2.038	0.050
HR pr (bpm)	82.2		83.02	0.675	0.505
HR po (bpm)	86.25		85.53	0.712	0.482
RPP pr (mmHg*bpm)	10871		10589	1.631	0.113
RPP po (mmHg*bpm)	12042		11828	0.966	0.342

Significant at $p < 0.05$ (2-tailed)
Key: 6MWT: 6-Minute Walk Test; 3MWT: 3-Minute Walk Test; BP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; HR: Heart Rate; RPP: Rate Pressure Product; pr: pre-test; po: post-test.

6-MWT among stroke survivors showed good reliability for both tests (ICC ≥ 0.8). Although the intra-class correlation coefficient for 6-MWT is more than that of the 3-MWT, nevertheless, the ICC obtained for 3-MWT are adequate to establish its reproducibility with strong internal consistency. Iriberri, et al. [21] obtained a high correlation ($r = 0.98$) when they compared the three- minute walk test with six- minute walk test among COPD patients while a study comparing 3-MWT in water with 6-MWT in healthy young subjects obtained a weak correlation ($r = 0.35$) between the two tests [24]. However, after literature search, no study was found to compare the values of validity and reliability of 3-MWT in stroke with as obtained in this study. Coupled with acceptable level of validity and reliability found in this study, the 3-MWT may also provide a more consistent means of evaluating uninterrupted functional walking capacity in stroke population due to the fact that all the participants successfully completed the 3-MWT without taking a rest while about 22% of the participants rested during the 6-MWT.

The average percentage of heart rate maximum (HR_{max}) obtained in this study did not reach high values. The Submaximal Heart Rate (SHR) reached by the participants in 6-MWT and 3-MWT are 54.7% and 54.3%. These findings indicate that both walk tests are indeed submaximal, and are comparable to values obtained in other studies examining the functional capacity of stroke patients during the 6-MWT [20,28]. Studies have shown that stroke survivors only reach 50% of their cardio respiratory fitness in walk tests when compared with their age- matched healthy individuals [29,30]. From the findings of this study, the two tests provide evidence of stressing the cardiovascular parameters of stroke patients. From pre- to post-

test, the diastolic and systolic arterial pressure, heart rate and the rate pressure product significantly increased except during 3-MWT diastolic blood pressure.

Comparing the cardiovascular variables between the 6-MWT and 3- MWT showed no significant differences of the level of physiological stress on the participants by the two tests. Although initial systolic blood pressure between the two tests showed significant difference, this could be said to be clinically insignificant because the value is still within the normal range [31]. Several researchers have shown that 6-MWT indeed did stress cardiovascular system of stroke survivors [10,27,28], however, there is no previous study attempting to evaluate the changes in cardiovascular variables of stroke survivors during 3-MWT. Meanwhile a study conducted by Iriberri, et al. [21] using 3-MWT reported significant changes of the cardiovascular variables in patients with COPD which is not comparable with stroke population examined in this study. Nevertheless, it is important to note that there is no significant difference in cardiovascular variables between the 3-MWT and 6-MWT confirming that both tests have similar cardiovascular stress on stroke survivors.

CONCLUSION

The 3-MWT has a high completion rate and good psychometric properties as a measure of functional capacity in stroke survivors. In addition, it evokes comparable cardiovascular responses with 6-MWT. Future studies should endeavour to develop nominal data for 3-minute walk test in healthy population.

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