Influence of clinical characteristics of stroke survivors on their walking capacity

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Abstract. The walking capacity of stroke survivors has been established to have multiple determinants making investigation of the potential contribution of the survivors' characteristics to the phenomenon a necessity. Thus, this study was aimed to assess the influence of clinical characteristics of stroke survivors on their walking capacity. *Material and Method*. Sixty-seven consenting stroke patients who were ambulant performed Six-minute Walk Test (6MWT) according to American Thoracic Society (ATS) guidelines. Data was collected on total distance walked and the clinical characteristics of stroke survivors including the paretic side, use of walking aids, duration of stroke, type and severity of stroke. Descriptive and inferential statistics were used to analyze the data. Alpha level was set at $p < 0.05$. *Results*. The average distance walked by the survivors during 6MWT was 188.39 ± 80.93m. Comparison of distance walked with various patients' characteristics revealed that participants with ischemic and minor stroke significantly covered more distance (Ischemic vs. Hemorrhagic; 205.42m vs. 166.07m; p = 0.048), (Minor vs. Moderate; 222.72m vs. 148.52m; p = 0.000), while those with walking aids significantly covered less distance compared to those without walking aids (131.64m vs. 222.17m; p = 0.000). The duration of stroke, paretic side, age, BMI and gender had no significant influence on the distance covered by the participants ($p > 0.05$). Multiple regression analysis revealed that stroke severity, type of stroke and the use of walking aids were independent predictors to distance covered by the participants ($R^2 = 0.477$; P = 0.000). However, only the use of walking aids (B = -0.389; P = 0.000) and increasing stroke severity (B = -0.503; p = 0.000) were significant determinants of walking capacity of the participants. *Conclusion*. The use of walking aids and increasing stroke severity significantly influence the walking capacity of stroke survivors.
Key words: *stroke, walking capacity, six- minute walk test, walking aids.*

Introduction

Stroke is a main cause of death and disability, resulting into incapacitation of more than half a million individuals per annum worldwide (1). It is reported that 75% of all deaths that resulted from stroke and 80% of individuals with disability post-stroke occur in developing nations (2). Individuals with stroke commonly present with sensory-motor impairment, unilateral or bilateral muscle weakness, balance impairment, visual and psychological dysfunction, and perceptual and language impairments (3). These stroke-induced impairments limit execution of functional activities, basic and instrumental activities of daily living, and social participation (4), occurred mainly from stroke-induced walking deficits (5).

Walking, as an essential human activity, is needed for productive living and social participation (6). Although walking is a main goal of rehabilitation post-stroke, and many individuals months after stroke onset retain or attain some ability to walk (7), however, functional walking capacity is compromised among stroke survivors (6, 8). Many of the stroke patients who attain or retain walking capacity post-stroke have their walking parameters at sub-maximal levels compared to healthy individuals (8, 9), and display even more reduced physical activity than most sedentary older adults(10). The reduction of physical activity after stroke could result to repeat stroke (11) and development of other diseases and mortality (12) which leads to a vicious cycle of physical inactivity and functional dependence (13). Typically, the 6-minute walk test (6MWT) has been used commonly to assess walking capacity.

The 6MWT is a functional walking test that was originally developed for the assessment of functional capacity of cardio-respiratory patients (14). The test is simple, inexpensive, reproducible and well tolerated by patients (15), making it appealing to health care professionals (8) and therefore commonly used in rehabilitation science (16), and clinical research (17). The test has been applied among apparently healthy individuals (18), and elderly with cardiovascular problems (19). The 6MWT has also been tested in patients of different ailments including fibromyalgia, cerebrovascular accident, amputations, morbid obesity, Down's syndrome, Alzheimer's disease and cerebral palsy etc. (20-24). The test has been employed to evaluate and monitor changes in walking capacity, and as a measure of cardiovascular endurance of stroke survivors (25). The test requires subjects to walk as fast as possible in 6 minutes with or without their walking aids and rest if needed during period of the test (8). The outcome measure in 6MWT is the total distance walked in 6 minutes (26).

Studies have shown that basic demographic and physical factors like age, height, gender etc. influence 6MWT performance in healthy populations (27, 28). Also, physical measures and gait indices are associated with 6MWT performance among community-dwelling older individuals and residents of nursing home (29, 17). However, correlations and equations derived from these studies cannot be extrapolated to individuals with mobility impairment following pathology (8), because it has been found that usage of predictors of 6MWT created for populations apart from the one studied resulted into errors on the predicted distances (30) including patients with stroke (8).

There are few studies that tried to evaluate the factors that influence walking capacity of stroke patients using 6MWT. They reported that neuromuscular and cardiovascular parameters including balance, lower limb motor function or strength and cardio-respiratory fitness are determinants of 6MWT performance (8, 31). Since walking capacity post-stroke is said to have multiple determinants (32), it is deemed necessary to evaluate the contribution of stroke patients' clinical characteristics to their walking performance. The objective of this study was to investigate the relative contribution of demographic, physical measures and clinical characteristics of stroke survivors to their walking capacity using 6MWT. It is essential to know the extent to which these measures may explain any 6MWT results in stroke survivors so that clinicians may include them in assessment and intervention protocols.

Material and method

Participants. Sixty-seven (67) stroke survivors receiving treatment at the Department of Physiotherapy, Ladoke Akintola University of Technology Teaching Hospital, Osogbo, Nigeria, participated in this cross-sectional study. Written informed consent was obtained from each participant and the study was cleared by the Research Ethics Committee of the institution (LTH/EC/2019/10/435). Inclusion criteria included: history of single ischemic or hemorrhagic stroke, ability to ambulate with or without walking aids, having stable medical history or no post-stroke complications like uncontrolled hypertension, arrhythmia etc., no significant musculoskeletal problems except from stroke and a Mini-Mental Status Examination score of ≥16. Participants were excluded if they had other neurological problem with stroke, myocardial infarction or heart surgery within the last 3 months, recent history of pulmonary embolus or infarct, conditions warranting palliative care or pregnancy, amputation of any kind, problem with communication.

Assessment of six-minute walk test. Participants were instructed to walk and cover as much ground as possible in six minutes with their comfortable speed in a 30m rectangular space marked by cone at each end inside Physiotherapy Department. Verbal encouragement was provided every 30 seconds or more in a standardized manner (36). Participants were allowed to walk in their normal footwear and use their usual walking aid. The distance walked, in meters, in 6 minutes was recorded to the nearest whole number. Prior to this, the demographic, anthropometric and clinical characteristics of each participant was evaluated including age, sex, type of stroke (hemorrhagic or ischemic), affected side, stroke duration, use of walking aid or not etc. Severity of stroke was assessed using Orpington Prognostic scale. The scale is reliable and validated among stroke survivors in prognostication and severity assessment, and incorporates the motor function of the arm, upper-limb proprioception, balance, and cognition of the patient with a score <3.2 considered as minor stroke, ≥ 3.2 and ≤ 5.2 as moderate stroke; and >5.2 as major stroke (33).

Data analysis. Descriptive statistics of means, standard deviations, proportions and percentages were applied to summarize the data. The normality of the distribution of the data was determined with the Kolmogorov-Smirnov test before performing parametric or nonparametric analysis. Student's t-test for independent samples and Analysis of variance (ANOVA) was used to compare the mean values of distance walked. The relationship between distance walked with demographic and clinical characteristics was determined by measuring the Pearson or spearman correlation coefficient. Multiple linear regression analyses were conducted to identify independent contributors to walking capacity using characteristics found to be significant in the univariate analysis. Statistical Software Package for Social Sciences (SPSS version 20.0; SPSS, Inc; Chicago, Illinois, USA) was used to analyze the data. Alpha level < 0.05 was considered significant.

Results

The mean age of the participants was 61.42 ± 11.06 years. A majority of the participants were male (58.20%) and 65.67% of stroke survivors had right sided paresis. The average distance walked by the survivors in 6MWT was 188.39 ± 80.93m while the mean duration of stroke onset was 13.82 months (Table 1). Table 2 shows the sub-group comparison of distance walked in various patients' characteristics.

Table 1. General characteristics of the participants (N=67)

Variable	Mean	Standard deviation	Proportion	Percentage
Age (years)	61.42	11.06		
Height (m)	1.62	0.07		
Weight (kg)	69.20	9.90		
BMI (kgm^{-2})	26.38	3.60		
6MWT Distance (m)	188.39	80.93		
Duration (months)	13.82	10.58		
Orpington score	2.99	0.84		
Sex (M/F)			39/28	58.20/41.80
Type (I/H)			38/29	56.71/43.29
Walking Aid (Yes/No)			25/42	37.31/62.69
Paretic Side (Left/Right)			23/44	34.33/65.67

M-Male, F-Female; I-Ischemic, H-Hemorrhagic

Table 2. Influence of demographic and clinical characteristics on 6MWT performance (N=67)

Variable	sub-group	6MWT Distance Mean	± SD	Test statistic	P-value
Gender	Male	197.67	13.34	- 1.109	0.324
	Female	175.46	14.57		
Age group	40-50	189.79	79.09	0.669	0.516
	51-60	206.00	93.75		
	>60	178.77	75.29		
BMI	Normal	160.79	72.24	1.715	0.188
	Overweight	201.62	81.96		
	Obesity	183.17	90.52		
Duration of Stroke	1-6 months	217.68	83.33	2.309	0.108
	7-12 months	180.67	84.73		
	>12 months	170.77	73.55		
Paretic side	Left	169.39	80.09	- 1.399	0.923
	Right	198.32	80.49		
Type of stroke	Ischemic	205.42	83.76	- 2.017	0.048*
	Hemorrhagic	166.07	72.52		
Use of waking Aid	Yes	131.64	46.84	- 5.241	0.000*
	No	222.17	78.28		
Stroke severity	Minor	222.72	86.16	4.184	0.000*
	Moderate	48.52	51.88		

** P < 0.05*

Patients with ischemic stroke significantly walked more distance than those with hemorrhagic stroke (p<0.05). Also, the participants with walking aids significantly walked less distance than those without walking aids while those with minor stroke significantly covered more mean distance than patients with moderate stroke (p<0.05). Although male participants covered more distance than their female counterparts, however, the difference was not significant (p = 0.324).

The correlation coefficients showed a moderately strong, significant and negative relationship between the 6MWT distance and Orpington score (r = -0.53; p = 0.000). However, there was no significant correlation between the 6MWT distance and age and stroke duration (Table 3).

Table 3. Correlation between 6MWT distance and clinical characteristics (N=67)

Variable	Correlation coefficient (r)	P-value
6MWT Distance		
Age	-0.09	0.450
Weight	0.21	0.096
Height	0.16	0.187
Duration	-0.12	0.334
Severity	-0.53	0.000*

** = p < 0.05*

Table 4. Multiple regression showing relationship between 6MWT performance to predictor variables

6MWT Distance	Beta	Test statistic	P-value	Lower CI	Upper CI
Constant		12.621	0.000*	351.479	483.722
Stroke severity	-0.389	-4.901	0.000*	-93.234	-32.042
Use of walking aid	-0.503	-5.497	0.000*	-113.995	-53.211
Type of stroke	-0.098	-1.034	0.305	-46.660	14.842

** = p < 0.05*

Table 4 shows the results of multiple regression showing the relationship between 6MWT performance and variables that best explained the walking capacity (use of walking aid, type and severity of stroke). Approximately 47% of the 6MWT performance of the survivors was explained by these three variables (Nagelkerke's R^2 = 0.477). However, only the use of walking aid (B = -0.389; P = 0.000) and increasing stroke severity (B = -0.503; p = 0.000) were significant negative predictors of walking capacity of the participants.

Discussion and Conclusion

Walking, which is needed for optimal functional and productive living (6), is mostly compromised among stroke survivors (6, 8). Previous studies have linked walking capacity of stroke patients to the level of motor recovery (8), postural balance (8, 34), spasticity (34), lower limb muscular strength (34, 35), physical fitness (35), and psychological variable like confidence level (36). Since walking capacity of stroke survivors is reported to have multiple determinants (32), it is imperative to investigate the direct influence of clinical characteristics of stroke patients on their walking capacity. Typically 6MWT is a common tool for assessing walking capacity post-stroke. This study related the stroke patients' clinical characteristics to their performance of 6MWT.

The mean distance covered in 6MWT by the stroke survivors in this study was 188.39m which is comparable with the data obtained in a similar study (37). Findings from this study show that participants who walked with walking aids covered significantly less distance compared to those who walked unaided. Similarly, Tung et al., in their study, found that balance impaired elderly subjects had low walking speed while walking with the use of walking aids than those who did not (38). Also, the result of an observational study by Maguire et al. concluded that stroke patients presented with poor walking capacity and function with the use of walking aids compared to those who walked unaided (39).

More than half of patients with stroke engage in the use of walking aids (40). Stroke survivors use walking aids to improve their walking capacity and compensate for the underlying neurological impairment. It also helps them to improve stability, increase sense of security and reduce fear of falling (41). The recent practice guideline development team of Royal Dutch Society for Physical Therapy stated that the use of walking aids is beneficial to patients with a stroke in terms of safety, independence, and efficiency of walking, as well as confidence (42). However, several studies have reported that long term use of walking aids by stroke survivors resulted to them having lower balance scores and reduced social activity when compared with those without walking aids (43), and high fall efficacy which make them more prone to falls (44). Also, a

study has shown that the sensory-motor function of the unaffected hand of stroke patients that employ the use of walking aids is significantly more affected than stroke patients who ambulated without walking aids (45), and that the use of walking aid post-stroke seems to undermine their self-esteem and confidence (46).
Although one of the aims of stroke rehabilitation is to improve walking capacity and the use of walking aids by stroke patients is believed to facilitate this aim, however, the use of walking aids have been discovered to inhibit muscular activity of the patient's paretic side (47), and this may impair recovery of muscle strength. The typical ankle and hip balance strategies needed for functional mobility is also found to be mechanically impaired by the use of walking aids, and the use of cane post -stroke encourages abnormal motor activity of the cane holding arm (48). Furthermore, the use of walking aids reduce joint-loading (49), and make the interplay between muscle activity and joint angles sub-optimal during walking (50). Further analysis of the findings in this study reveal that patients with walking aids had higher mean age compared with those who did not (Age: 65.84 years vs. 58.78 years), but not in their stroke duration (Duration: 14.16 months vs. 13.61 months). This indicates that age may also contribute to the distance covered by the participants who walked with aids in this study. Study has shown that ageing is associated with the use of walking aids (51). It must be stated that the univariate analysis did not show any significant relationship between age and walking capacity of the participants. Even at that, studies have revealed that walking capacity of stroke survivors is significantly reduced compared to their age-sex matched healthy individuals (8, 9).
The results of this study revealed that participants with moderate stroke significantly covered less distance during 6MWT compared with those with minor stroke. This finding is similar to results obtained by Patterson et al. while investigating the effect of stroke deficit differences to ambulatory capacity (35). They discovered that level of neurologic deficits correlated to the level of impaired balance, and lower limb strength which limit walking ability and speed (35). Furthermore, another study reported that stroke patients with less severity, evident by minimal impaired balance, muscular strength and lower-extremity spasticity, have better walking capacity (52), and therefore implying that motor impairment is associated with walking function (53). Walking is complex and thereby needs adaptation to the environment, task goals, motor control, and ability to maintain postural balance (54, 55). All these factors are compromised in stroke patients since stroke involves damage to motor and sensory pathways leading to impaired motor function (56), and ultimately resulting into neuromuscular dysfunction, impaired balance and lean muscle mass (57). These in turn result into increased mechanical work during walking (58), and coupled with low aerobic capacity exhibited by stroke patients, contributed to low walking capacity post-stroke (58). The level of dysfunction of these upper and lower motor neurons and the resultant gait capacity is dependent on the extent of motor damage or stroke severity (53), and the part of brain damaged. A study has found that some specific areas of brain if damaged in stroke resulted into more significant walking deficits compared to other areas of brain even after rehabilitation (59).
Summarily, walking capacity post-stroke is influenced by the use of walking aids and stroke severity. Since stroke survivors who walk with aids are many and utilize it repeatedly for a long period of time, the effect of walking aid on gait capacity obtained in this study may be profound for them and possibly alter the effects of rehabilitation of their gait and balance dysfunctions which may slow down recovery. Some stroke patients cannot walk without walking aids because of fear of falling or perceptual difficulties, at least walking with aids is better than being sedentary, however, it is imperative for clinicians to consider appropriate walking aids based on patients' characteristics and preference before prescription of the aid. It has been reported that patients' preference for a specific walking aid improves their walking capacity as against when clinicians choose the aids for them (60). When used appropriately, walking aids may be an inexpensive means of helping stroke survivors overcome their walking dysfunction and thereby reduce their dependence. As stated earlier, severity of stroke influence the walking capacity and therefore must be considered in gait assessment, rehabilitation and prognosis. Also, patients' severity of stroke is needed to be put into consideration in determining the frequency, duration and type of walking aids appropriate for patients.
This study has few limitations. One, we did not assess the effect of different walking aids on the walking capacity of the participants. The type of walking aids used by stroke patients has been discovered to have influence on their walking capacity (60). Also, the effects of socio-psychological factors on the walking capacity of the participants were not evaluated. Social and psychological status of individuals is reported to have significant effect on their walking capacity (61).

The use of walking aids and increasing stroke severity significantly influence the walking capacity of stroke survivors.

Acknowledgments. The authors will like to appreciate all participants in this study.

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Received: July 17, 2020 Accepted: October 1, 2020