

Full Length Research Paper

Differences in gait between haemorrhagic and ischaemic stroke survivors

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Abstract

Gait deviations in stroke survivors vary with stroke severity, location of infarct and other individual differences. This study aimed to determine the differences in gait characteristics between survivors with haemorrhagic stroke and those with ischaemic stroke. A cross-sectional study of patients who had survived six months or more after a stroke was undertaken. Participants consisted of patients treated at the outpatient physiotherapy clinics of two teaching hospitals in Osun, South-West Nigeria. Using Observational Gait Analysis and Foot Print Method, the following variables were assessed for each participant: gait speed, cadence, stride length, step length, step width and foot angle. A total of 70 stroke survivors (46 males and 24 females) with mean age of 53.52 ± 10.35 years participated in this study. Forty five (64.3%) had haemorrhagic stroke while 25 (35.7%) had ischaemic stroke. Results showed significant differences between gait speed, height normalized speed, cadence and step length of paretic limb of haemorrhagic and ischaemic stroke survivors, with those of haemorrhagic stroke survivors higher than those of ischaemic stroke survivors. There were differences in some gait characteristics between haemorrhagic and ischaemic stroke survivors. This suggests that stroke type should be taken into consideration as a factor in gait assessment and retraining of hemiparetic stroke survivors.

Keywords: Stroke survivor, gait, hemiparesis, haemorrhagic stroke, ischaemic stroke.

INTRODUCTION

Stroke, also known as a cerebrovascular accident, is a sudden loss of brain function caused by an interruption of blood flow to the brain or rupture of the blood vessels in the brain (Nolte, 2002). It is the leading cause of disability in adults (Leys, 2001). Stroke survivors are often left with neurological and functional deficits which impair their ability to walk (Chen and Patten, 2008).

Stroke is an important cause of morbidity and mortality in black Africans. It is responsible for 0.9 to 4% of total admissions to hospitals and 0.5 to 45% of neurological admissions (Komolafe et al., 2007). It also accounts for 2.8 – 4.5% of total deaths in Africa (Odusote, 1996). In Nigeria, most of the available data on stroke morbidity and mortality are derived from investigation and follow up of patients in the hospitals and information is rather scarce. However in most publications, stroke affects

men and women, resulting in death or major loss of independence with immense human and financial loss.

The two broad categories of stroke are haemorrhagic and ischaemic (Paolucci et al., 2003): haemorrhage is characterized by too much blood within the closed cranial cavity, while ischaemia is characterized by too little blood to supply an adequate amount of oxygen and nutrients to a part of the brain. Each of these categories can be divided into subtypes that have somewhat different causes, clinical pictures, clinical courses, outcomes, and therefore, different treatment strategies. Brain ischaemia can be due to thrombosis, embolism, or systemic hypoperfusion, while brain haemorrhage is due to intracerebral haemorrhage or subarachnoid haemorrhage. Approximately 80 percent of strokes are due to ischaemic cerebral infarction and 20 percent to brain haemorrhage (Caplan, 1998).

Gait is a major determinant of independent living, therefore, it is not surprising that improvement of walking function is the most commonly stated priority of stroke survivors (Bohannon et al., 1991). Approximately 80% of

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stroke survivors achieve this goal (Wade et al., 1987) though the quality of walking performance often limits endurance and quality of life. Both therapists and patients spend a lot of time in rehabilitation aimed at restoring walking ability and functional independence.

The population of stroke patients is a heterogeneous group. Severity but also location and type of stroke determine the symptoms and outcome, even in gait analysis (Huitema, 2004). Hence, patients who eventually regain some form of walking ability may vary greatly in walking speed, spatio-temporal characteristics and kinematic gait patterns. Nevertheless, in a number of studies it was attempted to classify hemiplegic gait patterns (Kramers de Quervain et al., 1996; Mulroy et al., 2003) and it appears that some specific movement patterns can be observed in sub-groups of patients. Treatment goals are usually determined by analyzing patients' gait characteristics during rehabilitation. Observational gait analysis (OGA) is a simple means of determining the gait deviation in patients that have ambulatory problems.

There is a changing pattern of stroke subtype with an increasing proportion of haemorrhagic stroke in the Nigerian stroke population. Few studies have assessed the gait of stroke survivors in Nigeria (Olawale and Akinfeleye, 2002; Kankanala et al., 2010; Onigbinde and Mustapha, 2010; Obembe et al., 2010; Adeniyi et al., 2011). This study was therefore designed to assess the gait characteristics of stroke survivors and to determine the difference in gait variables between haemorrhagic and ischaemic stroke survivors.

MATERIALS AND METHODS

Participants

A study sample of 70 stroke survivors participated in this study. The study included stroke survivors with hemiparesis, at least 6 months after stroke in the outpatient physiotherapy departments of the following hospitals; 1) Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife and Ilesha units, Osun state, Nigeria, 2) Ladoke Akintola University Teaching Hospital, Osogbo, Osun state, Nigeria.

Patients were included when they met the following criteria: (1) they experienced first episode of unilateral stroke with hemiparesis; (2) they were able to walk 15m without the physical assistance of a therapist or care giver on assessment; (3) they had no complicating medical history such as cardiopulmonary or orthopaedic disorders; (4) they had no severe deficits in understanding and following simple verbal instructions, and (5) they had provided written or verbal informed consent to participate.

A patient was excluded if he or she had indeterminate stroke type, a history of any other neurological pathology,

conditions affecting balance (dementia, impaired conscious levels) and musculoskeletal conditions affecting the lower limbs. Also, participants who scored 0, 1 or 2 on the Functional Ambulation Categories (FAC) classification (Holden et al., 1984) were excluded from the study. Participants for this study were recruited by purposive sampling method.

Procedure

The protocol was approved by the Ethics and Research Committee of Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife. All the participants received an explanation of the procedure of the study prior to enrollment for assessment and data collection. Demographic (age, gender, duration of stroke) and clinical (paretic side and type of stroke) information were obtained from the participants and from their case records. From physicians' diagnosis and clinical findings, each patient's stroke was classified as haemorrhagic or ischaemic.

Anthropometric (height and body weight) data were measured using standard procedures. Gait characteristics were assessed by observational gait analysis and foot print method. The modified Rankin Scale (mRS) (Wilson et al., 2005) was used to assess the disability of the participants.

Body mass index (BMI) of the participants used as a measure of relative body weight was calculated by using the Quetelets Body Mass Index formula;

$$\text{BMI} = \text{weight (kg)} / \text{height (m)}^2 \text{ (Garrow, 1987)}$$

The gait characteristics measured in this study are gait speed, cadence, stride length, step length, step width, and foot angle. Measurements of speed, cadence, stride length, stride duration, step width and foot angle were taken by observational gait analysis and foot print method at the Physiotherapy outpatient clinics of the selected hospitals.

Walking devices (e.g walking stick, quadripod) were allowed during the measurements with the exception of a walker, because its use may bias the outcome of measurements by offering too much support to the participant. Five of the stroke survivors used quadripods during assessment.

The measurement of gait speed was taken with the participant walking 10m on a 15 meter walkway without physical assistance while under the supervision of a physiotherapist. Distances of 2.5m were allowed before and after the 10m mark to allow for acceleration and deceleration respectively. Gait speed was assessed at comfortable and safe walking speeds using a standard approach to assess gait performance (Bohannon, 1997). To reduce measurement error of timed walking test, the mean of three repeated measurements was used. During each session, the participant walked at a comfortable and at a self-paced walking speed. Timing with a digital

Table 1. Characteristics of participants.

Variable	Frequency n= 70	Percentage (%)
Demographics		
Gender		
Female	24	34.3
Male	46	65.7
Premorbid sidedness		
Left	4	5.7
Right	66	94.3
Stroke Characteristics		
Side of paresis		
Left	23	32.9
Right	47	67.1
Type of stroke		
Haemorrhagic	45	64.3
Ischaemic	25	35.7
Walking ability (FAC score)		
3	23	32.9
4	43	61.4
5	4	5.7

FAC- Functional Ambulation Categories

stopwatch that registers time in seconds was manually initiated after the “go” instruction when the participant crossed the beginning of the 10m mark and stopped when the participant crossed the end of the 10-m mark.

Registered speed was converted to meters per second by dividing the distance walked by the time required. This was recorded as the actual gait speed. Higher scores indicated faster gait speeds.

Walking speed is a function of step length and step frequency. Step length relates to body height and body height to speed in normal persons. Given the relationship of height and gait speed and the established usefulness of height for reducing inter-individual variability in gait speed and because height is a significant factor when walking speed is being considered (Al-Obaidi et al., 2003), gait speed was normalized by dividing speed by height. Height normalized speed (HNS) was determined by the formula;

Height-normalized speed = Actual speed (m/s) / Height (m) (Bohannon, 1997; Al-Obaidi et al., 2003)

Cadence was recorded as the number of steps taken per minute.

For the foot print method, each participant put on a pair of canvas shoes with foam pads adhered to the sole, stood up and placed both shoes in an ink sponge. Then the participant stood at the end of the walkway and walked across the paper looking straight ahead and following the line of progression on the walkway. The footprints from the soles of the shoes were produced on the strips of paper as the participant walked from one end of the walkway to the other. Stride length, step length and

step width (walking base) were measured in meters with a ruler from the foot prints made by each participant on a plain white paper strip (2 meters in length) attached to the walkway. The angle the foot made with the nominal direction in which the participant walked known as the foot angle (toe-in toe-out angle) was measured with a protractor in degrees. No encouragement to facilitate performance during walking session was permitted.

Data Analysis

All statistical analyses were carried out using Statistical Package for Social Sciences (SPSS) 16.0 for windows program (SPSS Inc. Chicago, USA). Data were analyzed using both descriptive and inferential statistics. Independent samples t-test was used to determine the differences between gait characteristics of ischaemic and haemorrhagic stroke survivors.

RESULTS

This study recruited 70 hemiparetic stroke survivors to assess their gait characteristics. All the stroke survivors that participated in our study were able to walk unassisted during data collection. Forty eight (68.6%) participants had slight disability (score= 2) while 22 (31.4%) participants had moderate disability (score = 3) using the modified Rankin Scale.

Table 1 shows the frequency values and percentages

Table 2. Demographic and clinical characteristics of the two categories of participants.

	Haemorrhagic stroke	Ischaemic stroke	p-value
Mean age (years)	51.60±9.68	54.60±11.42	0.064
Mean height (m)	1.64±0.08	1.67±0.11	0.274
Mean weight (Kg)	68.38±9.58	66.48±9.67	0.919
Mean BMI (Kg/m ²)	25.48±3.37	24.06±4.68	0.591
Stroke duration (months)	16.07±7.01	15.96±6.49	0.600
FAC score	1.80±1.01	1.64±0.86	0.532

Table 3. Difference between gait characteristics of hemiparetic stroke survivors with haemorrhagic and ischaemic stroke.

	Haemorrhagic Stroke n=45	Ischaemic Stroke n=25	P value
Variables	Mean±SD	Mean±SD	
Gait speed (m/s)	0.66±0.31	0.46±0.17	0.012*
Height Normalized Speed	0.40±0.17	0.28±0.12	0.017*
Cadence (steps/min)	85.88±38.43	57.31±32.58	0.004**
Stride length (m)	0.86±0.29	0.71±0.29	0.065
Step length P (m)	0.57±0.27	0.39±0.18	0.006**
Step length NP (m)	0.41±0.19	0.34±0.15	0.122
Step width (m)	0.12±0.05	0.13±0.04	0.730
Foot angle P (°)	15.94±7.51	12.56±5.22	0.057
Foot angle NP (°)	13.49±8.91	10.56±6.83	0.174

*T-test is significant at 0.05 **T-test is significant at 0.01 NP- Nonparetic limb N-Paretic limb

of the demographic (gender and age) and stroke (side of paresis, premorbid sidedness, type of stroke, type of mobility and walking ability) characteristics of hemiparetic stroke survivors. Twenty three (32.9%) stroke survivors had left-side affection of hemiparesis while 47 (67.1%) had the right side affected. Of the 70 hemiparetic stroke survivors, 45 (64.3%) had haemorrhagic type of stroke while 25 (35.7%) had ischaemic type. Table 2 shows the characteristics of the two categories of participants.

The independent samples t-test analysis showing the differences between the gait characteristics of haemorrhagic and ischaemic hemiparetic stroke survivors is presented in Table 3. The results of the independent samples t-test showed statistically significant differences between the gait speeds, height normalized gait speeds, cadence and step length of paretic limb of hemiparetic stroke survivors with haemorrhagic and ischaemic stroke. No significant difference was found between the stride length, step length of nonparetic limb, stride width and foot angle (paretic and nonparetic limbs) of haemorrhagic and ischaemic stroke survivors.

DISCUSSION

This study assessed the gait characteristics of commu-

nity-dwelling stroke survivors in Osun State, Nigeria. The participants were stroke survivors with hemiparesis of at least 6 months after stroke. By 6 months (especially after ischaemic stroke), patients generally are assumed to have reached a plateau in their motor function and gait recovery (Silver et al., 2000).

The result of the study showed that haemorrhagic stroke was the most common type of stroke among the participants in this study. It accounted for 64.3% of the participants. This result agrees with the findings in some earlier studies in Nigeria (Osuntokun 1997; Njoku and Aduloju, 2004), but runs contrary to the findings in some other studies (Bwala, 1989; Komolafe et al., 2007; Onwuekwe et al., 2006; Desalu et al., 2011). This may be because the mean age of patients in this present study (53.5 years) is lower than those of stroke survivors in these other studies. Studies (Lai et al., 2005; Ruiz-Sandoval et al., 2006) have reported that majority of haemorrhagic stroke patients are aged between 30 and 50 years.

In a prospective study by Komolafe et al., (2007) carried out over a six year period, it was found that the most common type of stroke by clinical diagnoses was cerebral infarction which accounted for 70%. Their other findings were intracerebral haemorrhage (34.7%) and others such as atrophy and hydrocephalus accounted for

12.2%.

Ogun et al. (2005) reported in their study that ischaemic stroke accounted for 49% of their study population, whereas 51% had intracerebral haemorrhage and subarachnoid haemorrhage. Although uncertain, this finding suggests a changing pattern of the stroke subtype with an increasing proportion of haemorrhagic stroke in Nigerian stroke population. It is possible that the increasing frequency of uncontrolled hypertension, as well as other risk factors, in this population could be responsible. This may be the reason this present study reported more stroke survivors with haemorrhagic type than ischaemic type because the study and this present study were carried out in similar environments.

The results of this study showed significant differences in the following gait parameters between haemorrhagic and ischaemic hemiparetic stroke survivors; gait speed, height normalized speed, cadence and step length of paretic limb, with haemorrhagic stroke survivors having higher values. The results of a study by Paolucci et al. (2003) provided evidence of better functional prognosis in stroke survivors with haemorrhagic stroke. They reported that haemorrhagic patients had significantly higher Canadian Neurological Scale and Rivermead Mobility Index scores at discharge; higher effectiveness and efficiency on the Canadian Neurological Scale, Barthel Index, and Rivermead Mobility Index than ischaemic stroke survivors. They also reported that Intracerebral haemorrhage (ICH) patients had a better rehabilitative prognosis than cerebral infarction (CI) patients.

Paolucci and Colleagues (2003) stated that "the better functional recovery in ICH patients compared with CI patients is presumably due to a better neurological recovery. And because the mechanisms for neurological deficit from ICH may be caused by brain compression, as the haematoma resolves, neurological functions recover and functional status improves. Functional status is due to neurological recovery and compensatory capacity". Haemorrhagic stroke patients appear to regain function faster than their nonhaemorrhagic counterparts (Chae et al., 1996). This may also be the reason why the haemorrhagic stroke survivors in this present study have higher and better values in some gait characteristics than the ischaemic stroke survivors.

Though Dam et al (1993) reported that final outcome of the patients with haemorrhagic infarction was not different from that of the patients with ischaemic lesion, the findings of their study however revealed that at 3 and 12 months, the Barthel Index score of the haemorrhagic stroke patients was significantly higher compared with subjects with ischaemic type. They reported that the ability to walk (gait) assessed using the Graded Neurological Scale (Hemiplegic Stroke Scale) were comparable in all evaluation time points. This phenomenon may be due to a more rapid recovery of the former as previously suggested.

The results of this study showed no significant difference in the stride length, step length of nonparetic limb, stride width and foot angles (paretic and nonparetic limbs) of haemorrhagic and ischaemic stroke survivors. This is in agreement with the study by Sturm et al. (2004) whose findings showed no significant difference in handicap between ischaemic stroke and intracerebral haemorrhage in patients two years post stroke. But contrary to their findings, there were significant differences in the other gait characteristics (gait speeds, height normalized speed, cadence and step length) assessed in this present study.

To understand the impact of type of stroke on recovery, future research should focus on the impact of gait rehabilitation on functional movement. This information can then be used to determine the relationship between recovery of gait impairments and rehabilitative intervention.

This study concluded that the gait speeds, cadence and step length of paretic limb of hemiparetic stroke survivors with haemorrhagic are significantly greater than those of survivors with ischaemic stroke. But no significant difference was found difference in the stride length, step length of nonparetic limb, stride width and foot angles. This implies that the type of stroke is a factor to consider in the gait assessments and retraining of hemiparetic stroke survivors.

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