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SENSORIMOTOR FUNCTION, BALANCE AND DUAL-TASK WALKING SPEED AMONG STROKE SURVIVORS WITH HEMIPARESIS.

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ABSTRACT

Background: *Impaired dual-task ability increases the risk of fall and fall-related injuries among stroke survivors. It also limits the extent of community ambulation and overall reintegration into the community after rehabilitation. The aim of this study was to investigate the relationships among sensorimotor function, balance and dual-task walking speed of stroke survivors during a dual-task gait performance among stroke survivors with hemiparesis.*

Methods*: Purposely recruited stroke survivors with hemiparesis who could ambulate independently for at least 10 metres, and who had a score of ß˘20 on the Mini-Mental State Examination participated in this correlational cross-sectional survey. Motor and sensory functions were assessed using the Fugl-Meyer Assessment Scale while balance was assessed using the Berg Balance Scale. Walking speed while ambulating on a 10-meter walkway and button up and down shirts was also assessed. Data were summarized using descriptive statistics and analysed using Pearson's product moment correlation method at* $\alpha_{0.05}$.

Results*: Forty-five stroke survivors (35 males) aged 52.5±10.23 years participated in this study. The mean sensory, motor function and balance scores were 10.76± 2.47, 67.09± 19.80 and 47.02 ± 7.24 respectively. There was a significant relationship between motor function and walking speed, as well as between balance and walking speed* ($p < 0.05$).

Conclusion: *Sensory, motor and balance functions are related to dual-task walking speed. Hence, dual-task gait training should be incorporated into the rehabilitation plans for stroke survivors.*

Keywords: Balance, Dual-task, Sensorimotor function, Stroke survivors, Walking speed.

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INTRODUCTION

Stroke is increasingly becoming a public health challenge in Africa (Adeloye, 2014). It has been noted as a major cause of long-term disability due to its considerable impact on cognitive, perceptual, motor and visual functions (Desalu *et al*., 2011; Laver *et al*., 2015). Although stroke rehabilitation prioritises independent ambulation, the impact of post-stroke disability is significant enough to hinder community re-integration among many stroke survivors due to limitations in ambulatory function (Obembe *et al*., 2014; McLennon and Weaver, 2014). Deblock-Bellamy et al. (2020) related this restraint to need to perform other activities while walking within the community. The inability to perform two or more tasks simultaneously (dual- or multi- tasking) while walking has been identified as an indicator of a higher fall risk among this population (Quinn and Horgan, 2013). It has also been suggested that sensorimotor and cognitive impairments which may be present post-stroke, contribute to the difficulties that stroke survivors experience with community ambulation (Lesniak *et al*., 2008; Ursin *et al*., 2019).

Sullivan et al. (2011) opined, that sensorimotor impairments contribute significantly to activity limitations and participation restrictions after stroke. Although impairments of lower limb sensation are less common post-stroke, Tyson et al. (2013) observed that when present, they often interfere with the individual's function. The inability to perform sensorimotor dual-tasks increases the risk of stroke survivors experiencing a fall and sustaining an injury (Fritz *et al*., 2015; Hofheinz *et al*., 2016). Literature suggests that brain changes experienced by individuals who have experienced a stroke may result in the reduced ability to perform cognitive and/or motor functions simultaneously (Plummer *et al*., 2013; del Campo *et al*., 2016). Montero-Odasso et al. (2012) also described the process of cognition-motor interference. Oftentimes, stroke survivors tend to prioritize task accuracy and completion over gait speed during dual-task gait training (Goh *et al*., 2017). According to Manaf et al. (2014), this attentional loading leads to the deterioration of their gait performance. Balance is another important factor that has been closely linked with the ability to perform dual-task gait (Campo *et al*., 2015). Most studies on dual-task gait performance have focused on enhancing task performance, as well as the effect of balance and cognitive impairments on dual-task gait performance. Manaf et al. (2014) posited that there is a dearth of studies on the relationship between sensorimotor function and dual-task gait performance of stroke survivors. In this study, we investigated the relationships among sensorimotor function, balance and dual-task walking speed among stroke survivors with hemiparesis. We postulate that there would be no significant correlations among the sensorimotor function, balance and dual-task gait walking speed among stroke survivors with hemiparesis.

METHOD

This correlational cross-sectional study was conducted among hemiparetic stroke survivors who were 18 years and older. Eligible participants had to be literate in English and/or Yoruba languages, able to ambulate independently for at least 10 metres and with mild or no cognitive impairment.

Ethical consideration: Ethical approval for the study was obtained from the University of Ibadan/ University College Hospital (UI/UCH) Ethics committee. The procedure for the study was thoroughly explained to prospective participants after which informed consents were obtained. Patients who consented to participating in this study were assured of the confidentiality of all information obtained from them. They were made to understand that the information would only be used for the purpose of this study and their names would not be attached to any information shared in this study.

Outcome measures: Prospective participants were screened for cognitive impairment using the Mini Mental State Examination (MMSE). The MMSE is a valid measure of cognitive function that can pinpoint specific deficits and inform a diagnosis (Vertesi *et al*., 2001). The test can be administered verbally or through writing, by a clinician (Shahid *et al*., 2012). It takes about 10 to 15minutes to administer this questionnaire. MMSE has a test-retest reliability of 0.89 (Folstein *et al*., 1975). The scale is made up of 12 questions with 30 items. Each correct answer is scored '1' with total score ranging from 1 to 30. Contrary to the widely accepted cut-off (scores ß: 23 indicate cognitive impairment) for the criterion-referenced approach of interpreting the MMSE, the recommendation by many authors to increase the cut-off point in order to increase the sensitivity of the scale was adopted (Folstein *et al.*, 2001). Hence, the cut-off was set at < 26. Scores of between 26 and 30 were considered normal in the general population. Scores of between 20 and 25 indicate mild cognitive impairment resulting in problems with instrumental activities of daily living such as shopping, finances, use of medications and meal preparation. Patients who score between 10 and 19 have a moderate cognitive impairment. Scores from 0 to 9 denotes severe cognitive impairments (Vertesi *et al*., 2001). Patients who had an aggregate score of less than 20 on initial assessment were not recruited for the study.

Sensorimotor function in the affected upper and lower extremities was assessed using the motor and sensory functions domains of the Fugl-Meyer Assessment Scale. The scale is a validated instrument for measuring recovery after stroke. It has five domains which are: motor function (upper extremity score = 66; lower extremity score = 34); sensory function (maximum score = 24); balance (maximum score= 14); joint range of motion (maximum score = 44) and joint pain (maximum score = 44). Items are scored on a 3-point

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scale from 0 to 2 where 0 = cannot perform; 1 = performs partially; 2 = performs fully. Each domain of the scale can be used and scored independently. The maximum obtainable score is 226. The motor domain assesses the movement, coordination and reflex action of all the major joints of the upper limbs and lower limbs and this alone takes about 20minutes to administer. The total scale is administered within 30-35minutes. The motor sub-score has a test-retest reliability score of 0.97, while the sensory sub-score has a score of 0.81. Overall, the sensorimotor scale has an excellent test-retest reliability, good validity, but poor ceiling effect for the sensory subscale (Crow *et al*., 2008; Zeltzer, 2010). According to the scoring guide used by Duncan et al. (1994), a score of 0-35 (out of the maximum of 100 for the upper and lower limbs) indicates very severe motor impairment, 36-55 shows severe motor impairment, 56-79 indicates moderate motor impairment and a score greater than 79 means the individual has mild motor impairment. The sensory domain evaluates light touch on two surfaces on the bilateral arms and legs, as well as proprioception for eight (8) joints in the bilateral upper and lower limbs. Out of the maximum obtainable score, 8 is awarded for light touch (1 point for each spot evaluated), and 16 for proprioception (1 point for each of the assessed joints).

The Berg Balance Scale (BBS) was used to assess balance function among participants. This scale is very reliable (test-retest reliability score of 0.98), valid and responsive in assessing balance among the elderly population and people with acute stroke (Berg *et al*., 1992; Berg *et al*., 1995; Usuda *et al*., 1998; Whitney *et al*., 2003). The BBS is a 14-item scale for assessing static and dynamic balance (Berg *et al*., 1992). Each item is scored on a five-point ordinal scale from 0 to 4, with 0 indicating the lowest level of function and 4 the highest level of function. A score of 0-20 implies that the rated individual is wheel chair-bound; a score of 21-40 indicates that the rated individual requires assistance or a walking aid while a score of 41-56 indicates that the rated individual is independent (Berg *et al*., 1992). It takes about 20minutes to complete an assessment using the Berg balance scale. Instructions are given orally to the patients or demonstrated by the test administrator.

A 10-metre walkway was mapped out on the floor using a paper tape. Additional 2metres were placed at the beginning and end of the walkway to cater for acceleration and deceleration that occurs when ambulating on a mapped-out area. Participants were then instructed to walk the 10-metre walkway at his/her self-selected walking speed. Participants were requested to button up and down a shirt worn over a light clothing, continuously as they walk on the 10metre walk way. The time taken to walk the walkway was measured with the aid of a stop watch. Walking speed was calculated as the distance walked (10metres) divided by the time taken to walk the distance.

Data Analysis: Data obtained were entered, cleaned and analysed using the IBM SPSS version 20.0. Descriptive statistics of mean, standard deviation, percentage and frequency was used to summarise data. Pearson's product moment correlation was used to test the relationships among sensory, motor, balance and walking speed. The level of significance was set at 0.05.

RESULT

Forty-seven stroke survivors who met the inclusion criteria consented to participate in the study. However, only forty-five (95.7%) completed the study. Two participants dropped out because they found the test measurements demanding. The mean age of the participants was 52.5±10.23 years (range = 40 - 65years). Summary of participants' socio-demographic variables is as presented in Table I.

Participants carried out the dual-task gait by continuously buttoning and unbuttoning their shirt while simultaneously ambulating on a 10-metre walkway. The mean sensory, motor, and balance function scores were 10.76±2.47, 67.09±19.80 and 47.02±7.24 respectively while the mean walking speed was 49.82 ±26.86 metres.

Table I: Demographic and Clinical characteristics of the Participants (N =45)

Characteristics	Frequency (n)	%
Gender		
Male	35	77.8
Female	10	22.2
Occupation		
Skilled	36	80.0
Unemployed	2	4.4
Retired	7	15.6
Marital Status		
Married	34	75.6
Divorced	2	4.4
Widowed	9	20.0
Level of Education		
Formal	42	93.3
No formal Education	3	6.7
Limb Dominance		
Right	38	84.4
Left	7	15.6
Side of Affectation		
Right	27	60.0
Left	18	40.0
Mean Age (years)	52.5 ±10.23	

According to the proposed 30 cut-off point by Duncan et al. (1994), it can be deduced that an average participant in this study had moderate motor impairment, and some form of sensory impairment. The mean balance function score also reveals that most of the participants in this study could walk independently and had moderately good levels of balance while performing activities. There was a positive, though insignificant, correlation between sensory function and walking speed ($p>0.05$) (Table II).

Table II: Relationship among Sensory, Motor, Balance Function and Walking Speed among Participants

	Walking Speed	
	r	p
Sensory Function	0.13	0.40
Motor Function	- 0.31	0.04*
Balance Function	- 0.26	0.01*

There was a significant, negative correlation between motor function and walking speed ($p< 0.05$) (Table II). Similarly, a significant, negative correlation was found between balance and walking speed ($p<0.05$).

DISCUSSION

The mean age of participants in this study is comparable to the mean ages of participants in earlier studies among stroke survivors (Song and Park, 2014; Vincent-Onabanjo and Moses, 2016). Majority of the participants in this study were males. This is also in line with findings from previous studies indicating that stroke is commoner among males in Nigeria (Obembe *et al*., 2014, Vincent-Onabanjo and Moses, 2016). The high male to female ratio could be due to the observable higher prevalence of risk factors for stroke such as excessive alcohol use, tobacco smoking and hypertension among males in Nigeria.

Cognitive deficits such as attention deficits, decreased concentration and impaired memory function are associated with poor functioning in activities of daily living after stroke (Song and Park, 2014; Liu *et al*., 2017). However, because our participants were screened and ascertained to have had mild to no cognitive impairments as at the time of this study, we are assured that any impairment in the performance of the assigned dual task in this study is independent of the cognitive function of our participants.

About two-thirds of the participants were able to perform the dual-task, buttoning their shirt up and down while ambulating the 10metre walkway. Although the average balance function score reveals that an average participant in this study was independent and had moderately good balance, about one-third of them still could not successfully perform the dual task assigned to them. Since our results showed that most participants had moderate motor impairment and some form of sensory impairment, we can deduce that these impairments could be the key limiting factors to the performance of the dual task assigned to these participants.

Furthermore, we found a positive, though insignificant, correlation between sensory function and walking speed. This suggests that participants with better sensory function had better walking speed while performing the dual-task gait activity. Tyson et al. (2008) had earlier suggested that the severity of deficits experienced by a stroke survivor correlates with the extent of sensory disturbances, and not necessarily with muscle weakness. This suggestion supports our finding that people who had better sensory functions performed better with the dual-task assigned.

Similarly, the results from this study revealed a significant relationship between motor function and walking speed. This suggests that better motor function score was associated with better walking speed among participants in this study. Available literature supports the claim that gross motor impairment has a significant effect on gait performances (including walking speed) among stroke survivors while performing a dual-task compared with apparently healthy subjects (Plummer-D'Amato and Altmann, 2012; Lee *et al*., 2015; Muci *et al*., 2020). Lee et al. (2015) opined that the extent of the impact of motor function deficits on dual-task performance is dependent on the type of tasks involved. There was a significant relationship between balance and walking speed among our study participants. It has been reported that impairment of balance directly or indirectly limits mobility and results in stroke survivors having difficulty in initiating and/or controlling movement (Wesselhoff *et al*., 2018). Evidences suggest that there is an increase in the required cognitive demand to perform a dual-task when there is an underlying limiting factors, the implication of this is that stroke survivors who have balance impairment tend to spend more time processing their gait. This duration is further lengthened by adding a cognitive task such as buttoning a shirt while walking.

CONCLUSION

The results from this study have shown that sensory, motor and balance functions are important in the performance of a dual-task walking activity. Most rehabilitation programmes for stroke patients are however, focused on the recovery of motor and balance functions only. Our results suggest that rehabilitation programmes for stroke patients should include strategies to improve sensory function as well, in order to optimise gait performance. Improved performance of dual-task gait activity may enhance community participation and improve quality of life among stroke survivors. Overall, while assessing stroke survivors on follow-up appointments, it is important to evaluate dual task performance. This may help to identify areas of deficits in sensorimotor function and it may also help to train dual-task gait among stroke survivors. We also recommend that future longitudinal studies could examine at what motor and/or sensory functional level a stroke survivor should commence dual-task gait performance. This would help to improve rehabilitation outcomes for stroke survivors.

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