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Impact of Walking Speed on Risk of Fall among Stroke Patients Assessed using Cognitive Motor Dual Task: A Cross-sectional Study

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ABSTRACT

Introduction: Fall is a common complication of stroke. People must use both their higher cognitive abilities and their motor skills simultaneously in everyday situations. Falling is much more likely to occur when performing multiple tasks requires continuous attention. Implementing a Cognitive Motor Dual Task (CMDT) might give more accurate information regarding how stroke survivors function throughout daily activities.

Aim: To identify the walking speed in stroke patients using CMDT and to determine the impact of walking speed on risk of fall.

Materials and Methods: In this cross-sectional study, 23 Middle Cerebral Artery (MCA) stroke patients with and without the risk of fall according to morse fall scale were included from Justice KS Hedge Charitable Hospital, Mangaluru, Karnataka, India from March 2023 to March 2024. After which the selected participants performed CMDT, the step count and time taken to complete the test was recorded using a pedometer and stop watch, the total and correct number of cognitive responses was recorded manually. The walking speed was calculated in m/sec. Based on the outcome measures of the present study; the statistical analysis was performed. Data collected was analysed by using the Statistical Package for the Social Sciences (SPSS) software version 29.0. To compare the data Independent sample t-test, One-way Analysis of Variance (ANOVA) was used.

Results: The study participants consisted of an average age of 54.6±14.8 years. Individuals categorised as low-risk exhibited a mean walking speed of 0.238±0.014 m/sec, while those in the moderate risk group had a mean walking speed of around 0.211±0.024 m/sec and individuals at high-risk showed a lower mean walking speed of approximately 0.177±0.020 m/sec. The statistical analysis revealed a significant difference in walking speeds among the risk groups, with an F-value of 15.486 and a p-value less than 0.001.

Conclusion: The study showed that walking speed will impact the risk of fall in stroke patients while performing CMDT. The time and step count are more in patients with high fall risk compared to patients with low fall risk therefore, walking speed is reduced in patients with high-risk of fall.

Keywords: Cognition, Gait, Motor activity, Pedometer, Risk assessment

INTRODUCTION

Individuals with cerebrovascular disorders are at an increased risk of experiencing falls due to reduced sensory perception, compromised balance and motor limitations [1]. Among stroke patients, there is a notable prevalence of falls, with studies indicating incidences ranging from 14% to 39% during hospitalisation [2].

Falling poses a significant challenge for patients with neurological conditions, as they face an elevated risk compared to their healthy counterparts. Research suggests that approximately 46% of individuals with neurological disorders experience at least one fall annually, with their likelihood of falling being 2-4 times greater than that of age-matched individuals without such conditions [3]. Consequently, their susceptibility to falls is notably heightened when compared to individuals of similar age and health status [3].

Majority of the patients with stroke struggle with balance issues and motor impairments. Functional mobility in the community and at home requires a specific speed in gait and in the ability to keep balance while walking and turning which put stroke patients at a high-risk of fall and the prevalence of falls can be as high as 73% [4]. In addition to causing physical harm, fall can also have unintended psychosocial effects like depression and social disengagement, decreased independence, a lower quality of life and a significant financial burden for the cost of fall related medical care. Thus, in this community, a good fall prediction model is crucial [5].

People must use both their higher cognitive abilities and their motor skills simultaneously in everyday situations. Patients with stroke may have impaired motor, cognitive and sensory functions as well as a fear of falling. When performing a task that needs simultaneous focus, the chance of falling significantly increases [6].

Thus, it would be ideal to evaluate performance using a dual task paradigm to more accurately predict fall risk among stroke survivors. Implementing a CMDT might give more accurate information regarding how stroke survivors function throughout daily activities [7]. Additionally, this could elevate stroke survivor's performance to an immensely difficult level, making it easier to distinguish between people with high fall risks and those with low fall risks [7].

During rehabilitation therapist will interact with the patient for giving instruction and feedback but the cognitive verbal integration during walking can have adverse effect on the patient's speed and balance [8]. Many studies have demonstrated an association between slower gait speed and increased fall risk in post stroke patients. Decrements in both the cognitive performance and walking velocity in dual-task walking among stroke survivors were reported [9]. However, it is not clear if walking speed during dual task is strongly related to fall risk in patients with stroke, as stroke patients have impaired safety awareness and decision-making. CMDT implementation would provide more realistic information about the functionality of stroke patients during daily activities. Thus, identifying the risk of fall in patients and help in the prevention of fall.

The aim of the study was to determine the impact of walking speed on risk of fall in stroke patients using CMDT. The objectives of the study were to identify the walking speed in stroke patients using CMDT and to determine the impact of walking speed on risk of fall.

MATERIALS AND METHODS

The present cross-sectional study was conducted from March 2023 to March 2024 in Justice K.S Hegde Charitable Hospital, Mangaluru, Karnataka, India. The study proposal was ethically approved by

Nitte Institute of Physiotherapy's Institutional Ethical Committee, Mangaluru, Karnataka, India on February 9th 2023, with reference number: Ref: NIPT/IEC/Min//28/2022-2023. It was registered in the Clinical Trial Registry: India (CTRI) with the registration number: CTRI/2023/04/051545.

The target population for the study was poststroke patients and sample size being Time bound sampling. Informed consent was taken from the participants who agreed to participate in the present study.

Inclusion and Exclusion criteria: The study criteria included male and female stroke patients between the age of 18 to 80 years and above who are diagnosed with MCA stroke and have a Standarised Mini-mental State Examination (SMMSE) score greater than or equal to 24 [10,11]. They should be able to walk 10 feet without using any assistive device and be able to follow and respond to verbal instruction. In the exclusion criteria, patients with significant aphasia, recurrent stroke taking any psychiatric drug and who have any other neurological conditions or orthopaedic complications like amputation, fractures or orthopedic deformities.

Study Procedure

After obtaining informed consent from the participants, the study measured patient's walking speed while engaging in a CMDT [12,13]. Initially, participants were instructed to walk a distance of 10 feet at their regular pace, starting from a stationary position. Those who successfully completed this task were then asked to perform the CMDT.

The risk of falls among the patients involved in the study was evaluated using the Morse Fall Scale. This standardised scale assigns scores ranging from 0 to 24 for low fall risk, 25 to 44 for moderate fall risk, and 45 or higher for high fall risk, thereby categorising the participants based on their risk level [14]. In CMDT, the motor task is to perform Timed Up and Go (TUG) test [15]. To initiate the activity, the patient should be seated comfortably in a chair, and a line positioned 3 m away on the floor should be identified. Upon the therapist's instruction of "Go," the patient will rise from the chair, walk to the designated line at their usual pace, turn, walk back to the chair at their normal pace, and then resume a seated position. Recording of the time commences at the verbal cue "Go" and cease once the patient is seated back in the chair. Pedometer is attached to the patient during the task to measure the step count and time taken to complete the test is measured using stop watch. TUG test is divided into subtasks and the time taken to walk 3 m forward and retuning back is recorded excluding the time taken for getting up and sitting down in the chair [16]. Walking speed was calculated as distance by time (i.e., the time taken to walk the total distance of 6 m) [17].

In CMDT, the cognitive task was to perform the following task. Patients were asked to do serial three subtractions: Repeatedly subtracted three from a random number (e.g., 399, 396, 393, 390). Following the completion of the CMDT, the total number of cognitive responses and the correct number of cognitive responses was manually recorded [18].

STATISTICAL ANALYSIS

Data collected was analysed by using the SPSS software version 29.0. The data was summarised using descriptive statistics: frequency, percentage; mean and standard deviation. To compare the data Independent sample t-test, One-way ANOVA was used. The multiple comparisons of data were analysed by using the Post-hoc analysis, Tukey test and Bonferroni was used.

RESULTS

The study was conducted among 23 post stroke patients with MCA stroke. The study participants consisted of an average age of 54.6±14.8 years. Among them, the mean duration of stroke was 1.3±1.6 years [Table/Fig-1]. In the 23 stroke patients, 7 (30.4%) had low fall risk, 9 (39.1%) had moderate fall risk and 7 (30.4%) had high fall risk. The majority were male 17 (73.9%) and female 6 (26.1%) were in minority [Table/Fig-2].

Variables	Range	Mean	SD
Age (Years)	24 to 79	54.6	14.8
Duration of stroke (Years)	1 month to 7 years	1.3	1.6

[Table/Fig-1]: Descriptive statistics for age and duration of stroke (N=23).

Variables		Frequency	Percentage
Gender	Male	17	73.9%
	Female	6	26.1%
Duration of stroke	<6 months	10	43.5%
	6 months to 1 year	3	13%
	1 to 2 years	4	17.4%
	2 to 4 years	4	17.4%
	4 to 6 years	1	4.3%
	6 to 8 years	1	4.3%
Risk of fall (Morse fall scale)	Low	7	30.4%
	Moderate	9	39.1%
	High	7	30.4%

[Table/Fig-2]: Distribution of gender, duration of stroke and risk of fall (N=23).

The statistical analysis revealed a significant difference in time taken, step count, total and correct number of cognitive responses among with risk groups [Table/Fig-3,4].

Variables	Risk of fall	Mean	SD	F-value	p-value
Time taken (TUG)	Low	30.29	1.50	29.93	<0.001*
	Moderate	35.67	3.24		
	High	42.86	3.85		
Step count	Low	25.14	1.46	28.96	<0.001*
	Moderate	27.44	1.42		
	High	32.14	2.34		
Total number of cognitive responses	Low	10.29	1.11	74.24	<0.001*
	Moderate	8.89	0.60		
	High	4.86	0.90		
Correct number of cognitive responses	Low	9.57	1.90	34.03	<0.001*
	Moderate	7.56	0.88		
	High	4.29	0.49		

[Table/Fig-3]: Comparison of time taken (TUG), step count, total number of cognitive responses, and correct number of cognitive responses according to risk of fall.

Multiple comparisons			Mean difference	p-value
Time taken (TUG)	Low	Moderate	-5.38	0.006*
		High	-12.57	<0.001*
	Moderate	High	-7.19	<0.001*
Step count	Low	Moderate	-2.30	0.044*
		High	-7.00	<0.001*
	Moderate	High	-4.70	<0.001*
Total number of cognitive responses	Low	Moderate	1.40	0.012*
		High	5.43	<0.001*
	Moderate	High	4.03	<0.001*
Correct number of cognitive responses	Low	Moderate	2.02	0.010*
		High	5.29	<0.001*
	Moderate	High	3.27	<0.001*

[Table/Fig-4]: Multiple comparisons of Time taken (TUG), step count, total no. of cognitive responses and correct no. of cognitive responses according to risk of fall.

The statistical analysis revealed a significant difference in walking speeds among the risk groups, with an F value of 15.486 and a p-value less than 0.001 [Table/Fig-5]. Significant differences are noted in walking speed between the low and high-risk groups (p<0.001) and between the moderate and high-risk groups (p=0.010) after employing the Bonferroni correction for multiple comparisons [Table/Fig-6].

Variables		n	Mean	Std. Deviation	F-value	p-value
Time taken to walk 6 meters (seconds)	Low	7	25.286	1.496	15.393	<0.001
	Moderate	9	28.667	3.240		
	High	7	34.143	3.761		
Walking speed (meter per second)	Low	7	0.238	0.014	15.486	<0.001
	Moderate	9	0.211	0.024		
	High	7	0.177	0.020		

[Table/Fig-5]: Comparison of time taken to walk 6 meters and walking speed based on risk of fall.

to impaired executive functioning [28]. Prior studies have already outlined an independent association between executive functioning and balance as well as mobility in stroke patients [28].

Executive functions refer to higher cognitive processes that occur in both the anterior and posterior regions of the brain. These processes are responsible for modulating and generating effective, goal-directed actions, as well as managing attentional resources [29].

In the study done by Hyndman D et al., showed reduced stride length while walking on flat ground while performing a memory task, which distinguished fallers from non-fallers. The research revealed that patients with strokes had increased walk time and poorer cognitive task performance these findings were consistent with the current study [30].

In a study conducted by Tsang CS and Pang MY, it was discovered that among various single-task and dual-task walking assessments, the degree of motor interference during obstacle crossing coupled with a categorical naming task exhibited greater efficacy in predicting future falls [31]. The study's findings revealed that individuals who experienced falls demonstrated significantly longer walking times compared to non-fallers, both during single-task and dual-task obstacle crossing, which aligns with the results of the current study. According to the study, in situations where dual task walking presents attention competing contexts, patients will slow down in order to maximise their postural stability [31].

Dependent variable			Mean difference (I-J)	Std. Error	Sig.	95% Confidence interval	
						Lower bound	Upper bound
Time taken to walk 6 metre (seconds)	Low	Moderate	-3.38095	1.52143	0.114	-7.3558	0.5939
		High	-8.85714*	1.61372	0.000	-13.0731	-4.6412
	Moderate	Low	3.38095	1.52143	0.114	-0.5939	7.3558
		High	-5.47619*	1.52143	0.005	-9.4510	-1.5013
Walking speed (metre per second)	Low	Moderate	0.02649	0.01032	0.055	-0.0005	0.0535
		High	0.06071*	0.01094	0.000	0.0321	0.0893
	Moderate	Low	-0.02649	0.01032	0.055	-0.0535	0.0005
		High	0.03422*	0.01032	0.010	0.0073	0.0612

[Table/Fig-6]: Multiple comparison of time taken for 6 meters walk and walking speed based on risk of fall.

DISCUSSION

In the present study, significantly reduced walking speed was noted during dual-task walking. This finding aligns with previous research indicating a comparable decline in gait speed under dual-task conditions. Typically, this modulation in gait speed involves a decrease in step length and cadence, coupled with an increase in double support time [19]. Executing two tasks that require comparable cognitive or motor skills can result in slower performance in both tasks or delays specifically in the secondary task. This phenomenon is explained by theories such as capacity-sharing and bottleneck theory [20,21].

Lee KB et al., the result of the study demonstrates that age, Morse fall scale and TUG could identify fallers and non fallers [22]. The MFS has the ability to predict a patient's risk of falling using a cut-off score of 32.5 points which come under moderate fall risk in the current study and the TUG test proved to be the most reliable assessment of walking ability for predicting falls in patients with neurological conditions [22]. Turning during walking, such as in the TUG test, is a task that requires considerable attention from healthy individuals. It includes slowing down gait speed, adjusting gait parameters, and reorienting body segments in a sequence [23-25]. A prior study indicated that both anterior-posterior and medial-lateral ground reaction forces undergo changes before individuals decelerate their walking speed to initiate a turn [26]. Step lengths and step widths become uneven in order to shift the Center of Mass (COM) towards the new direction during turning [24]. Therefore, successfully executing a turn requires integrated control of multiple systems, including motor, sensory, and postural control [27].

The current study showed that the time and step count taken to complete CMDT increased with increase in risk of fall and the total and correct number of cognitive responses was reduced with increase in risk of fall. The relationship between working memory and executive functions is well-established. Hence, the greater gait decrement observed during the counting dual task among individuals at a high-risk of falls, compared to those at low-risk, might be attributed

Baetens T et al., study revealed that fallers may be discriminated from non-fallers by a reduction in the stride length and the non paretic step length when walking while counting back. Fall-prone stroke patients can be identified by a decrease in their spatial gait features during performing a working memory task [32]. In contrast to the study gait parameters like cadence, velocity, and paretic step length did not show any significant difference. However, distinct gait decrement percentages, particularly pertaining to stride length and non-paretic step length, serve as distinguishing factors between fallers and non-fallers [32]. Moreover, the decrement percentage associated with paretic step length can differentiate between individuals experiencing multiple falls versus those experiencing a single fall [32].

The study conducted by Plummer-D'Amato P et al., demonstrated a decrease in gait decrements in dual-task scenarios among post-stroke individuals, a finding consistent with the present study [33]. Notably, significant dual-task effects were observed for various gait parameters including gait speed, stride time, average stride length, and cadence. Additionally, the study revealed that speech performance was significantly influenced by concurrent walking tasks [33].

In the study conducted by Al-Yahya E et al., it was found that individuals who had experienced a stroke exhibited an increased requirement for prefrontal cortex activity during walking [34]. This demand intensified when performing a concurrent cognitive task. Under dual-task conditions, there was heightened activation not only in the prefrontal cortex but also in the inferior temporal cortex and basal ganglia [34]. These findings provide evidence regarding the neural mechanisms involved in real-life walking under dual-task conditions, highlighting how elevated cognitive demands, as indicated by increased prefrontal cortex activity, could potentially restrict walking abilities in everyday life after a stroke [34].

Limitation(s)

Comparatively smaller sample size of the study may affect the generalisability of the result. The study included both acute and chronic stroke and less female patients compared to male with may affect results of study. Considering the present findings, future studies can be conducted focusing on impact of walking speed on risk of fall in stroke patients other than MCA stroke using CMDT. With reference to the current results, the study can be extended to a stroke population belonging to Anterior Cerebral Artery (ACA) and Posterior Cerebral Artery (PCA) type of stroke and other spatial and temporal gait parameters could be assessed using an electronic walkway connected to a computer with specific software.

CONCLUSION(S)

The study showed that walking speed will impact the risk of fall in stroke patients while performing CMDT. In conclusion, the study demonstrates that walking speed in stroke patients, assessed using CMDT, is significantly associated with the risk of falls. The findings indicate that patients at higher risk of falls exhibit slower walking speeds and poorer performance in CMDT activities. Factors such as age, duration since stroke onset, and gender contribute to fall risk, with older patients and those with shorter durations since stroke showing higher fall risk, particularly among females.

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