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Effect of Sit-to-Stand Training on Balance, Muscle Strength, and Activities of Daily Living in Patients with Stroke: A Randomised Controlled Trial

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ABSTRACT

Introduction: Patients who have had a stroke often experience issues with static balance while sitting and standing. Additionally, they may encounter problems with dynamic balance, particularly when transitioning between sitting and standing positions, leading to reduced postural stability in both static and dynamic standing. This also contributes to weakness in the affected lower limb and decreased engagement in Activities of Daily Living (ADL). Nevertheless, few studies have investigated the impact of sit-to-stand training on balance, muscle strength, and ADL in stroke patients.

Aim: To assess the impact of sit-to-stand training on balance, muscle strength, and ADL in patients who have had a stroke.

Materials and Methods: This trial was an experimental, parallel, and assessor-blinded allocation with a computer-generated randomisation sequence. Sixty-six stroke patients (33 in each group) were enrolled from the inpatient Department of Medicine and the neurosurgery ward of Justice KS Hegde Charitable Hospital in Deralakatte, Mangaluru, Karnataka, India based on specific selection criteria. The trial was conducted from March 2022 to March 2023. Inclusion criteria included patients who had experienced a stroke involving the Anterior Cerebral Artery (ACA) and Middle Cerebral Artery (MCA), encompassing both ischaemic and haemorrhagic types of stroke, aged between 35-60 years, and including both male and female stroke patients who were able to effectively communicate and comprehend instructions. Other criteria included a Mini-Mental State Examination (MMSE) score greater than or equal to 23, the ability to independently have a transition from a supine position to a seated position, and a minimum score on the trunk impairment scale. In the experimental group, participants received sit-to-stand training for 45 minutes over five days, while the control group received conventional physical therapy, including tandem walking, single leg stance, double leg stance, early mobilisation, position and balance training exercises for 45 minutes over five days. The primary outcomes used for balance assessment were the Berg Balance Scale (BBS), and for ADL, the Barthel Index (BI) Scale was used, with muscle strength being measured using a push and pull dynamometer. The independent sample t-test was used to compare between groups, and within-group comparisons were conducted using the paired t-test. A p-value <0.05 was considered significant.

Results: Significant differences (p-value=0.044) were observed in BBS score and muscle strength between the groups during both the pretest (Day-1) and post-test (Week-1). The BI exhibited a significant difference (p-value=0.016) during the post-test (Week-1) only. Additionally, a significant difference (p-value <0.001) was found in muscle strength, specifically in the Hip Extensors (HE) between the groups.

Conclusion: The results of the current study showed a statistically significant difference in muscle strength of the HE. However, no significant difference was observed in BI and BBS between the groups. No side-effects or harms were reported, indicating that the approach is safe and feasible for stroke patients.

Keywords: Barthel index, Berg balance scale, Dynamometer, Muscle strength

INTRODUCTION

Stroke remains the leading cause of permanent disability. Recent studies estimate that it affects more than 1 million people in Europe and more than 0.7 million in the United States of America (USA) each year [1,2]. The degree of recovery highly depends on the severity and location of the lesion. However, only 18% of stroke survivors regain full motor function after six months [3]. The incidence rate of stroke is 119-145/100,000 based on recent population-based studies in India. The estimated prevalence rate of stroke ranges from 84-262/100,000 in rural areas to 334-424/100,000 in urban areas in India [4].

The sit-to-stand exercise (also known as the chair stand or chair rise exercise) helps individuals maintain or improve their mobility and independence by strengthening the lower body. The objective is to perform the sit-to-stand exercise without using hands. This becomes easier as strength increases. The sit-to-stand exercise helps strengthen the muscles in the thighs as well as the core muscles that provide stability [5-10]. Sit-to-stand training is a crucial functional motor performance ability in everyday life. When standing, the lower extremities support the body weight, and efficient standing ability precedes normal gait [6]. In contrast, patients with stroke tend to experience instability, reduced postural control, and muscle weakness, leading to falls when standing. Additionally, the time required to transition from sitting to standing increases, and the centre of gravity shifts, posing challenges in different directions. This type of sit-to-stand training requires postural control, symmetrical weight bearing in both lower limbs, and strength in the lower limb extensors [5-10].

However, there have been very few well-conducted studies in the past to determine the effect of sit-to-stand training on balance, muscle strength, and ADL in stroke patients. This study was conducted to investigate how sit-to-stand training would impact the balance, ADL, and lower limb muscle strength of stroke patients. The aim of this study was to determine the effect of sit-to-stand training on balance, muscle strength, and ADL in patients with acute stroke. The null hypothesis of the study was that there would be no significant effect of sit-to-stand training on improving balance, muscle strength, and ADL in stroke patients, while the alternative hypothesis proposed a significant effect of sit-to-stand training on improving these parameters in stroke patients.

MATERIALS AND METHODS

The present trial was an experimental, parallel, and single-blinded randomised controlled trial. The trial aims to investigate the hypothesised effect of sit-to-stand training on balance, muscle strength, and ADL in stroke patients. Patients meeting all the inclusion criteria were selected from the inpatient department of medicine and the neurosurgery ward at Justice KS Hegde Charitable Hospital, Deralakatte, Mangaluru, Karnataka, India. The trial was conducted from March 2022 to March 2023.

Ethical approval was obtained from the Institutional Ethics Committee (IEC) of Nitte Institute of Physiotherapy, Mangaluru, Karnataka, India with reference number NIPT/IEC/Min//02/2021-2022 dated 12-02-2022. After approval from IEC, the trial was registered prospectively in the Clinical Trial Registry of India under the registration number CTRI/2022/06/043449, registered on 23/06/2022. Prior to participation, all participants were provided with information about the trial process, including the study's purpose, intervention procedures, and possible therapeutic and adverse effects of the allocated interventions. The informed consent form was prepared in English, Kannada, and Malayalam by the researcher and research guide. Participants were informed that they could withdraw from the trial at any point if they were unwilling to continue.

Inclusion criteria: Sixty-six patients who have experienced a stroke involving ACA and MCA were included in the study, encompassing both ischaemic and haemorrhagic types of stroke. Patients aged between 35 and 60 years, both male and female, who are capable of proper communication and comprehension of instructions were included. Additionally, the MMSE score should be greater than or equal to 23 [11]. The MMSE data has been collected as part of daily routine care and as a screening tool. Patients should be able to achieve independent sitting from a supine position to a high sitting position, and the minimum score on the trunk impairment scale should be 23 [12].

Exclusion criteria: Patients with fractures, other orthopaedic deformities, and those undergoing chemotherapy were excluded from the study.

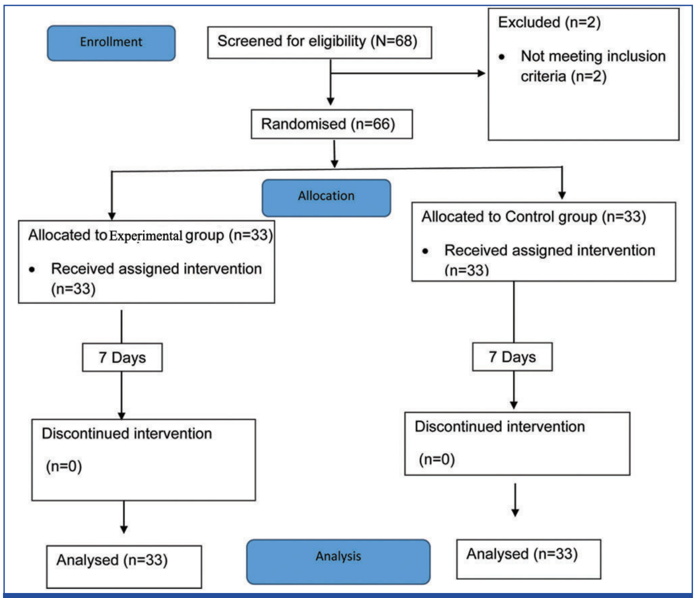
Sample size: The study's sample size was 66 (33 in each group). The sample size calculation was based on the standard deviation of BBS in group 1, which was 5.56 [5], and in group 2, which was 8.62 [5]. The mean difference was 5, and the effect size was 0.70521, with an alpha error of 5% and a power of 80% for a 2-sided hypothesis test [5]. The required samples per group were 33, totaling 66. This was calculated using nMaster software version 2.0.

Randomisation and allocation: Randomisation was performed by generating random numbers from 1 to 66 using the website www.random.org. These 66 random numbers were divided into two groups, with 33 numbers in each group. The random number generation was conducted by an independent researcher who was not part of the study. Each random number was individually concealed within a small opaque envelope (SNOSE), and the subjects were equally allocated into two groups with a 1:1 allocation ratio [Table/Fig-1].

Blinding: Outcome measures were conducted by a graduate physiotherapist who was blinded to the random allocation of participants and their individually allocated interventions throughout the study period. Assessor blinding was maintained throughout the study by instructing the assessor not to inquire about the type of intervention from the participants. Participants were also instructed not to disclose the intervention they received.

Procedure

The participants were screened based on inclusion and exclusion criteria, and the consent form was obtained. The subjects were



[Table/Fig-1]: Flowchart of participants (CONSORT flow chart).

then randomly allocated equally to either group and received 45 minutes of treatment each. The materials used included a well-ventilated room, a dynamometer (Baseline, USA), a chair, a bed, paper, a pencil, an outcome measure form, data collection sheet, an assessment form, and an informed consent form.

Experimental group (Group A=33): Participants received sit-to-stand training. Instructions on how to perform the sit-to-stand training were provided to the patients in their regional language. A trained physiotherapist guided the patients through sit-to-stand training in armrest chair with support during the initial stage of the training session for five days. After the initial stage, progression training was conducted on a stool without armrest, with feedback provided on both knowledge of performance and knowledge of results. Additionally, conventional physical therapy treatment was administered, and all training was conducted within a 45-minute session for five days [5].

Control group (Group B=33): Participants received conventional physical therapy, which included tandem walking, single leg stance, double leg stance, early mobilisation, position and balance training exercises for 45 minutes for five days [13-15].

Outcomes: The primary outcome, balance, was measured using the BBS (maximum score is 56), and secondary outcomes by using the BI (maximum score is 100, with higher scores indicating greater independence in ADL) and muscle strength measured using a dynamometer for knee flexors in the prone position, knee extensors in high sitting, Hip Flexors (HF) in high sitting, and HE in the prone position. Outcomes were assessed before and after seven days by a blinded assessor. BBS and BI were freely available [16-18].

STATISTICAL ANALYSIS

The collected data were summarised using descriptive statistics such as frequency, percentage, mean, and standard deviation. Chi-square or likelihood ratio tests were used to compare gender, type of stroke, and affected side between the groups. The independent sample t-test was used to compare age, duration of stroke, trunk impairment score, MMSE score, BBS, BI and muscle strength between the groups. Paired t test was used to compare within group.

RESULTS

The study was conducted among 66 individuals with stroke, with the experimental group comprising 33 cases (50%) and the control group comprising 33 cases (50%). The majority of the participants, 38 (57.6%), were males. The statistics for age, duration of stroke, trumk impairment score and MMSE is shown in [Table/Fig-2]. The majority of the cases, 64 (97%), had acute stroke, with 46 (69.7%)

affected by stroke on the left-side there was a statistical difference (p-value <0.05) in affected side between the groups, and all 66 participants (100%) were able to perform sit-to-stand [Table/Fig-3].

Parameters	Range	Mean±SD
Age (years)	35 to 60	53.8±6.7
Duration of stroke (months)	0 to 12	2.9±1.7
Trunk impairment score	18 to 24	20.7±1.2
MMSE score	23 and above	24.5±1.4

[Table/Fig-2]: Descriptive statistics for age, duration of stroke, trunk impairment score, and MMSE score.
MMSE: Mini mental status examination; The MMSE has been taken from the data as a part of daily routine care and as a screening tool

Variables		Groups		Chi-square/ Likelihood ratio#	p-value
		Experimental	Control		
		n (%)	n (%)		
Gender	Male	20 (60.6)	18 (54.5)	0.248	0.618
	Female	13 (39.4)	15 (45.5)		
Type of stroke	Acute	32 (97.0)	32 (97.0)	0#	1
	Subacute	1 (3.0)	1 (3.0)		
Side of affected	Right	6 (18.2)	14 (42.4)	4.591	0.032*
	Left	27 (81.8)	19 (57.6)		

[Table/Fig-3]: Comparison of gender and affected sides between the groups.
(*Significant) The Chi-square or likelihood ratio test was used to compare the gender, type of stroke, and affected sides between the groups. There was a statistical difference (p<0.05) in the affected side of the group

The independent sample t-test was used to compare BBS, BI and muscle strength between the groups. There was a significant difference (p-value <0.05) in BBS, BI, and muscle strength between the groups during the pretest (Day-1) and post-test (7 days) [Table/Fig-4].

The paired t-test was used for within-group comparison of BBS, BI, and muscle strength. There was a significant difference (p-value <0.05) in BBS, BI, and muscle strength within both the experimental and control groups [Table/Fig-5].

DISCUSSION

Most patients with stroke experience problems with static and dynamic balance during sitting and standing activities due to poor postural control. Additionally, weakness in the lower limb on the affected side and reduced ADL are common. The current study's results demonstrate a statistically significant difference in muscle strength of HE, BI and BBS between the groups.

The current study rejected the null hypothesis for BBS, BI, and muscle strength and accepted the alternate hypothesis. As the type of stroke was acute, there was an increase in muscle strength.

In contrast to present study findings, a study conducted by Hyun SJ et al., aimed to assess the effects of sit-to-stand training combined with real-time visual feedback on strength, balance, gait ability, and quality of life in stroke patients. The study found that this combined training had a positive effect on these components [5]. According to the study, sit-to-stand training was combined with real-time visual feedback for 20 minutes once a day, five days a week for six weeks, and general physical therapy was provided for 30 minutes before training. Long-term follow-up revealed the beneficial effects of sit-to-stand training. However, the absence of an assessor-blinded method may have resulted in some bias due to the participants' tendency to favour the intervention. In contrast, the current study was a single-blinded randomised controlled trial where the assessor was blinded for all outcome measures, including BBS, BI, and dynamometer.

According to the study by Hyun SJ et al., 40 patients were approached to participate, of which none were excluded, resulting in 20 patients in each group with no dropouts. In comparison, the current study has a sample size of 66 [5].

The possible explanations for the result of the interventions were that sit-to-stand training, which is task-specific training focusing on improving functional independence, functional balance, and strength of the lower limb muscles, was initiated when the patient was medically stable, and given for one week. Lower limb strength improvement typically requires atleast a few weeks in stroke patients; however, in the current study, lower limb muscle strength started to

Variables		Pre (Day-1)			Post (7 days)		
		Mean±SD	"t"	p-value	Mean±SD	"t"	p-value
BBS	Experimental	34.7±4.2	2.113	0.038*	36.9±4.3	2.060	0.044*
	Control	32.6±4.1			34.9±3.8		
BI	Experimental	63.9±8.5	0.566	0.573	76.8±6.0	2.467	0.016*
	Control	62.7±8.8			72.9±7.0		
HF	Experimental	9.8±1.3	6.229	<0.001*	10.8±1.3	6.259	<0.001*
	Control	8.0±1.0			8.8±1.3		
HE	Experimental	9.8±1.1	6.400	<0.001*	10.9±1.3	7.679	<0.001*
	Control	8.1±1.0			8.8±0.9		
KF	Experimental	9.4±1.1	4.862	<0.001*	10.3±1.3	5.009	<0.001*
	Control	8.2±1.0			8.8±1.2		
KE	Experimental	9.3±1.1	4.206	<0.001*	10.3±1.2	5.116	<0.001*
	Control	8.1±1.2			8.8±1.2		

[Table/Fig-4]: Comparison of Berg Balance Scale (BBS), Barthel index (BI), and muscle strength between the groups.
(t=Independent sample t-test; *Significant)
BBS: Berg balance scale; BI: Barthel index; HF: Hip flexors; HE: Hip extensors; KF: Knee flexors; KE: Knee extensors

Variables		Experimental			Control		
		Mean±SD	"t"	p value	Mean±SD	"t"	p value
BBS	Pre (Day-1)	34.7±4.2	-9.937	<0.001*	32.6±4.1	-12.566	<0.001*
	Post (Week-1)	36.9±4.3			34.9±3.8		
BI	Pre (Day-1)	63.9±8.5	-12.074	<0.001*	62.7±8.8	-9.241	<0.001*
	Post (Week-1)	76.8±6.0			72.9±7.0		
HF	Pre (Day-1)	9.8±1.3	-10.966	<0.001*	8.0±1.0	-10.115	<0.001*
	Post (Week-1)	10.8±1.3			8.8±1.3		

HE	Pre (Day-1)	9.8±1.1	-12.279	<0.001*	8.1±1.0	-7.091	<0.001*
	Post (Week-1)	10.9±1.3			8.8±0.9		
KF	Pre (Day-1)	9.4±1.1	-6.456	<0.001*	8.2±1.0	-4.99	<0.001*
	Post (Week-1)	10.3±1.3			8.8±1.2		
KE	Pre (Day-1)	9.3±1.1	-7.235	<0.001*	8.1±1.2	-6.435	<0.001*
	Post (Week-1)	10.3±1.2			8.8±1.2		

[Table/Fig-5]: Comparison of Berg Balance Scale (BBS), Barthel index (BI), and muscle strength within the groups.
t=Independent sample t-test; *Significant; BBS: Berg balance scale; BI: Barthel index; HF: Hip flexors; HE: Hip extensors; KF: Knee flexors; KE: Knee extensors

improve, possibly attributed to early sit-to-stand functional training. Hence, the sit-to-stand training intervention is necessary with appropriate follow-up sessions.

Jeon MJ et al., on the other hand, conducted a preliminary study on the effects of virtual reality combined with balance training on upper limb function, balance, and ADL in patients with acute stroke. They concluded that ADL-focused virtual reality training on an unstable surface was more effective than training on a stable surface for improving upper limb function, balance, and ADL in patients with acute stroke. These findings suggest that virtual reality combined with balance training had a greater effect on balance improvement in patients with acute stroke than virtual reality training alone [15].

The findings of this study showed that authors reject the null hypothesis, which states that sit-to-stand training is effective in stroke patients, and accept the alternative hypothesis. The strength of the study was that there were no dropouts, and the sit-to-stand training as well as conventional physical therapy did not had any adverse effects on the patients. The intervention was safe and feasible, and sit-to-stand training did not cause any discomfort for the patients. The scope of the study was that future studies can include long-term follow-up to see the effect of muscle strength. Long-term follow-up would have been beneficial to observe the results on muscle strength with a dynamometer.

Limitation(s)

The treatment duration was short, and only people who could understand Kannada, Malayalam, and English languages were included in the study. There was no long-term follow-up.

CONCLUSION(S)

The current randomised controlled trial concludes that sit-to-stand training was significantly effective in improving muscle strength of HE, balance, and ADL in patients with stroke. Sit-to-stand training can also be included in day-to-day life to observe changes in stroke patients.

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