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The Effects of Intensive Multiplanar Trunk Training Coupled with Dual Task Exercises on Mobility and Fall Risk in Patients with Subacute Stroke Survivors: A Randomized Control Trial

Yashashwini R S[1], Dr. Rajendra Kachhwaha[2]

[1]Post Graduate Physiotherapy student,[2]Principal& Professor;
Narayana Hrudayalaya Institute of Physiotherapy, Bommasandra, Bengaluru

Corresponding Author: Dr. Rajendra Kachhwaha

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ABSTRACT

BACKGROUND: Stroke is the leading cause of long-term disability and the second leading cause of death worldwide. The first month after a stroke is a vital period since the brain goes through major plastic changes during this time. The trunk being the central key point of the body, proximal trunk control is a prerequisite for distal limb movement control, balance and functional activities. Dual task training aims to improve the ability to do two or more things simultaneously and thus reduce the risk of falling. Diagonal pattern training is one of the trunk rehabilitation training methods that improve the movement, trunk asymmetry, flexibility, and strength provided by various planes.
OBJECTIVE: To find the effectiveness of intensive multiplanar trunk training coupled with dual task exercises to improve mobility and reduce the fall risk in subacute stroke patients.
METHOD: 46 stroke survivors were apprehended and randomly assigned to experimental and control groups. 23 people were divided into each group, which underwent intensive multiplanar trunk training coupled with dual task exercises conjunction with conventional physiotherapy and conventional therapy and dual task exercises respectively. For three months, both groups had training for 70 minutes per day, five days per week. Utilizing the stroke impact scale -16 and fall efficacy scale international as outcome measures, treatment effects were documented.
RESULTS: The difference between the pre- and post-test results between the groups for mobility and fall risk are both deemed to be significant for Independent T-Test.
We observed significantly increased mean SIS-16 scores from baseline to 3 months post treatment in the experimental group, outcome measure showed significant and clinically meaningful results. Fall risk between groups was significantly reduced at 3months.
CONCLUSION: Intensive multiplanar trunk movements coupled with dual-task practice promoted functional recovery in patients with stroke, reduced fall risk, and improved independent mobility.

KEYWORDS: Subacute stroke, Intensive multiplanar trunk training, Dual task, Stroke impact scale -16, Fall efficacy scale international.

INTRODUCTION

Stroke is typically defined as a neurological impairment resulting from an acute, localized injury to the central nervous system (CNS) caused by vascular events such as cerebral infarction, intracerebral hemorrhage (ICH), and subarachnoid hemorrhage (SAH). It is a leading contributor to disability and mortality globally[1.] Often referred to as a cerebrovascular accident or brain attack, stroke represents a significant global health issue. Proper blood circulation is essential for brain function; stroke occurs when the blood supply to a specific area of the brain is disrupted, either by a clot or by the narrowing or rupture of blood vessels. As a result, brain cells become oxygen-deprived and begin to die within minutes, leading to irreversible brain damage[2.]

Clinically, stroke can present with a range of focal deficits, including alterations in consciousness, as well as impairments in sensory, motor, cognitive, perceptual, and language functions. For a diagnosis of stroke, neurological deficits must endure for a minimum of 24 hours. Motor deficits are commonly manifested as paralysis (hemiplegia) or weakness (hemiparesis), usually affecting the side of the body contralateral to the location of the lesion[3.]

Each year, approximately 15 million people worldwide experience a stroke, with about 25% occurring in individuals under the age of 65[4.] Stroke affects roughly 13.7 million people annually and is responsible for approximately 5.5 million deaths. Ischemic infarctions account for about 87% of all strokes, a proportion that has significantly increased between 1990 and 2016, largely due to reduced mortality rates and advancements in clinical treatments[5.] The two primary types of cerebrovascular accidents (CVAs) are ischemic and hemorrhagic, with ischemic strokes constituting up to 80% of cases, while hemorrhagic strokes account for the remaining 20%[6,7.]

The trunk serves as the central core of the body, and proper proximal trunk control is essential for regulating distal limb movement, maintaining balance, and performing functional activities.

Trunk control refers to the capacity of the trunk muscles to support an upright posture, facilitate weight shifting, and execute selective trunk movements to keep the center of mass within the base of support during both static and dynamic postural adjustments[8.] Stroke patients exhibit significantly lower trunk control performance compared to healthy individuals of the same age and gender, often accompanied by marked asymmetry in the trunk and pelvis[9.]

A key objective of stroke rehabilitation is to restore mobility; therefore, it is essential to inform patients and their families about the potential outcomes of mobility recovery to help them lead a normal social life[10.]

Dual-task training aims to enhance the ability to perform two or more activities simultaneously, thereby reducing the risk of falling. It can be categorized into two types: 1) dual-task training involving a cognitive task, and 2) dual-task training involving a manual task. This training involves a primary task along with an additional secondary task, where both tasks can be carried out independently as separate activities with distinct goals[11.]

Diagonal pattern training is a trunk rehabilitation approach designed to enhance movement, reduce trunk asymmetry, and improve flexibility and strength across various planes. This method involves diagonal trunk movements that facilitate rotation, separate the thorax and pelvis, and incorporate repetitive weight shifts to promote the activation of trunk muscles[12.]

The therapeutic challenge of incorporating multiplanar movements into trunk training is crucial due to the loss of trunk control across all three planes, which leads to difficulties in performing functional activities after a stroke. Since activities of daily living (ADLs) involve multiplanar movements and the risk of falls is higher in lateral and diagonal directions, reestablishing trunk control in all three

cardinal planes should be a primary goal of stroke rehabilitation. Recent studies provide evidence that incorporating three-dimensional movements is beneficial. Additionally, dual-task (DT) practice emerges as a promising strategy in stroke rehabilitation to enhance trunk control and balance for safe mobility, as both community walking and ADLs typically involve multitasking. Trunk training exercises are recognized as effective in improving balance, mobility, and functional outcomes. However, clinical observations and recent literature suggest that two additional strategies—integrating more multiplanar trunk exercises and dual-tasking—can be incorporated into the Standard Care Trunk Regimen (SCTR) to achieve better outcomes for stroke patients[13.]

METHODS

Eligibility criteria

We consecutively recruited patients with stroke from the Neurology ward Mazumdar Shaw Medical Center, Narayana Health City, Bangalore. The study was registered with the clinical trial registration India (Reg no: CTRI/2023/12/060742**).** We included patients with subacute stroke of age group between 45-60 years, patients who could sit and stand for 30 s or more and walk for at least 10 mtr without assistance from a therapist or caregiver were eligible, Patients who had experienced a stroke in the past 3 to 6 months and scored 24 or more on the Mini-mental status examination. We excluded patients who had other neurological or musculoskeletal conditions that caused severe balance problems (such as cerebellar or basal ganglia disorders), patients who had joint diseases, used braces or other instruments that limited their walking ability, patients whose body mass index > 31 kg/m^2 , patients who had severe visuospatial impairment such as hemineglect or pusher syndrome, patients who had scored <24 in mini-mental status examination, Patients with sensory impairment. The estimated total sample size of the study was 46 participants. All participants provided oral and written informed consent before starting the clinical trial.

46 participants that passed the criteria for selection were randomly assigned in the group. Non-blinders randomization of the subjects using computer generated table was done after obtaining informed consent and based on this they were allocated by using sequentially numbered, opaque, sealed envelope (SNOSE) technique. After which the group was given standardized exercise protocol

All data-collection scoring was performed by a single investigator blinded to group allocation. CAIT is a reliable and valid tool which is available for free online as a portable document format. A physical therapist with complete knowledge and technique was assigned for participant's interactions and treatment. The techniques to be applied in the study is of standard of care (DTT).

The study was registered and approved by the Narayana Health Academic Ethics Committee and given a registration number ECR/772/Inst/KA/2016/RR-22

Interventions

A total of 46 participants, who fulfill the inclusion criteria, was selected for the study. Further, they were divided into two groups of 23 each. Pre and Post intervention assessment was taken Pre and post both the groups by using stroke impact scale -16&Fall efficacy scale. The intensity and pace of the tasks was explained to the individuals before training began. Each task was practiced with the proper breaks in between. Total time of treatment was 70 minutes for both experimental group and control group. The treatment was given as 3 sets of 8-10 repetitions per trail for 5 days per week for 3 months for both the groups. Total duration of the study was 9 months. Pre and post assessment was done for both the groups by using stroke impact scale -16 and fall efficacy scale –International.

Experimental group received intensive multiplanar trunk training coupled with dual task exercises along with conventional physiotherapy.

Conventional physiotherapy protocol-

- Functional mat exercises (supine to prone on the elbow, to prone on hand, to quadruped position, to kneeling, then at the end to standing, each position was maintained for 2min) for around 10 min/sessions.
- Stretching exercises (for hamstrings, quadriceps, gastrocnemius, glutei, elbow and finger flexors, with 15 – 30 s hold for 3 repetitions for each muscle) for around 5min/sessions.
- Active – assisted ROM exercises to progressive resistance with 10-15s hold,15 repetitions for affected muscles.
- Gait training– front walking, back walking, side walking, circle walking.
- Core stability– pelvic bridging, pelvic tilt, partial curl, side plank 10sec hold, 3 repetitions.
- Weight shift training- Forward weight shift, lateral weight shift.

Intensive multiplanar trunk training coupled with dual task exercises protocol

1. static trunk control and Basic and multiplanar movements trunk control (will be given for 2 weeks)
   - Sitting balancing, sitting balancing with external assistance.
   - Sitting- lateral pelvic shift, kneeling – pelvic shift, trunk rotation – lateral, Diagonal side
2. Linking – coordinated trunk and extremity movements with dual task exercises (will be given for 2 weeks)
   - Reaching – trunk forward bending, trunk lateral bending, trunk diagonal
   - Bending, trunk diagonal cross bending
3. Kneel walking (diagonal), catching (diagonal) – (will be given for 2 months)

Control group received conventional physiotherapy and dual task training**.** conventional physiotherapy – It includes the same conventional physiotherapy protocol as given in the experimental group.

Dual task training includes

- Single task balance training exercises – dynamic weight shifting, sit to stand exercises, heel rise while sitting on chair. Cognitive motor dual task balance training exercises- sitting and recite numbers, days, or months backward, walking while telling story, tell opposite direction of action.
- Motor dual task balancing training exercises – standing while throwing and catching a ball, walk and kick a ball, walking while holding a cup of water without spilling it.

RESULTS

STATISTICAL ANALYSIS

The Statistical analysis was performed using SPSS version 27 and R- programming version 4.3.1

Descriptive statistics - All the categorical variables were expressed using frequency and percentages. All the continuous variables are expressed using mean and standard deviation. Inferential statistics - Shapiro wilk test was used to check the normality of the data. A p-value of > 0.05 was considered statistically significant. Based on the normality of the data an independent T test was used to compare the mean between the two groups based on the normality of the data. A p-value of <0.005 was considered as statistically significant. MS-EXCEL and MS-WORD were used to generate the tables and graphs suitably.

Descriptive Statistics

Categorical Data

Table-1

GENDER					
		Experimental Group		**Control Group**	
		Frequency (N=23)	**Percent (100%)**	**Frequency (N=23)**	**Percent (100%)**
Valid	Female	6	26.1	9	39.1
	Male	17	73.9	14	60.9

Table 1 shows gender distribution in both the groups

Table-2. Comparing the Pre-Test and Post- Test Outcomes between the groups

	Group	**Mean**	**Std. Deviation**	**t**	**P- Value**
AGE	Control	52.96	4.557	0.155	0.877
	Experimental	52.74	4.920		
SIS-16: PRE-TREATMENT	Control	54.78	2.315	-1.753	0.087
	Experimental	55.83	1.669		
FES-I: PRE-TREATMENT	Control	45.26	2.378	7.709	<0.001*
	Experimental	37.26	4.372		
SIS-16: POST-TREATMENT	Control	62.35	1.898	-17.625	<0.001*
	Experimental	75.87	3.152		
FES-I: POST-TREATMENT	Control	33.43	2.128	7.812	<0.001*
	Experimental	26.70	3.548		

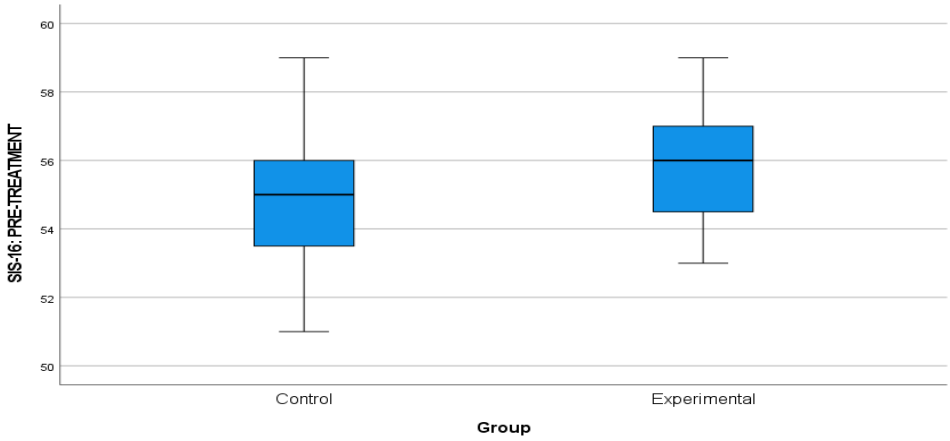
Statistical Test: Independent T- Test; P-Value <0.05- Significant*

Table 2Shows the comparison of pre and post –test of all the outcome measure (SIS-16, FES-I) between the groups. In terms of SIS-16 both the groups showed significant increasing in mobility. In experimental group the mean difference is 75.87±3.152 with the t- value of -17.625. This result shows that there is a significant increasing in mobility which is statistically significant (p<0.001). In control group the mean difference was 62.35±1.898 with the t- value of -17.625. This result shows that there is a significant increasing in mobility which is statistically significant (p<0.001).

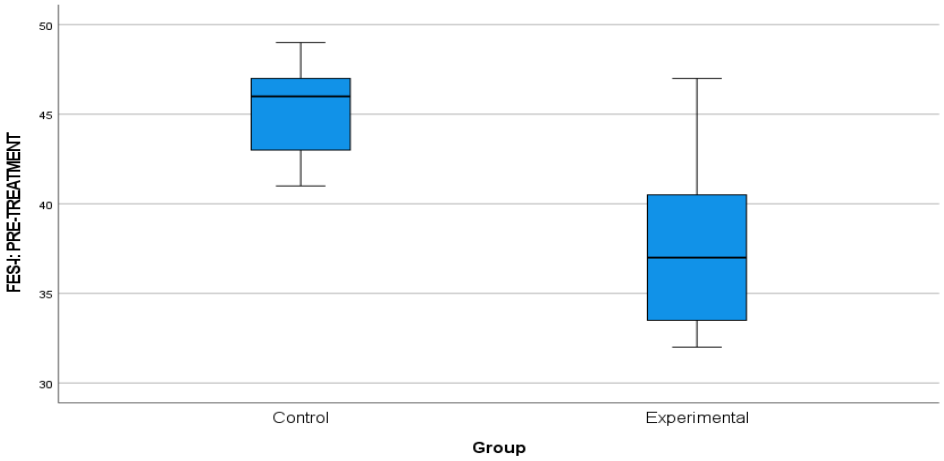
In terms of FES-I both the groups showed significant decrease in fall risk. In experimental group the mean difference is 26.70±3.538 with the t- value of 7.812. This result shows that there is a significant decrease in fall risk which is statistically significant (p<0.001). In control group the mean difference was 33.43±2.128 with the t- value of 7.812 This result shows that there is a significant decrease in fall risk which is statistically significant (p<0.001).

Comparing between the Experimental and Control Groups within each variable

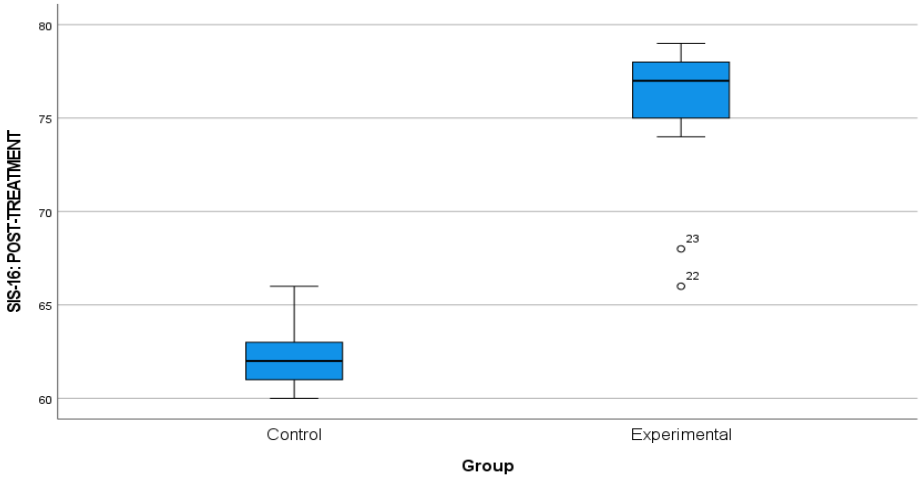
Graph-1: SIS-16: PRE-TREATMENT



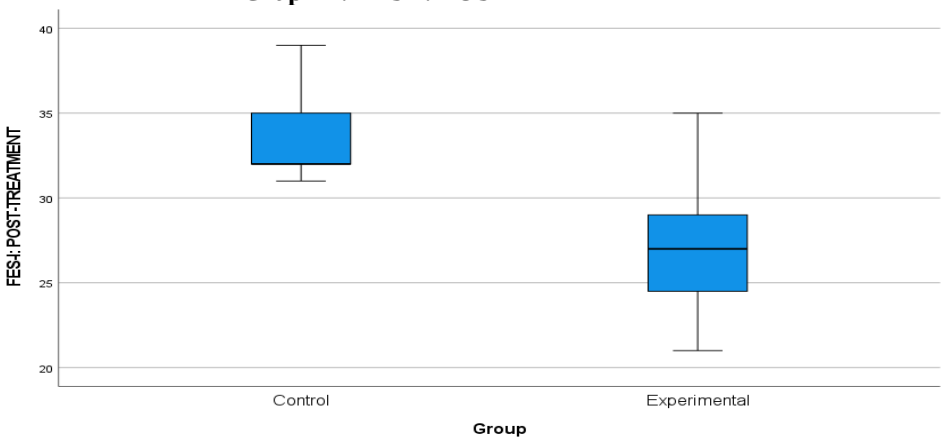
Graph-2: FES-I: PRE-TREATMENT



Graph-3: SIS-16: POST-TREATMENT



Graph-4: FES-I: POST-TREATMENT



RESULTS

In this study 46 subjects were included, the statistical analysis was done by using Independent t test to see the effectiveness of both the intervention of intensive multiplanar trunk training coupled with dual task exercises and conventional physiotherapy with dual task exercises. The Independent T test analysis for the pre- test and post-test variable for the SIS-16 for assessing the mobility and FES –I for assessing fall risk in patients with sub-stroke for experimental group and control groups. Table 1 shows gender distribution in both

the groups, Experimental group has 73.9% males and 26.1% females and control group have 60.9% males and 39.1% of females. The independent T test analysis (between group) for the pre-test and post-test variables for experimental group and control group for SIS-16 and FES-I for assessing mobility and fall risk in patients with subacute stroke which was shown in the table 2. Both the groups show significant difference in the pre-test and post-test values. The (post test) t test value for experimental group and control group for SIS-16 is -17.625 and FES-I is 7.812. The result showed that there was a significant difference when compared pre-test and post-test difference in experimental group and control group on SIS-16 and FES-I with p (<0.001, statistically significant) at the duration of 3months. In terms of statistical analysis, there were marginally significant differences between the pre- and post-test results for both groups. However, intensive multiplanar trunk training coupled with dual task exercises when given as an adjuvant to conventional treatment, significantly improves the patient's mobility and reduce fall risk. The interventions implemented for both the experimental and control group demonstrated individual effectiveness in enhancing mobility and decreasing fall risk among subacute stroke subjects. However, a significantly greater improvement was observed within the experimental group compared to the control group.

DISCUSSION

In this present study the main objective of this clinical trial was to find out the effectiveness of intensive multiplanar trunk training coupled with dual task exercises to improve mobility and reduce the fall risk in subacute stroke patients. We hypothesized that trunk exercises performed with sufficient intensity and complexity (carried out together with a cognitive task and multiplanar movements) could increase functional outcomes and reduce fall risk among patients with stroke. Our results were in line with this hypothesis, showing that an increase in intensive multiplanar trunk training coupled with dual task exercises improved mobility, and fall risk compared with standard treatment regimes. The study results were interpreted on the basis of the outcome measure used in this study. However, a greater improvement was observed for both SIS-16 and FES-I Score after performing intensive multiplanar trunk training coupled with dual task exercises in conjunction with the conventional physiotherapy and dual task exercises.

The stabilization of trunk trajectory, especially in terms of directional control, is a critical focus in stroke rehabilitation. Stroke patients often struggle to effectively coordinate specific combinations of trunk muscles needed to stabilize the trunk's movement. Ryerson's proposal emphasizes the importance of retraining stroke patients to achieve full trunk control across all three spatial dimensions, highlighting the significance of this objective within the rehabilitation process[14.] The findings of our study are consistent with previous research that demonstrates the superior effectiveness of three-dimensional trunk training compared to conventional interventions in improving balance and gait in patients recovering from subacute stroke. This alignment further reinforces the evidence supporting the effectiveness of comprehensive trunk rehabilitation approaches in enhancing functional outcomes for this patient group[15.] The significant improvements observed in patients undergoing intensive multiplanar trunk training combined with dual-task exercises can be attributed to the broader range of multidirectional exercises provided. This expanded exercise regimen likely facilitated improvements in anticipatory postural adjustments, enhancing dynamic balance and coordination across all spatial planes. Furthermore, the incorporation of intensive multiplanar trunk training with dual-task exercises appears to optimize the use of beneficial muscle synergies while reducing the impact of destabilizing muscle synergies. This

suggests a mechanistic understanding of how these interventions contribute to improved trunk control. This insight highlights the potential of such combined approaches to offer a targeted and effective strategy for addressing the complexities of trunk rehabilitation following stroke. The enhanced trunk and balance control, along with the reduced fall risk observed in the experimental group, can be attributed to several factors. Notably, participants in the experimental group received more intensive trunk training than those in the control group, allowing them to engage in more challenging exercises. This increased training intensity likely played a crucial role in the observed improvements in trunk control and balance, contributing to a reduced risk of falls among the participants[16.] As a result, these patients likely demonstrated improved coordination between trunk and extremity movements during various transitional movements and mobility tasks. Additionally, individuals in the experimental group frequently performed movements essential for functional abilities, such as lateral and diagonal trunk movements, including forward trunk rotation towards the uninvolved side[17.] These control mechanisms are often impaired in stroke patients, and the added retraining of trunk movements in these directions may have contributed to overcoming these control deficits. Additionally, the multiplanar exercises combined with dual-task (DT) practice likely promoted more automatic balance control in the experimental group compared to the control group, possibly due to more efficient allocation of attentional resources[18.] As a result, the experimental group experienced fewer falls and fall-related injuries due to improved management of distractions and complex multiplanar movements in activities of daily living (ADLs). Additionally, their lateral and diagonal trunk control was enhanced during sitting, standing, and walking. Finally, motor performance in the experimental group was less impacted by distractions, likely due to dual-task (DT) practice. Moreover, the increased frequency of multiplanar exercises may have contributed to better segmental trunk and body movements across various movements[19.] Multiplanar movements are more effective than uniplanar movements in improving trunk control. Various trunk and gait training programs focus on this type of control to enhance balance and functional mobility skills in stroke rehabilitation[20.]

CONCLUSION

The impact of intensive multiplanar trunk training coupled with dual task exercises on sub-acute stroke patients was extensively examined and evaluated in this study.

It can be concluded there were marginally significant differences between the pre- and post-test results for both groups. However, intensive multiplanar trunk training coupled with dual task exercises when given as an adjuvant to conventional treatment, significantly improves the patient's mobility and reduce fall risk.

Declaration by Authors

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