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Effectiveness Of Core Stability Exercises In Improving Dynamic Sitting Balance In Post-Stroke Cases

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ABSTRACT

Background: Dynamic sitting balance is a significant early indicator of mobility and independence after stroke, but trunk control is usually disturbed. Core stability exercises (CSEs) could be used to enhance postural control in this population.

Objective: To determine the effectiveness of CSEs in improving dynamic sitting balance in adults after stroke.

Methods: A randomized controlled trial in a tertiary center in Bhubaneswar involving 60 patients (45–75 years) who were randomized into CSE + routine physiotherapy (Group A) or routine physiotherapy alone (Group B). The most significant inclusion criteria were first-ever unilateral stroke in the past year, sitting ability ≥10 s, and baseline Trunk Impairment Scale (TIS) ≤10. Primary measures were TIS and an age-predicted sitting balance scale, both of which were measured at baseline and 3 months. Sessions were delivered 5 days/week for 45–60 minutes; CSEs targeted deep and global trunk stabilizers with increasing difficulty.

Result: Both conditions exhibited important improvement in Trunk Impairment Scale (TIS) scores ($p<0.001$). The experimental condition improved from 7.37 ± 1.71 to 13.43 ± 2.06, while the control condition improved from 7.50 ± 1.94 to 12.10 ± 2.19. Between-group comparison revealed a significant difference in the experimental group's favor ($t=4.303$, $p<0.001$). The findings reveal that the experimental treatment induced greater improvement in sitting balance and trunk control compared to routine therapy.

Conclusion: The integration of a systematic CSE program with routine physiotherapy results in clinically and statistically improved gains in post-stroke trunk control and dynamic sitting balance. CSEs are simple, low-cost, and can be integrated into routine rehabilitation procedures.

KEYWORDS : *Stroke Rehabilitation,Core Stability Exercise, Dynamic sitting balance, Trunk control, Trunk Impairment Scale (TIS)*

1. INTRODUCTION

Stroke is one of the leading causes of chronic disability all over the world, with extensive effects on independence and quality of life. Stroke is characterized by an acute deficit of neurological function due to disruption of cerebral blood flow leading to ischemic or haemorrhagic damage of the brain parenchyma [1]. Across the globe, 15 million individuals have a stroke every year, of whom approximately 5 million are left permanently disabled, imposing a huge socio-economic load on caregivers and healthcare systems [2]. Arguably the most disabling stroke after-effect is compromised postural control, particularly the ability to maintain dynamic sitting balance, which is of utmost importance for functional mobility, activities of daily living (ADLs), and safe transfers [3].

Both dynamic and static postural stability are essential motor functions controlled by the coordination of sensory input, central processing, and neuromuscular output. In the stroke patient population, neurological damage frequently interferes with sensorimotor integration, and subsequently, produces postural asymmetries, trunk muscle weakness, and impaired proprioception [4]. Dynamic sitting balance requires, in particular, the ability to actively control the trunk upon perturbation, an ability frequently disrupted by hemiparesis or hemiplegia due to stroke [5]. Unsatisfactory sitting balance not only predicts unsatisfactory mobility outcome but also long-term dependency and institutionalization [6].

In neurorehabilitation, dynamic sitting balance and trunk control are important initial targets. The trunk is used as a stable base to move the limbs and is needed for coordination of the upper and lower limbs. Trunk deficits in stroke survivors are linked with increased fall risk, reduced walking ability, and difficulty with the performance of ADLs such as dressing, grooming, and transfer [7]. Hence, enhancing trunk control through specific interventions may increase functional independence, decrease the risk of falls, and enhance overall quality of life [8].

There is increasing evidence pointing towards the therapeutic applications of core stability exercises (CSEs) in neurorehabilitation, especially for improving trunk control and balance among patients with neurological impairment [9]. Core stability is defined as the ability of the lumbopelvic-hip complex muscles to support the spine in a stable, neutral position during motion [10]. The core consists of both local stabilizers (e.g., transverse abdominis, multifidus, pelvic floor muscles) and global muscles (e.g., rectus abdominis, external obliques)

that synergistically function to support spinal control and alignment during dynamic tasks [11].

In stroke survivors, core stability is often lost due to neuromuscular weakness, compromised motor control, and faulty muscle activation patterns. These impairments result in decreased trunk stability and impaired execution of voluntary movements such as weight shifting, reaching, or transfer [12]. Core stability exercises are designed to retrain the coordination of trunk musculature, augment the strength, and alter anticipatory postural adjustments (APAs), which are crucial in achieving balance during functional activities [13].

Some of these rehabilitation techniques have been promoted to improve dynamic sitting balance following stroke, including task-specific training, proprioceptive neuromuscular facilitation (PNF), biofeedback, and robotic-based interventions [14]. CSEs have been of particular interest, nonetheless, due to the relatively simple implementation, flexibility across various stages of stroke rehabilitation, and effectiveness in the treatment of deep stabilizing muscles [15]. CSEs are possible in varying postures (e.g., lying, sitting, standing) and difficulty levels, enabling progressive and individualized rehabilitation regimens [16].

Recent systematic reviews and RCTs have demonstrated favorable findings for the use of core training in stroke rehabilitation. For instance, a study by Verheyden et al. demonstrated that a four-week trunk training program was very effective for enhancing stroke patients' trunk control and mobility [17]. Similarly, studies by Saeys et al. and Tasseel-Ponche et al. showed the benefits of trunk exercises in terms of increased functional reach, balance scores, and capacity for walking [18,19]. Furthermore, electromyographic studies have revealed increased activation of deep abdominal muscles such as the transverse abdominis and multifidus following core training, indicative of neuromuscular re-education and improved postural stability [20].

Yet, despite mounting evidence, utilization of core stability training in post-stroke rehabilitation is not effectively used in the clinics. There are several reasons for this, including inadequate training of therapists, lack of standardised protocols, and heterogeneity of response of patients due to differences in stroke severity, lesion location, and cognitive impairment [21]. Secondly, there are no high-quality large-scale studies focusing on the impact of CSEs on dynamic sitting balance as an outcome measure. Most of the current research emphasizes gross balance, control of the trunk, or gait and passes over the specific problems of dynamic sitting, particularly in severely impaired or wheelchair-bound persons [22].

Because of the critical need for balance in dynamic sitting as the foundation for early mobilization and long-term functional independence, there is a pressing need to determine the effectiveness of CSEs with regard to dynamic sitting balance. A focused intervention of sitting balance would bridge the gap between sitting bed mobility and walking and standing activities, allowing for more effective movement along the continuum of rehabilitation [23]. Furthermore, training in dynamic sitting balance provides an integrated rehabilitation program for those patients that cannot walk or stand due to stroke-induced impairments [24].

The theory underlying the use of CSEs in dynamic balance rehabilitation is founded on the knowledge of motor control and neuroplasticity. Motor control theories suggest that anticipatory postural adjustments and feedback mechanisms are critical to maintaining balance during voluntary movement [25]. These mechanisms are disrupted by stroke, but systematic, repetitive, task-specific, and intensive training like core stability programs can facilitate cortical reorganization and motor learning [26]. In addition, trunk dissociation, selective control, and shifting of weight are central training, all of which are essential to effective sitting balance [27].

Additionally, from the biomechanic perspective, trunk stability is used as a platform for distal extremity and posture movement. The lumbo-pelvic region acts as a kinetic linkage that transfers force between the upper and lower part of the body. Core musculature impairment gives rise to compensatory patterns, including over-use of upper limbs or asymmetrical postures, which further impair function and can create secondary complications [28]. Thus, restoring trunk symmetry and activation of core may preclude maladaptive patterns and encourage more effective movement strategies [29].

In the Indian setting, with stroke rates increasing because of demographic changes, urbanization, and life styles, efficient and cost-effective rehabilitation programs are acutely required [30]. Core stability exercises, as cost-efficient and transportable to home-based programs, provide a scalable option for low- and middle-income countries (LMICs) with restricted availability of institutional rehabilitation [31]. The inclusion of these exercises at the onset of the recovery period has the potential to accelerate functional achievement and decrease the financial burden on care providers and healthcare systems [32].

The present study is intended to bridge the existing gap in knowledge by examining the efficacy of core stability exercises in enhancing dynamic sitting balance in patients with a history of stroke, targeting measurable improvements in trunk control, functional reach, and patient self-report. Through the use of a randomized controlled design and standardized intervention protocol, the study will obtain empirical proof to prove or disprove the presence of core training as an integral part of stroke rehabilitation programs. The outcomes are likely to inform the creation of evidence-based guidelines and promote interdisciplinary cooperation among occupational therapists, neurologists, and physiotherapists. The results would contribute to the development of evidence-based recommendations and also facilitate interdisciplinary care by occupational therapists, neurologists, and physiotherapists.

Finally, core stability is a critical component of functional mobility, particularly under conditions of dynamic balance. While impairment of the trunk is a common and disabling stroke complication, it is also responsive to training through targeted interventions such as CSEs. With increasing emphasis on patient-centered care models and functional outcomes, the addition of core stability training to stroke rehabilitation potentially offers a useful strategy for optimizing recovery and maximizing quality of life.

2. METHODS AND MATERIALS

Source of data:

Population-Subjects from Hitech Medical College& Hospital, Bhubaneswar

Sample size- 60 subjects ranging from 45-75years satisfying the sampling criteria

The materials used for studies are as follows: Bed, Pillow, Towel, Bedsheet, Gym ball, Foam roller.

Methods of collection of data

Study Design: Randomised Controlled Trial

Sampling method: Randomisation

Sampling size

60 subjects

Experimental group (Group A)- 30 subjects

Control group (Group B)- 30 subjects

Tools used: Standard Sitting Balance Scale, Trunk Impairment scale

Inclusion Criteria

Patients must have experienced their first-ever stroke within the last 30 days including both cortical and subcortical ischemic or haemorrhagic strokes not more than 1 year.

Stroke must be localized to one side (unilateral) and confirmed by CT;

Both male and female participants with a history of first-time stroke were eligible for the study.

patients with no prior neurological or clinical impairments are eligible.

Participants must be aged 45-75-year-old, inclusive of both genders, who have achieved sitting for at least 10s

Sitting balance impairment assessed using the Trunk Impairment Scale must score ≤10 points.

Must possess the ability to comprehend and follow simple instructions.

Exclusion Criteria

Presence of concurrent neurological conditions (e.g., Parkinson’s disease) or major orthopaedic issues (e.g., amputation) that affect sitting balance.

Psychiatric conditions that could interfere with following instructions.

Ongoing treatments that might impact the effectiveness of the intervention.

Physical activity restrictions (e.g., due to heart failure).

Patients with implanted cardiac pacemakers.

History of haemorrhagic strokes that required intracranial decompression surgery. Strokes confined exclusively to the cerebellum and brainstem. Patients with a primary stroke in another region but a small lesion in the cerebellum and brainstem would not be excluded.

Uncooperative patient

Patient with cardiorespiratory diseases, bone metastasis etc..

Procedure

All the stroke subjects, who had come to the physiotherapy department were screened after determining their suitability according to the inclusion and exclusion criteria's and then they were asked to undergo the study. The participants willing to undergo the study were confirmed regarding the nature of the study and intervention.

Following briefing, they were told to give their written consent. Demographic information of their subjects were taken. Participating subjects were assessed in detail for the requirements of the study. The static sitting balance of the subjects were measured by employing Standard Sitting Balance Scale and the trunk impairments are measured by employing Trunk Impairment Scale.

This research is a randomised controlled trial over 3 months in 60 post-stroke patients. Subjects were randomly divided into two groups of 30 each: - Group A and Group B.

Experimental Group (Group A) subjects were initially tested for sitting balance through the use of the Trunk Impairment Scale (TIS). Core strengthening (CSE) were subsequently given in the second step to enhance the endurance of the trunk as well as the pelvic stabilizing muscles of the transverse abdominis, multifidus, pelvic floor muscles, rectus abdominis, obliques, and erector spinae.

Exercise included: back extensor isometric hold, trunk rotation, oblique crunches, seated trunk extension, trunk circles, forward and lateral punches seated marching, leg rotations, leg raises, bridges, and crunches.

Each exercise was done for 10-15 repetitions, first in supine lying and later progressed to sitting with a physio ball. Progression was individualized based on patient tolerance and improvement.

Core Strengthening Exercises for Post-Stroke Patients

1. Back Extensor Isometric Hold **Position:** Lie on the mat in Prone lying. **Movement:** Extend the body, with alternate lower limbs lifted up and hold the position for some time **Dosage:** Hold for **10–15 seconds**, repeat **10 times**. Progress by increasing holding time.	
2. Trunk Rotation (Twists) **Position:** Sit upright with feet flat. Place right hand on the outside of left thigh. **Movement:** Twist trunk towards the left while keeping spine straight, then return to centre. Repeat on both sides. **Dosage: 15 repetitions** each side × **2 sets**.	

3. Oblique Crunches (Lateral Trunk Flexion) **Position:** Sit on a chair or mat. **Movement:** Dip left shoulder towards left hip, return to upright. Repeat on both sides. **Dosage: 10–15 reps** each side × **2 sets**.	
4. Seated Trunk Extension **Position:** Sit upright at the edge of a chair. **Movement:** Slowly lean backward, engaging core muscles, then return upright. Use arms for support if needed. **Dosage: 10–15 reps** × **2 sets**.	
5. Trunk Circles **Position:** Sit upright on a chair. **Movement:** Move trunk slowly in a circular motion clockwise, then counterclockwise, keeping core muscles engaged. **Dosage: 10 circles** each direction × **2 sets**.	
6. Forward and Lateral Punches **Position:** Sit upright, clasp hands together. **Movement:** Punch arms forward while leaning trunk slightly forward. Then punch sideways (left and right) while leaning trunk to the same side. **Dosage: 10 reps** forward, **10 each side** lateral × **2 sets**.	
7. Seated Marching **Position:** Sit upright on a chair. **Movement:** Alternately lift each knee towards chest while engaging core muscles. **Dosage: 15 marches per leg** × **2 sets**.	
8. Leg Rotations **Position:** Lie supine with knees bent at 90°, feet flat. **Movement:** Slowly drop knees to one side while keeping shoulders flat, then return to centre and repeat on opposite side. **Dosage: 10 reps each side** × **2 sets**.	

9. Leg Raises **Position:** Lie supine with one knee bent, other leg straight. **Movement:** Raise the straight leg up to 45°, hold for 2–3 sec, then lower slowly. Alternate legs. **Dosage: 10 reps each leg** × **2 sets**.	
10. Bridges **Position:** Lie supine, knees bent, feet flat. **Movement:** Lift hips up, squeezing glutes and core, hold for 5 sec, then lower slowly. **Dosage: 10–12 reps** × **2 sets**.	
11. Crunches **Position:** Lie supine with knees bent at 90°. **Movement:** Place hands on thighs, slide hands up towards knees while lifting shoulder blades off mat. **Dosage: 10–15 reps** × **2 sets**.	

Group B subjects in control group were treated with **conventional physiotherapy**, which included therapeutic stretching, resisted exercises, and soft tissue mobilization.

Therapeutic Stretching **Target muscles:** Tight and spastic muscles commonly affected in post-stroke patients (e.g., hamstrings, hip flexors, calf muscles, trunk flexors, and shoulder muscles). **Procedure:** Each stretch was held in a pain-free range for **15–30 seconds** and repeated **3–5 times** per session. **Frequency:** Performed daily under therapist supervision.
Resisted Exercises **Target muscles:** Weak trunk and limb muscles. **Procedure:** Manual resistance or use of light weights/therabands applied to improve strength. Exercises performed in **supine, sitting, or standing** as per patient capacity. **Dosage: 10–12 repetitions × 2 sets** for each major muscle group. Resistance progressed gradually depending on tolerance.
Soft Tissue Mobilization **Technique:** Gentle manual mobilization and massage techniques applied to reduce muscle stiffness, improve circulation, and promote relaxation. **Duration: 10–15 minutes** per session, focused on affected trunk and limb muscles.

Treatment Duration and Frequency

Each patient in Group A and Group B received therapy for **3 months**.

Sessions were conducted **5 days per week**, lasting approximately **45–60 minutes**.

Both groups received treatment sessions for a period of **3 months**.

Statistical analysis of data

Statistical analysis was done using SPSS version 22. The Kolmogorov Smirnor test was used to assess the normality of data. The data run a three and SST did not follow a normal distribution because p value <0.05. However, the sebt, bomb, sls, cjt was normally distributed because the p >0.05 for run a three and SST, the man whitney u test wad performed for between group and the Wilcoxon test for within group in terms of the sebt, bomb, sls, cjt an independent t test was used for between group and paired t test was used for within group.

Table 1a: Test of Normality

Variables	EG Mean (SD)	P-value	CG Mean (SD)	P-value
Age	57±7.86	.200	60.566±8.352	.200
TIS pre	7.366±1.711	.112	7.5 ±1.943	.001

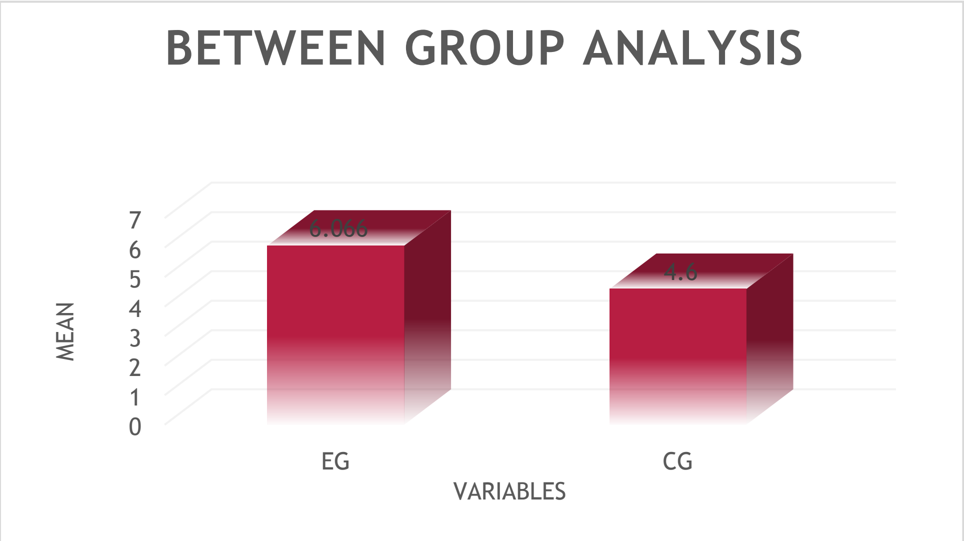
As the sample size >50 Kolmogorov Smirnov test chosen for normality testing.

EGAGE, CGAGE, EGTIS normally distributed as the p value >0.05 whereas, CGTIS not normally distributes p < 0.05.

Table 1b: Independent t-test chosen for Between group Analysis

Between group Analysis

Variables	Group-1 EG	Group-2 CG	Mean Difference	t	P-value
	Mean (SD)	Mean (SD)			
TIS	6.066±1.257	4.600±1.379	1.46667	4.303	.000

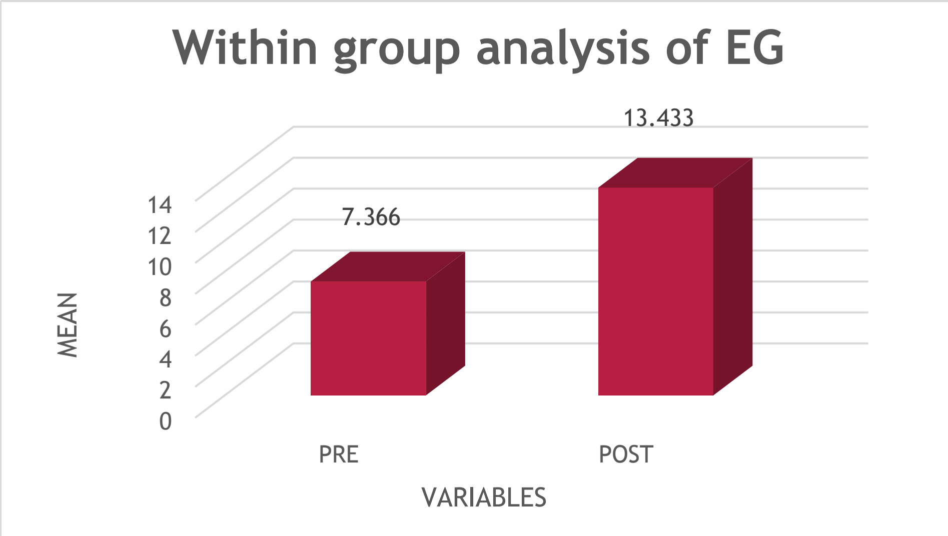


Graph 1: Independent t-test chosen for Between group Analysis

Paired t-test chosen for Between group analysis

Table 1c: Within group analysis of EG

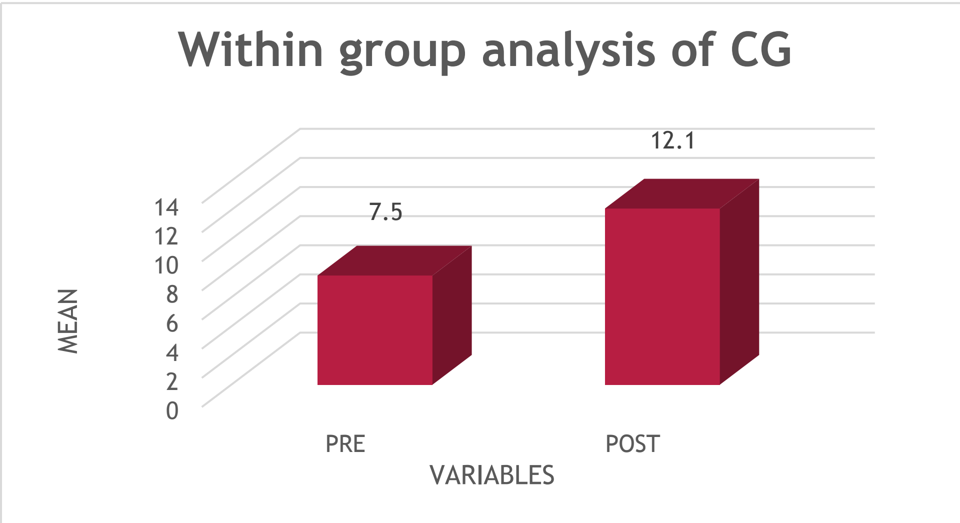
Variables	PRE	POST	t	p
	Mean (SD)	Mean (SD)		
TIS	7.366±1.711	13.433±2.062	-26.422	.000



Graph 2: Within group analysis of EG

Table 1d: Within group analysis of CG

Variables	PRE	POST	t	p
	Mean (SD)	Mean (SD)		
TIS	7.5 ±1.943	12.1±2.186	-18.262	.000



Graph 3: Within group analysis of CG

3. RESULT

This result includes 60 patients, 30 in both experimental groups (Group A) who received Core Stability Exercises and (Group B) who were administered traditional physiotherapy only.

The demographic profile participants shown in the table no. 1A & 1B are as under.

Gender distribution (female : male) of experimental group was 13:17 & control group was 12:18. This is not statistically significant ($p=0.79$).

Each group had 30 subjects and the experimental group's mean age was 57.0 years with a standard deviation 7.86 & that of the control group was 60.57 years with a standard deviation of 8.35.

Both conditions exhibited important improvement in Trunk Impairment Scale (TIS) scores ($p<0.001$). The experimental condition improved from 7.37 ± 1.71 to 13.43 ± 2.06, while the control condition improved from 7.50 ± 1.94 to 12.10 ± 2.19. Between-group comparison revealed a significant difference in the experimental group's favor ($t=4.303$, $p<0.001$). The findings reveal that the experimental treatment induced greater improvement in sitting balance and trunk control compared to routine therapy.

4. DISCUSSION

The current randomized controlled trial (RCT) examined the significance of core stability exercises (CSEs) in enhancing dynamic sitting balance in post-stroke patients. Results showed noteworthy enhancements in Trunk Impairment Scale (TIS) scores in the experimental group compared to the control group, suggesting that specific trunk training had a better influence than normal physiotherapy alone. These results concur with the previous research demonstrating the advantage of core training in enhancing trunk control, postural stability, and functional independence among stroke survivors

This enhancement aligns with the postulate that CSEs enhance activation of global and local stabilizing muscles, restoring anticipatory postural adjustments (APAs) and reactive postural responses (RPRs). This is consistent with the neurophysiological underpinnings of motor control and neuroplasticity, where task-specific and repetitive trunk exercises induce cortical reorganization and functional recovery.

Interestingly, the exercises used—such as trunk rotations, seated trunk extensions, bridges, and leg raises—engaged the deep stabilizers (transversus abdominis, multifidus, pelvic floor muscles) that are responsible for maintaining the erect sitting posture and responding to perturbations.

Numerous studies have reported similar outcomes. Verheyden et al. showed that four weeks of trunk training had improved mobility outcomes for stroke patients.

Similarly, Saeys et al. and Tasseel-Ponche et al. emphasized the importance of trunk training in rehabilitation with improvements in dynamic sitting balance and walking. Later systematic reviews, like Gamble et al., concluded that adding core training to routine care enhances trunk control and reduces fall risk.

The findings of the present study contribute to this body of evidence by specifically addressing dynamic sitting balance, a significant yet less-studied outcome.

In contrast, few have reported little or no significant effects of CSEs on sitting balance when taught in isolation. Lee and Jeon, for example, reported enhanced thickness of the abdominal muscles and gait, but inter-group differences on balance outcomes were not always significant. Differences can be attributed to variations in the duration, intensity, and patient selection of interventions. The present study, with its standardized three-month intervention with scheduled escalation, can explain its more seen outcomes.

Clinical importance of improved dynamic sitting balance cannot be overemphasized. Sitting balance is a fundamental prerequisite for the transfer of safety, starting of walking, and performance of activities of daily living (ADLs). Early restoration of trunk control can hasten rehabilitation, reduce caregiver dependency, and improve quality of life.

Besides, dynamic sitting balance training is a viable option for severely disabled or wheelchair-reliant patients who are unable to engage in initial upright or walking training. With its bridging across the functional hierarchy of bed mobility to higher-level functional activities, CSEs present a scalable and cost-efficient modality of rehabilitation, particularly well-suited for low- and middle-income environments such as India.

5. CONCLUSION

The present randomized controlled trial evaluated the effectiveness of core stability exercises (CSEs) in improving dynamic sitting balance among post-stroke patients. Outcomes indicated that patients who were given CSE, along with standard physiotherapy, exhibited significantly greater improvements in Trunk Impairment Scale (TIS) scores than those who were given standard physiotherapy only. This highlights the central role played by trunk-centered rehabilitation in recovering postural control and overall functional performance.

Dynamic sitting balance is an essential prerequisite of activity of daily living independence, safe transfer, and gait initiation. With a specific emphasis on deep stabilizing muscles of the lumbopelvic-hip complex, CSEs offered improved trunk alignment, anticipatory postural adjustments, and reactive responses, thereby contributing to stability and motor recovery in a positive way. The result of this study accords with contemporary evidence for the incorporation of trunk training in stroke rehabilitation interventions.

Though limited by small sample size, single center study, and short follow-up, this research provides clinically useful evidence that CSEs are cost-effective, feasible, and adaptable intervention. They are institutional as well as home-based rehabilitation and therefore extremely helpful in resource-poor healthcare setups.

In conclusion, core stability exercises are an effective rehabilitative strategy for optimal dynamic sitting balance in stroke patients. Their use as part of regular rehabilitation protocols could accelerate recovery, minimize dependency, and improve quality of life. Larger studies with higher numbers, multicentric enrollment, and longer follow-up are required to validate these findings and formulate standardized protocols for their universal application.

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