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THE EFFECTIVENESS OF ADDITIONAL CORE STABILITY EXERCISES TO IMPROVE TRUNK CONTROL, SITTING BALANCE AND QUALITY OF LIFE IN PATIENTS WITH SPINAL CORD INJURY” (T1 TO T12 LEVEL)

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ABSTRACT

Background: Thoracic spinal cord injury (SCI) leads to impaired trunk control, compromised sitting balance, and reduced functional independence despite preserved upper limb function. Conventional physiotherapy improves general mobility but may not adequately target deep trunk stabilizers. **Aim:** To determine the effectiveness of additional core stability exercises in improving trunk control, sitting balance, and quality of life in individuals with thoracic SCI. **Methodology:** An experimental study was conducted on 30 participants with thoracic SCI (T1–T12), randomly allocated into an experimental group (core stability + conventional physiotherapy) and a control group (conventional physiotherapy alone). Intervention lasted 4 weeks. Outcome measures included Trunk Muscle Manual Muscle Testing (MMT), Modified Functional Reach Test (mFRT), and Spinal Cord Independence Measure (SCIM III). Non-parametric tests were used for analysis. **Results:** Both groups showed significant improvements ($p < 0.05$). The experimental group demonstrated greater mean improvements in trunk strength, lateral reach, and SCIM scores, although between-group differences were not statistically significant. **Conclusion:** Core stability exercises enhance trunk control, sitting balance, and functional independence in thoracic SCI and should be integrated into rehabilitation programs.

Keywords: Thoracic SCI, Core Stability, Trunk Control, Sitting Balance, SCIM III, Rehabilitation

INTRODUCTION

Spinal cord injury (SCI) is a neurological condition that results in motor, sensory, and autonomic impairments, significantly affecting functional independence and quality of life. Thoracic SCI commonly leads to paraplegia and is associated with impaired trunk muscle activation, reduced sitting balance, and decreased postural stability [1-4].

Core stability plays a vital role in maintaining trunk control and providing a stable base for functional activities. In individuals with thoracic SCI, impaired trunk control can limit reaching ability, increase fall risk, and reduce independence in daily activities. Dynamic sitting balance, often assessed using the Modified Functional Reach Test (mFRT), is a key component of functional performance, while the Spinal Cord Independence Measure (SCIM III) evaluates independence in daily living tasks [5-8].

Although rehabilitation is essential for recovery after SCI, evidence regarding the effectiveness of core stability exercises specifically in thoracic SCI remains limited. Therefore, this study aimed to investigate the effects of additional core stability exercises on trunk control, sitting balance, and functional independence in individuals with thoracic spinal cord injury.

METHODOLOGY

This experimental pre-test–post-test control group study was conducted at Jaya

Rehabilitation Institute and Research Centre, Bidada, Gujarat, India. Thirty individuals with thoracic spinal cord injury (T1–T12) were recruited using convenience sampling and randomly allocated to an experimental group ($n = 15$) or a control group ($n = 15$).

Participants aged ≥ 18 years with traumatic or non-traumatic SCI, injury duration > 2 months, ASIA grades A or B, and neurological level T1–T12 were included. Individuals with associated neurological disorders or those who withdrew during the study were excluded.

The intervention was administered for 4 weeks (24 sessions; 6 sessions/week). Both groups received conventional rehabilitation, while the experimental group received additional core stability exercises.

Outcome measures included the ASIA Impairment Scale, Manual Muscle Testing (MMT) for trunk muscle strength, Modified Functional Reach Test (mFRT) for sitting balance, and Spinal Cord Independence Measure (SCIM III) for functional independence. Ethical approval was obtained from the Institutional Ethics Committee, and written informed consent was secured from all participants.

Intervention

Group A: Core Stability Exercises with Conventional Physiotherapy

Table 1: Intervention Protocol for Group A

Position	Exercises	Repetitions and Time
Supine	Pelvic anteversion- retroversion	20 reps × 3 sets
	Upper trunk rotation	20 reps × 3 sets
	Bridging	20 reps × 3 sets
	Lateral pelvic movements	20 reps × 3 sets
Sitting	Trunk flexion and extension	20 reps × 3 sets
	Upper trunk rotation	20 reps × 3 sets
	Lateral trunk inclination	20 reps × 3 sets
	Pelvic lifting	20 reps × 3 sets
On physio ball	Unilateral bridging	20 reps × 3 sets
	Lower trunk rotation	20 reps × 3 sets
	Upper trunk rotation	20 reps × 3 sets
	Trunk inclination	20 reps × 3 sets

Table 2: Conventional Physiotherapy Exercises

Exercises	Repetitions and Time
Range of motion activities (active, active assisted/ passive) for all the limbs	10 reps × 2 sets
Stretching (for all the tight muscles according to assessment)	5reps × 2 sets
Bed mobility activities (supine to side-lying, side-lying to prone, and side-lying to sitting)	10 reps × 2 sets
Compensatory approaches for standing: orthosis, parallel-bars, walkers transfer techniques, and wheelchair skills	30 min
Upper limb Strengthening	10 reps × 2 sets
pelvic bridging and abdominal curls	10 Reps × 2sets
Cardiovascular Strengthening (Spirometry, Treadmill, Hand held Cycle ergometer)	10 Reps × 2sets

RESULTS

Demographic profile

1. Age Distribution:

The age proportions of the participants were that 50% of individuals were between the ages of 18 to 27; 16.7% of people were 28 to 37 years old; another 16.7% were 38 to 47 years old; 10% were between 48 and 57 years; and 0% fell into any other older aged categories. Mean value was 33.5 and standard deviation was 13.98 (Table 3).

2. Gender Distribution:

Gender Distribution graph showed that 77% were male participates and 23% were female participates (Table 4).

3. ASIA Grade:

In this study the ASIA Grade A and B was included, 90% of participates were ASIA Grade A and 10% of participates were Diagnosed with AISA Grade B (Figure 3).

Table 3: Age Distribution of Participates

AGE	PARTICIPATES
18-27	15
28-37	5
38-47	5
48-57	3
58-67	1
68-77	1

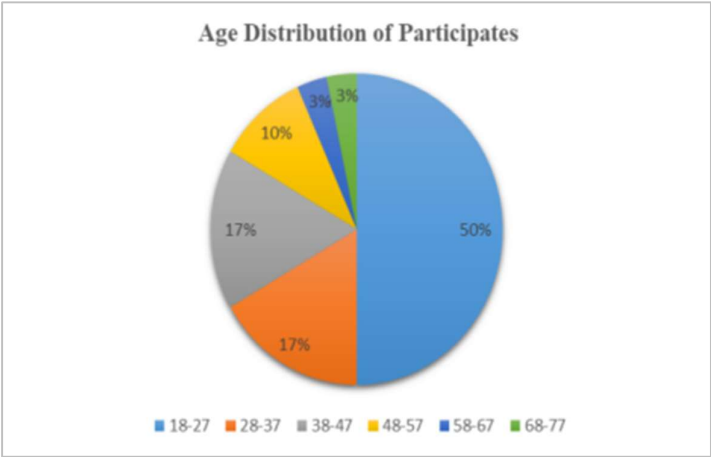


Figure 1: Mean Age of Participates

Table 4: Gender Distribution of Participates

GENDER	NUMBER OF PARTICIPATES
MALE	23
FEMALE	7

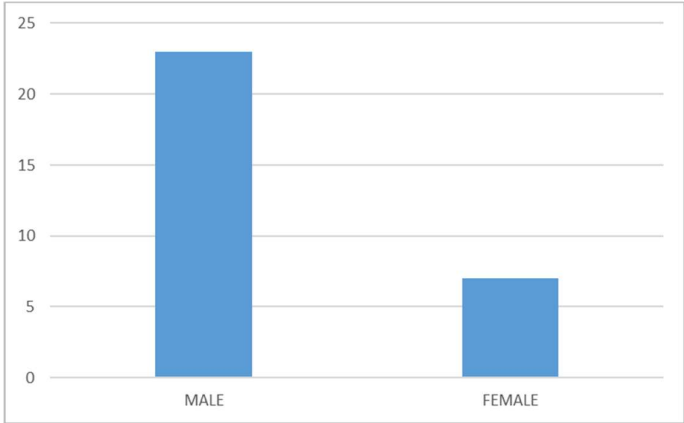


Figure 2: Gender Distribution of Participates

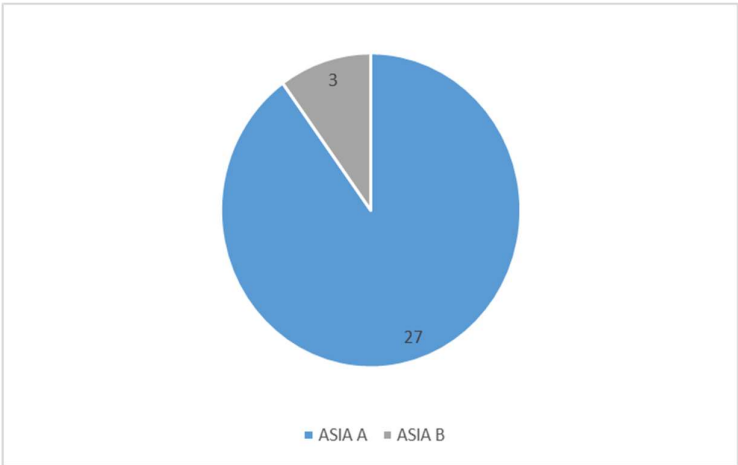


Figure 3: Distribution of AISA Grade A and B

Table 5: Within-Group Pre-Post Comparison of Outcome Measures

Outcome Measure	Group	Pre-test Mean $\pm$ SD	Post-test Mean $\pm$ SD	Z value	p value
Trunk Flexors (MMT)	Group A	2.13 $\pm$ 0.74	2.67 $\pm$ 1.05	-2.828	0.005*
	Group B	2.13 $\pm$ 1.06	2.53 $\pm$ 1.12	-2.449	0.014*
Trunk Extensors (MMT)	Group A	1.80 $\pm$ 0.86	2.67 $\pm$ 0.90	-3.606	<0.001*
	Group B	2.00 $\pm$ 1.07	2.40 $\pm$ 1.06	-2.449	0.014*
Right Lateral Flexors (MMT)	Group A	2.00 $\pm$ 0.85	3.13 $\pm$ 0.74	-3.690	<0.001*
	Group B	2.13 $\pm$ 1.06	2.67 $\pm$ 1.05	-2.828	0.005*
Left Lateral Flexors (MMT)	Group A	2.20 $\pm$ 0.76	3.40 $\pm$ 0.63	-3.448	<0.001*
	Group B	2.20 $\pm$ 0.94	2.73 $\pm$ 1.03	-2.530	0.011*
mFRT – Forward Reach (cm)	Group A	9.60 $\pm$ 3.60	11.80 $\pm$ 4.35	-3.331	<0.001*
	Group B	11.16 $\pm$ 5.29	11.73 $\pm$ 5.09	-2.226	0.026*
mFRT – Right Lateral Reach (cm)	Group A	6.40 $\pm$ 2.56	8.80 $\pm$ 2.96	-3.497	<0.001*
	Group B	7.67 $\pm$ 3.73	8.27 $\pm$ 3.67	-2.714	0.007*
mFRT – Left Lateral Reach (cm)	Group A	6.40 $\pm$ 2.59	8.47 $\pm$ 3.07	-3.497	<0.001*
	Group B	7.20 $\pm$ 3.73	8.00 $\pm$ 3.68	-2.807	0.005*
SCIM Score	Group A	51.00 $\pm$ 11.64	59.60 $\pm$ 13.16	-3.187	0.001*
	Group B	49.53 $\pm$ 18.35	58.13 $\pm$ 21.31	-3.304	<0.001*

Both groups demonstrated statistically significant improvements in trunk muscle strength, sitting balance, and functional independence following the intervention (p

< 0.05). However, the experimental group showed greater mean improvements across all outcome measures.

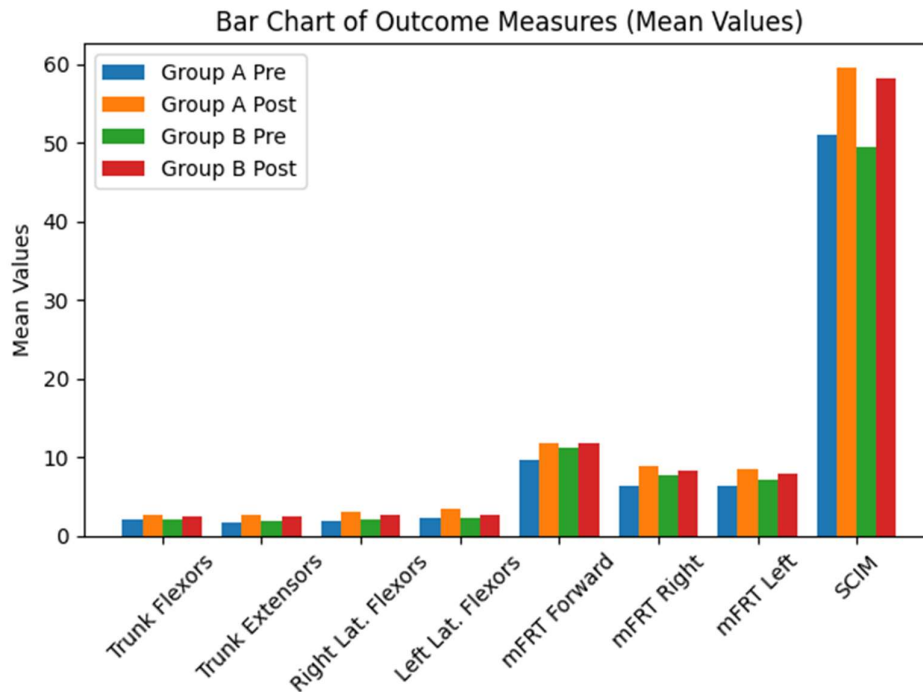


Figure 4: Within group Pre and Post Analysis

Table 6: Compare Post Value of Both Group Outcome measure

Outcome Measure	Group	Mean $\pm$ SD	Z value	p value
MMT- Trunk Flexors	Group A	2.67 $\pm$ 1.05	-0.345	0.730
	Group B	2.53 $\pm$ 1.13		
MMT- Trunk Extensors	Group A	2.67 $\pm$ 0.90	-0.784	0.433
	Group B	2.40 $\pm$ 1.06		
MMT- Trunk Lateral Flexors Right Side	Group A	3.13 $\pm$ 0.74	-1.264	0.206
	Group B	2.67 $\pm$ 1.05		
MMT- Trunk Lateral Flexors Left Side	Group A	3.40 $\pm$ 0.63	-1.854	0.064
	Group B	2.73 $\pm$ 1.03		
Modified Functional Reach Test (Forward Reach)	Group A	11.80 $\pm$ 4.35	-0.084	0.933
	Group B	11.73 $\pm$ 5.09		
Modified Functional Reach Test (Right Lateral Reach)	Group A	8.80 $\pm$ 2.96	-0.448	0.654
	Group B	8.27 $\pm$ 3.67		
Modified Functional Reach Test (Left Lateral Reach)	Group A	8.47 $\pm$ 3.07	-0.420	0.674
	Group B	8.00 $\pm$ 3.68		
SCIM Score	Group A	59.60 $\pm$ 13.16	-0.166	0.868
	Group B	58.13 $\pm$ 21.31		

Results of post-intervention between-group analysis did not show any significant

differences between experimental and control groups in all variables at $p > 0.05$.

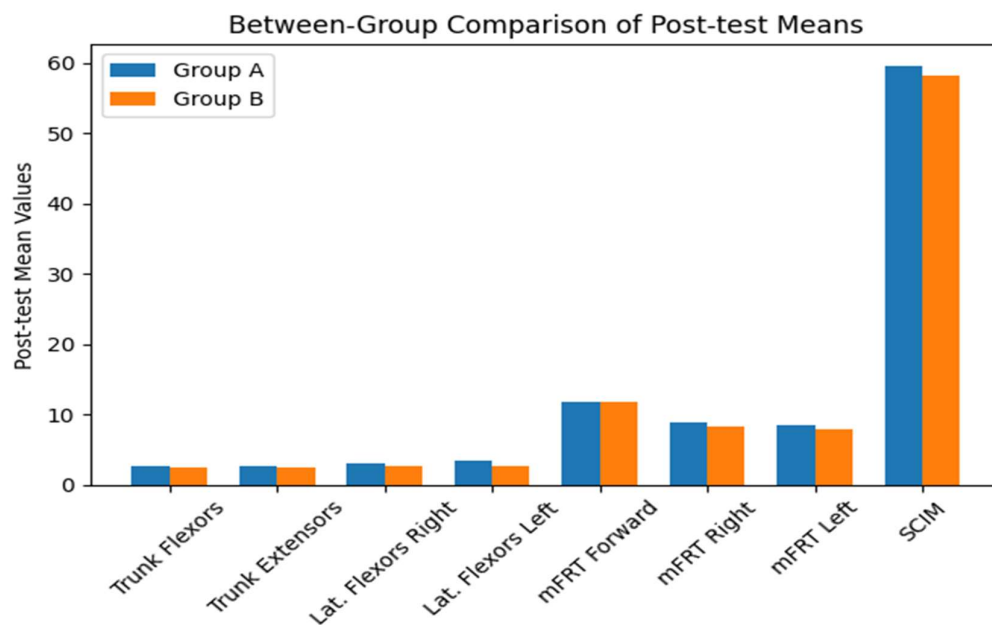


Figure 5: Between Group Post Value Analysis

DISCUSSION

The present study investigated the effectiveness of additional core stability exercises combined with conventional

physiotherapy in improving trunk control, dynamic sitting balance, and functional independence in individuals with thoracic spinal cord injury (SCI). The findings

demonstrated statistically significant improvements in both experimental and control groups following the four-week intervention. However, the experimental group consistently showed greater mean improvements across all outcome measures, indicating the added clinical value of core stability exercises.

Significant improvements in trunk flexor, extensor, and lateral flexor muscle strength were observed in both groups, with more pronounced gains in the experimental group. The greatest improvements were noted in lateral trunk musculature, which plays a critical role in mediolateral stability during sitting. Core stability exercises such as pelvic tilting, trunk rotation, and lateral weight shifts likely enhanced neuromuscular recruitment, co-contraction patterns, and postural control strategies. These exercises promote activation of deep stabilizing muscles and improve trunk alignment, contributing to enhanced postural stability. Although the control group also showed improvements, the smaller magnitude suggests that conventional physiotherapy alone may not sufficiently target deep trunk stabilizers essential for optimal trunk control.

Both groups demonstrated significant improvements in forward and lateral reach distances on the Modified Functional Reach Test (mFRT), reflecting enhanced dynamic sitting balance. The experimental group

showed greater improvements in all directions, indicating improved control of the center of mass within the base of support. Dynamic sitting balance is essential for functional tasks such as reaching, dressing, transfers, and wheelchair mobility. Core stability exercises likely improved sensorimotor integration and trunk coordination, enabling participants to maintain equilibrium during voluntary movements. These findings support previous research demonstrating that trunk-focused interventions improve sitting balance and confirm that trunk stability is a modifiable impairment in SCI [9-29].

Significant improvements in SCIM III scores were observed in both groups, indicating enhanced functional independence in self-care, mobility, and daily activities. The experimental group demonstrated slightly greater improvements, suggesting that enhanced trunk control and sitting balance may reduce caregiver dependence and improve efficiency in performing activities of daily living. Improved trunk stability enables individuals to maintain an upright posture with less effort, facilitating functional mobility and self-care tasks. These findings are consistent with previous studies reporting improvements in SCIM scores following core stabilization programs [30]. Despite greater clinical improvements in the experimental group, between-group analysis

did not reveal statistically significant differences. This may be attributed to the small sample size, short intervention duration, and variability in neurological levels within the thoracic region. Muscular adaptations and functional recovery following SCI often require longer training periods to demonstrate statistically significant differences. Nevertheless, the consistent trend toward superior outcomes in the experimental group highlights the clinical importance of incorporating core stability exercises into rehabilitation programs.

Thoracic SCI results in impaired activation of abdominal and lower thoracic musculature, leading to reduced trunk stability and increased reliance on upper limb support. Core stability exercises aim to restore active trunk control by improving recruitment and coordination of preserved musculature. Exercises involving pelvic control and trunk movements enhance lumbopelvic dissociation, optimize muscle length–tension relationships, and improve postural alignment.

Training on unstable surfaces, such as physio balls, introduces controlled perturbations that enhance proprioceptive feedback and postural reflexes. This promotes adaptive motor responses and improved balance control. Repetitive trunk movements may also facilitate neuroplastic adaptations and motor learning, enabling

functional compensation despite fixed neurological deficits.

The findings of this study align with previous literature emphasizing the importance of trunk-focused rehabilitation in SCI. Mahajan and Gokhale (2025) reported improved sitting balance following core strengthening exercises [30-39], while Bari (2023) demonstrated improvements in functional independence after core stabilization programs [40]. Studies by Marchesi *et al.* (2022) and Paglierani *et al.* (2023) highlighted the relationship between trunk control and functional outcomes [35-38]. Systematic reviews have also confirmed that exercise therapy improves trunk performance and sitting balance in individuals with SCI [40].

The results underscore trunk control as a modifiable factor influencing sitting balance and functional independence in thoracic SCI. Incorporating core stability exercises into routine physiotherapy may enhance rehabilitation outcomes, promote independence, and improve quality of life. Although further large-scale studies are needed, the present findings support the inclusion of trunk-focused interventions in rehabilitation protocols for individuals with thoracic SCI.

CONCLUSION

The current study concludes that incorporating additional core stability exercises alongside conventional

physiotherapy could enhance trunk control, dynamic sitting balance, and functional independence for patients with thoracic spinal cord injuries. Significant improvements were noted among both the experimental and control groups, reflecting the efficacy of conventional physiotherapy, but larger improvements were noted among the experimental group who implemented additional core stability exercises. The enhancements can be attributed to the neuromuscular control of the preserved trunk muscles, postural regulation, and the management of the center of mass during seated activities. There was a major impact on quality of life due to the enhancement in trunk control, which was demonstrated by improved sitting balance and functional independence. Even though the groups did not show significant differences, these trends indicate that structured core stability exercises may be clinically relevant for rehabilitating individuals with thoracic spinal cord injury. The research has demonstrated the importance of trunk control for the rehabilitation of people with thoracic spinal cord injury. Including exercises aimed at enhancing trunk control can yield beneficial effects on functional outcomes and quality of life.

LIMITATION OF THE STUDY

1. Small sample size may have limited statistical power and reduced the likelihood of detecting significant between-group

differences. 2. Short intervention duration (4 weeks) restricts understanding of long-term neuromuscular adaptations and sustained functional improvements. 3. Lack of long-term follow-up prevents evaluation of the durability of improvements in trunk control, balance, and independence. 4. Absence of blinding of therapists and participants may have introduced assessment and performance bias. 5. Single-center study limits generalizability of findings to other clinical settings and populations.

Recommendations for Future Research

1. Include larger sample sizes to increase statistical power and strengthen between-group comparisons. 2. Use longer intervention durations with extended follow-up to assess long-term effects on trunk control, sitting balance, and quality of life. 3. Incorporate objective assessment tools such as electromyography, gait analysis, and force plate measurements to improve evaluation accuracy. 4. Explore technology-assisted rehabilitation approaches, including electronically assisted and virtual training programs, for trunk stabilization. 5. Conduct multi-center studies with diverse populations and rehabilitation settings to enhance generalizability of findings.

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