International Journal of Medical Science and Research
www.medicaljournals.in
Online ISSN: 2664-8768, Print ISSN: 2664-875X
Received: 22-05-2025, Accepted: 21-06-2025, Published: 07-07-2025
Volume 7, Issue 2, 2025, Page No. 1-6

To evaluate the effectiveness of lumbar and pelvic stabilization exercises on balance, functional mobility and coordination in patients with ataxia

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Abstract
Background: Ataxia is a neurological disorder characterized by impaired coordination and balance, significantly affects mobility and quality of life. While pharmacological interventions remain limited, rehabilitation strategies, particularly lumbar and pelvic stabilization exercises, have shown promise in improving functional outcomes.
Objective: This study aims to evaluate the effects of a structured lumbar and pelvic stabilization exercise program on individuals with ataxia, assessing improvements in balance, coordination, and overall mobility.
Methods: A randomized controlled trial was conducted with participants diagnosed with ataxia. Subjects were assigned to an intervention group A undergoing lumbar stabilization exercises and group B undergoing pelvic stabilization exercises. Balance and mobility were assessed using standardized clinical tests, including the Berg Balance Scale (BBS) and the Timed Up and Go (TUG) test, at baseline and post-intervention.
Results: Participants in the intervention group demonstrated significant improvements in BBS and TUG scores compared to the group A ($p < 0.05$). Additionally, qualitative assessments indicated enhanced postural control and gait stability.
Conclusion: Lumbar and pelvic stabilization exercises provide a beneficial, non-invasive approach to improving balance and mobility in individuals with ataxia. Incorporating such exercises into rehabilitation programs may enhance functional independence and quality of life.

Keywords: Ataxia, lumbar stabilization, pelvic stabilization, balance, rehabilitation, mobility

Introduction

Ataxia is a movement disorder characterized by incoordination due to inadequate postural control, affecting balance and gait without muscle weakness. While muscle strength remains normal, individuals struggle with coordinated actions, impacting their ability to perform multi-muscle tasks accurately. Although commonly manifesting in mid-adulthood, ataxia can occur at any age and significantly impairs mobility and independence, often leading to wheelchair dependence and early mortality.

Epidemiological studies estimate the prevalence of ataxia at 26 per 100,000 in children, with dominant hereditary cerebellar ataxia occurring at 2.7 per 100,000 and recessive hereditary cerebellar ataxia at 3.3 per 100,000. Ataxia can be categorized into frontal, vestibular, cerebellar, and sensory types, with mixed ataxia involving multiple symptom manifestations. It arises from cerebellar dysfunction or impaired vestibular or proprioceptive input and may be associated with hereditary, metabolic, immune, or acquired conditions, including stroke, tumors, infections, and alcohol misuse.

Ataxia disrupts coordinated limb movements, leading to inefficient motor control, prolonged reaction times, and reduced movement velocity. Postural instability, increased sway, impaired gait, dysarthria, and cognitive dysfunction are common. Cerebellar damage affects motor and non-motor functions, including speech and language comprehension.

Pharmacological treatments for ataxia remain limited, with some benefit from potassium channel inhibitors like 4-aminopyridine. However, rehabilitation therapies, including balance and gait training, task-oriented exercises, and lumbar and pelvic stabilization exercises, have shown promise in improving motor function, stability, and quality of life. Pelvic stabilization exercises enhance proprioception, neuromuscular control, and core strength, reducing fall risk and promoting mobility. Similarly, lumbar stabilization exercises improve postural alignment, balance, and coordination.

Despite individual studies highlighting the benefits of these exercises, no research has directly compared their effects on balance, coordination, and functional mobility in ataxia patients. This study aims to bridge this gap by evaluating and comparing the efficacy of lumbar and pelvic stabilization exercises in improving functional outcomes for individuals with ataxia.

Materials and Methods

This experimental study was conducted at the Neurology Outpatient Department (OPD) and College of Physiotherapy, PGIMS Rohtak, from August 2023 to July 2024. Ethical clearance was obtained from the Institutional Biomedical Research Committee of Pandit Bhagwat Dayal Sharma University of Health Sciences, Rohtak (reference no. BREC/23/TH-Physiotherapy/01). Informed consent was acquired from all participants after providing a patient information sheet in a language they could understand. A total of 38 subjects diagnosed with ataxia were screened based on inclusion and exclusion criteria using a structured screening proforma. Eight subjects were excluded—four

dues to non-eligibility and four dues to dropout—resulting in a final sample of 30 participants. These individuals were randomly assigned to two experimental groups: Group A (n=15) and Group B (n=15). Demographic details, including age, gender, occupation, hand dominance, and address, were recorded.

Experimental Group A underwent a pelvic stabilization exercise program consisting of six exercises designed to enhance core stability and balance. The exercise regimen included pelvic bridging with postural sway on a Swiss ball, lower trunk and pelvic rotation stability exercises, tri-phasic activity of hip extensors and flexors, clamshell exercises for gluteus medius, dynamic pelvic stability exercises in sitting with forward, sideways, and diagonal reach, and dynamic pelvic stability exercises in standing with weight shifting. Each session lasted approximately 45 minutes and was conducted three times a week for four weeks. Warm-up and cool-down exercises were included.

Experimental Group B performed lumbar stabilization exercises aimed at strengthening the abdominal and lumbar muscles to improve posture and coordination. Participants were initially trained in abdominal breathing and abdominal hollowing to increase awareness of core activation. The exercise protocol was progressive and included seven levels: abdominal hollowing in supine and quadruped positions, unilateral abduction, unilateral knee raises, unilateral heel slides, bilateral heel slides, and bilateral heel hover. Each exercise was performed with an abdominal contraction, progressing in difficulty based on individual performance. Sessions lasted approximately 45 minutes, with a one-minute rest period between exercises, and were conducted three times per week for four weeks.

A follow-up assessment was conducted four weeks after the completion of the treatment protocol at eight weeks to evaluate the long-term effects of the interventions.

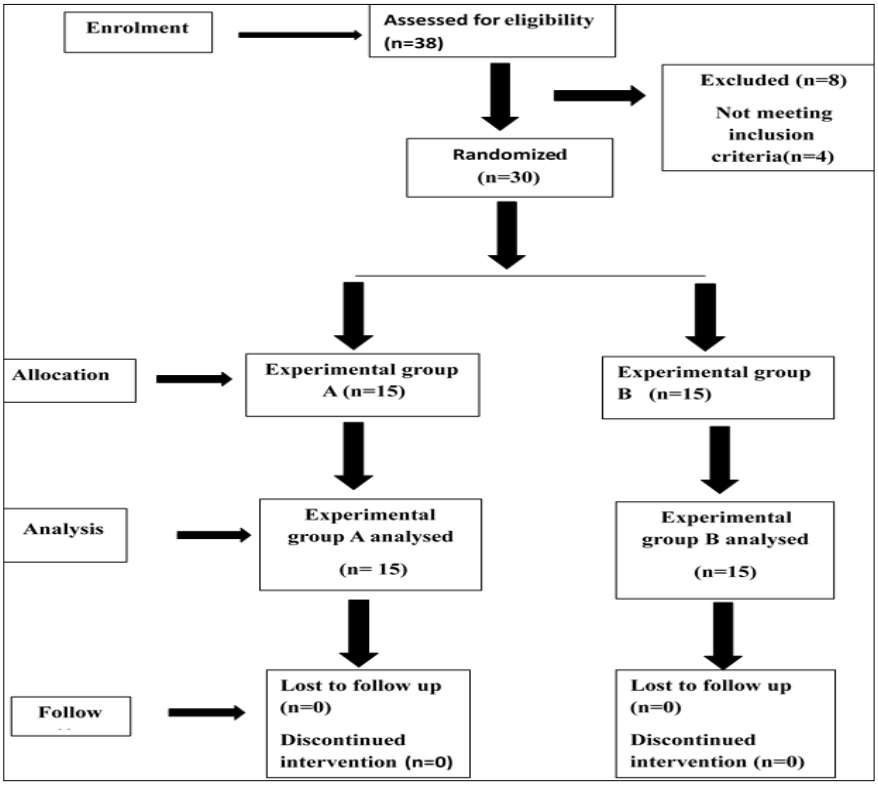

Fig 1: Flow Diagram of methodology of the study

Result

The collected data were analysed using SPSS software version 26.0. Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as mean ± standard deviation (SD). Within-group analysis was performed using repeated measures ANOVA to assess changes over time, while an independent t-test was used for between-group comparisons. A p-value of ≤0.05 was considered statistically significant for all analyses.

Demographic profile of study participants:

Table 1: Age wise distribution of participants

Variable	Experimental group A (Mean ± SD)	Experimental group B (Mean ± SD)	p-value	t-value
Age (years)	38.867± 11.544	34.933± 14.210	0.832	0.412 ^{NS}

Table 2: Gender wise distribution of participants

		GROUP						Chi-Square	p-value
		Group-A		Group-B		Total			
Gender	Male	11	73.3%	6	40.0%	17	56.7%	3.394	.065^{NS}
	Female	4	26.7%	9	60.0%	13	43.3%		
	Total	15	100.0%	15	100.0%	30	100.0%		

Table 3: Comparison of BBS, TUG, 10MWT, and HTS Scores in Experimental Groups A and B at Baseline, 4 Weeks, and 8 Weeks

Assessment	Group	Time Point	Mean ± SD	t-value	p-value
Berg Balance Scale (BBS)	A	Baseline	39.733 ± 7.025	-	-
		Week 4	46.533 ± 5.397	-	-
		Week 8 (Follow-up)	48.733 ± 4.183	-	-
	B	Baseline	40.200 ± 7.399	0.177	0.86 NS
		Week 4	47.600 ± 4.925	1.62	0.11 NS
		Week 8 (Follow-up)	49.667 ± 3.697	-3.997	0.04**
Time Up and Go Test (TUG)	A	Baseline	7.320 ± 1.234	-	-
		Week 4	5.712 ± 1.321	-	-
		Week 8 (Follow-up)	5.581 ± 1.287	-	-
	B	Baseline	8.040 ± 2.490	1.61	0.0001**
		Week 4	6.430 ± 1.720	-	-
		Week 8 (Follow-up)	6.190 ± 1.750	-	-
10 Meter Walk Test (10MWT)	A	Baseline	1.220 ± 0.270	-	-
		Week 4	0.990 ± 0.240	-	-
		Week 8 (Follow-up)	0.840 ± 0.310	-	-
	B	Baseline	1.030 ± 0.310	-	-
		Week 4	0.910 ± 0.300	-	-
		Week 8 (Follow-up)	0.850 ± 0.280	-	-
Heel to Shin Test (HTS)	A	Baseline	2.400 ± 1.320	-	-
		Week 4	1.130 ± 0.990	-	-
		Week 8 (Follow-up)	0.800 ± 0.860	-	-
	B	Baseline	2.130 ± 1.350	1.26	0.0001**
		Week 4	0.860 ± 0.830	-	-
		Week 8 (Follow-up)	0.660 ± 0.720	-	-

A total of 30 participants were randomly assigned into two experimental groups: Experimental Group A (n=15) and Experimental Group B (n=15). The mean age of participants in Experimental Group A was 38.86 ± 11.54 years, while in Experimental Group B, it was 34.93 ± 14.21 years. In Experimental Group A, 26.7% (n = 4) were females and 73.3% (n = 11) were males. In contrast, Experimental Group B consisted of 60.0% (n = 9) females and 40.0% (n = 6) males.

Outcome measures for both groups included the Berg Balance Scale (BBS), Functional Mobility, Gait Speed, and Coordination, assessed at baseline, 4 weeks, and 8 weeks follow-up. Experimental Group A received interventions targeting pelvic bridging, lower trunk and pelvic rotation stability, tri-phasic activity of hip extensors and flexors, gluteus medius exercises, dynamic pelvic stability in standing, and other related activities. Experimental Group B, on the other hand, engaged in exercises such as abdominal hollowing, unilateral and bilateral knee raises, heel slides, and bilateral heel hovers. Both groups participated in these interventions three times a week for a total of four weeks.

Within-group analyses indicated significant improvements in balance, as measured by the BBS, for both Experimental Group A and Group B between baseline and 4 weeks (p=0.0001), as well as between baseline and 8 weeks (p=0.0001). Both groups also showed significant improvement in functional mobility, gait speed, and HTS scores at both 4-week and 8-week assessments. However, some differences were observed: there was no significant difference in functional mobility in Experimental Group A between 8-week and 4-week follow-ups (p=0.42), while Group B exhibited a significant change (p=0.02).

For gait speed, both groups showed significant improvements between baseline and 4 weeks, as well as between baseline and 8 weeks. However, there were no statistically significant differences found in gait speed between the 4-week and 8-week follow-ups in either group. Similarly, HTS scores improved significantly within Experimental Group A but showed no significant change between the 4-week and 8-week follow-ups.

Between-group analyses revealed that, at the 4-week mark, the mean BBS score for Experimental Group A was 44.53 ± 5.39, while Group B's mean was 47.60 ± 4.92, with no statistically significant difference between the two groups (p=0.11). However, at the 8-week follow-up, there was a significant difference between the groups (p=0.04), with Experimental Group A showing a mean BBS score of 49.66 ± 4.27 and Group B at 49.66 ± 3.69. For the Timed Up and Go (TUG) test, there was a significant difference between the groups at both 4 weeks (p=0.03) and 8 weeks (p=0.05), with Experimental Group A showing better performance.

The 10-Meter Walk Test (10MWT) showed no significant difference between the groups at baseline (p=0.56). However, at 4 weeks, Experimental Group A showed a significantly better score (1.00 ± 0.16) compared to Group B (0.86 ± 0.18), with a p-value of 0.03. At the 8-week follow-up, the scores were still significantly different, with Group A achieving a mean score of 0.92 ± 0.13 and Group B 0.80 ± 0.17 (p=0.04).

Finally, HTS scores at baseline were similar between the two groups, with Experimental Group A at 2.40 ± 1.35 and Group B at 2.13 ± 1.35. At the 4-week follow-up, there was no significant difference between the groups (p=0.43), with Group A scoring 1.13 ± 0.99 and Group B at 0.86 ± 0.83. Similarly, at the 8-week follow-up, there were no significant differences observed between the groups (p=0.33), with Group A scoring 0.86 ± 0.83 and Group B at 0.60 ± 0.63.

Discussion

Ataxia is a movement disorder characterized by impaired coordination due to inadequate postural control, which often leads to disturbances in balance and walking without muscle

weakness. This condition severely impacts the quality of life by limiting mobility and functional independence, and its progressive nature further exacerbates the challenges faced by affected individuals. The present study aimed to compare the effects of pelvic stabilization exercises (PSE) and lumbar stabilization exercises (LSE) on balance, functional mobility, gait speed, and coordination in patients with ataxia, particularly those with stroke.

The results of the current study demonstrate that both PSE and LSE significantly improved balance, functional mobility, gait speed, and coordination in patients with ataxia. However, between-group analysis revealed that PSE was more effective than LSE in enhancing these outcomes, particularly in improving balance, mobility, and gait speed. These findings suggest that pelvic stabilization exercises may be a more potent intervention for ataxic patients, especially in individuals recovering from stroke.

The improvement in Berg Balance Scale (BBS) scores observed in both experimental groups underscores the importance of targeted balance training in ataxic rehabilitation. Group A, which underwent PSE, demonstrated significantly greater improvements in balance at the 8-week follow-up compared to Group B. The positive effects of pelvic stabilization exercises on balance are likely due to the increased activation of core stabilizing muscles and task-specific movements that enhance postural control. These exercises may also promote neuroplasticity, reinforcing neural pathways involved in motor control and balance. Previous research supports the notion that task-specific training, such as PSE, strengthens postural control and mobility by engaging sensory feedback systems that aid in motor recovery (Wilson *et al*., 2007) [2].

Functional mobility, as measured by the Timed Up and Go (TUG) test, also showed significant improvements in both groups. Group A demonstrated earlier improvements compared to Group B, with significantly better TUG scores at both the 4-week and 8-week follow-ups. The difference in TUG scores between the groups is indicative of the faster recovery of mobility in patients receiving PSE. This enhanced functional mobility can be attributed to the visual feedback generated by stabilization exercises, which activate motor neurons and help the brain reorganize motor functions. Neuroplasticity, a key mechanism behind the improvements in motor performance, is especially relevant in the rehabilitation of stroke patients with ataxia, as the brain forms new neural connections to compensate for impaired pathways.

Gait speed, assessed through the 10-Meter Walk Test (10MWT), also improved significantly in both groups, with Group A exhibiting more pronounced progress at the 8-week follow-up. This finding aligns with previous studies that suggest gait training in ataxic populations results in enhanced walking ability over time (Luo *et al*., 2017; Scivoletto *et al*., 2011) [2]. The gradual improvement in gait speed seen in both groups points to the importance of long-term interventions. Pelvic stabilization exercises, in particular, seem to offer a more sustainable benefit, likely due to their focus on strengthening the muscles involved in walking and posture control.

Coordination improvements, as measured by the Heel-to-Shin Test (HTS), were observed in both experimental groups, though the results were less conclusive. The lack of significant differences between the groups at the 8-week follow-up suggests that coordination improvements may require more specialized or targeted exercises. Coordination recovery in ataxic patients is primarily driven by neuroplasticity, where the brain forms new neural connections to adapt and restore motor function. Key brain areas, such as the motor cortex, cerebellum, and basal ganglia, are involved in refining movement patterns. Sensory feedback and task-specific training, such as that used in stabilization exercises, are essential for promoting coordinated movement in these patients. However, the relatively modest improvements in coordination observed in this study may indicate that more intensive or prolonged training could be necessary to produce more substantial changes in coordination.

The overall findings of this study support the hypothesis that both PSE and LSE can significantly improve balance, mobility, gait speed, and coordination in patients with ataxia. However, the superior effectiveness of PSE in enhancing these outcomes may be attributed to the more comprehensive engagement of core stabilizers and postural muscles. These exercises contribute to improved sensory feedback, motor control, and neural reorganization, all of which play key roles in restoring functional independence in patients with ataxia. Furthermore, the findings underscore the importance of integrating specific stabilization exercises into rehabilitation programs for ataxic patients to optimize motor recovery and enhance overall quality of life.

Conclusion

This study demonstrates that both pelvic stabilization exercises (PSE) and lumbar stabilization exercises (LSE) are effective in improving balance, functional mobility, gait speed, and coordination in patients with ataxia. Within-group analysis indicated significant improvements in both experimental groups over the course of the intervention. However, between-group analysis revealed that pelvic stabilization exercises were more effective than lumbar stabilization exercises in enhancing these outcomes. These findings suggest that PSE may offer superior benefits in the rehabilitation of ataxic patients, particularly in improving postural control, mobility, and motor coordination. Therefore, pelvic stabilization exercises should be considered a more effective therapeutic approach for enhancing functional outcomes in patients with ataxia.

Limitations

In this study, only 30 subjects were included to assess the effect of lumbar and pelvic stabilization exercise on balance, functional mobility and coordination in patients with ataxia. There is absence of a true control group.

Acknowledgements

I would like to express my sincere gratitude to my co-author for their invaluable contributions and unwavering support throughout the development of this literature.

Declaration

Funding: No funding sources

Conflict of interest: None declared

Ethical approval

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