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"Exploring the Potential of Augmented Active Control Exercise Program in Managing Disc Prolapse: A Pilot Study"

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Abstract

BACKGROUND: *While traditional active control exercises have demonstrated efficacy in improving spinal stability and reducing pain in individuals with chronic low back pain, their effectiveness in specifically addressing intervertebral disc prolapse has been less comprehensively explored.*

OBJECTIVE: *To find the efficacy of Augmented Active Control Exercise Program in Managing Disc Prolapse on ROM, Proprioception, Endurance (Static and Dynamic) and functional disability in individuals with chronic LDP, and to compare with Conventional Exercise.*

METHODS: *This single blind randomized controlled trial included twenty participants with a mean age of 40.75 years and Standard Deviation of 5.53 years having chronic LDP with or without radiating symptoms were included in the study. The experimental group received Augmented Active Control Exercise Program and control group received Conventional exercises. At day one and at the end of fourth week Range of Motion, Proprioception, Endurance and Owestry Disability Index was measured by physical therapist.*

RESULTS: *Both treatments had positive effect for improving ROM, Proprioception, Endurance and Owestry Disability Index. Although there was a significant differences in these parameters in Experimental group as compared to Control Group except there was a slight improvement in Extension in Experimental group post intervention.*

CONCLUSION: *Augmented Active Control Exercise Program (AACEP) show promise in enhancing mobility, proprioception, muscular endurance, and reducing disability in patients with lumbar disc prolapse. By integrating motor control and neuromuscular training, AACE offers a comprehensive, evidence-based approach to spinal rehabilitation and may play a vital role in managing discogenic low back pain.*

Keywords: *Lumbar Disc Prolapse, Augmented Active Control Exercise Program, Proprioception, Muscular Endurance, Range of Motion, Oswestry Disability Index, Rehabilitation.*

1. INTRODUCTION

Intervertebral disc prolapse, commonly referred to as disc herniation, remains a significant contributor to lower back pain and disability worldwide, affecting individuals' quality of life and imposing a substantial socioeconomic burden (Foster et al., 2018). The condition arises when the nucleus pulposus breaches the annulus fibrosus, often resulting in nerve root compression, radiculopathy, and debilitating pain (Deyo & Weinstein, 2001). Deep trunk muscles, such as the transversus abdominis and multifidus, which play a critical role in maintaining spinal stability. Dysfunction of these muscles has been consistently associated with lumbar spine pathologies, including disc prolapse (Hodges & Richardson, 1996)

Traditional management strategies have ranged from conservative therapies — including pharmacological interventions, rest, and physical therapy — to surgical procedures in refractory cases. However, the optimal non-surgical rehabilitation approach continues to be an area of active investigation, particularly regarding the reestablishment of spinal stability and functional mobility (Luoma et al., 2000).

In response to these challenges, conservative management strategies have increasingly turned to exercise-based interventions. The underlying mechanism is primarily related to the restoration of proper muscle activation and alignment, thereby reducing mechanical stress on the spine and limiting further disc degeneration. Exercises such as lumbar stabilization exercises (Jeong et al., 2017), McKenzie therapy, and motor control exercises (Halliday et al., 2015) have demonstrated varying degrees of success in reducing pain and improving function. Therefore, this pilot study aims to explore the potential of augmented active control exercises as a management strategy for individuals with intervertebral disc prolapse. We hypothesize that incorporating augmented active control exercises into a standard rehabilitation program will result in significant improvements in pain, functional disability, and trunk muscle activation compared to traditional exercise approaches alone. The findings of this study will provide valuable insights into the feasibility, safety, and potential efficacy of augmented active control

exercises for individuals with disc prolapse, laying the groundwork for future randomized controlled trials and clinical implementation.

2. METHODOLOGY

A single-blinded randomized controlled trial received approval from the Institutional Ethical Committee of SGT University, Gurugram (Approval number: SGTU/FPHY/2023/329). The study was conducted at the Physiotherapy OPD Department of SGT Hospital between November 2024 and April 2025. The exercise protocol titled Augmented Active Control Exercise Program used in this study is an original work registered with the Indian Copyright Office under Registration Number: L-148816/2024, dated 05 June 2024. The study's objectives and procedures were thoroughly explained to eligible participants, and they provided written informed consent before enrolment.

2.1 Participants

The inclusion criteria for the study required participants to be 30–50 years old and diagnosed with chronic disc prolapse or low back pain, with or without radiculopathy at any lumbar level. Exclusion criteria included the presence of tumours, infections, tuberculosis, trauma affecting the pelvis or lower limb, uncontrolled mood disorders, metallic implants, recurrent disc herniation, recent analgesic drug use impacting pain perception, and progressive motor neurological deficits (e.g., bladder or bowel dysfunction, difficulty walking).

Eligible participants were randomly assigned to either the Augmented Active Control Exercise Programme or the Control Group. Baseline assessments were conducted for range of motion, proprioception, and endurance (both static and dynamic). Randomization was performed using sealed envelopes, and each participant independently selected their envelope. Additionally, they were instructed not to undergo any other treatment during the study period.

2.2 Outcome Measurements

Patient demographic information, including age, gender, body mass index (BMI), height, weight, and lumbar level involvement, was recorded. The precise levels and segments of herniated discs were identified using MRI findings. Participants who provided demographic details were required to complete the Oswestry Disability Index questionnaire. After finishing the exercise sessions, the same physiotherapist conducted follow-up physical evaluations, adhering to the original assessment procedures.

Joint repositioning is commonly employed to assess lumbar position sense and is categorized into active and passive methods. Absolute error (AE) is a crucial evaluation metric, representing the difference between the intended and actual angles. Lower AE values indicate improved joint position awareness and enhanced proprioception. AE is widely utilized for assessing joint position sense in clinical settings.

A goniometer is a standard tool frequently used by healthcare providers to measure joint angles during repositioning assessments. However, measurement protocols are not consistently standardized in clinical practice. For evaluating lumbar position sense, the examiner vertically positioned the goniometer at the designated lumbar region to assess the reduction angle. After familiarizing themselves with the target angle, participants completed three active lumbar repositioning trials from different positions, with AE recorded accordingly. A manual goniometer was used for these evaluations.

Lumbar range of motion (ROM) was assessed using an inclinometer with reference points at the T12 and S1 vertebrae. To evaluate lateral core muscle endurance, the side bridge test was conducted. Participants lay on their side with extended legs and a 90-degree flexed elbow, lifting their hips off the surface while maintaining stability on their forearm and toes. The duration was recorded in seconds, stopping when they could no longer hold a straight-body posture.

To assess dynamic endurance and trunk flexor strength, the sit-up test was performed. Participants completed trunk flexion movements while maintaining bent knees and stable feet, with the number of sit-ups recorded within a 30-second period.

The Oswestry Disability Index (ODI)—recognized as the gold standard for assessing functional impairment related to low back pain—was utilized to evaluate disability levels. The questionnaire consists of ten sections addressing different aspects of daily activity limitations.

2.3 Intervention Procedure

Participants in the experimental group engaged in 20-minute exercise sessions, conducted six times per week for six weeks. During the first two weeks, each exercise was repeated 10 times. In the following weeks, repetitions were reduced to five, while exercises from the initial weeks remained in the regimen. For instance, participants

in their fourth or fifth week would perform exercises assigned for weeks 0–2 and 4–5, but not those from weeks 2–3 or 3–4 (Table 1).

Table 1. Augmented Active Control Exercise Program (AACEP)**rogramme**

0-2 Weeks	**2-3 Weeks**	**3-4 Weeks**	**4-5 Weeks**	**5-6 Weeks**
Exercises will be given once a day & each exercise will be done with 10 reps each	**Exercises of 0-2 weeks will be continued along with the exercises of 2-3 week**	**Exercises of 0-2 weeks will be continued along with the exercises of 3-4 week**	**Exercises of 0-2 weeks will be continued along with the exercises of 4-5 week**	**Exercises of weeks 0-2 will be continued along with the exercises of 5-6 week**
Abdominal Bracing	Tripod Leg circles	Half kneeling Twist	Standing Twist on Bosu Ball – ½ kg Medicinal Ball	Tripod Leg swing
Lying side kicks	Single knee to chest isometric abdominal exercises	Medicine ball Slashes – ½ kg	Seated Twists	Forearm Plank
Crook back press	Single Knee Slide ups	Quadripod knee lift dynamic exercise	Standing Twist on Bosu Ball – ½ kg Medicinal Ball	Trunk Side rotation on Bosu ball
Side hunch	Fire Hydrants	Single knee to chest isometric abdominal exercises - Advance	Knee lunge stretch	Back extension on Bosu ball
Supine hip abduction with knee bends	Extended Slopes	Thera twirls- Yellow theraband	Resisted Angular twist (45^0, 90^0, 130^0)- Yellow theraband	Mould pattern
Sloping Position	Hump & Hollow Pose			Trunk Side flexion on Bosu ball
Supine Twirls	The Hundred			
	Exercises will be given once a day & each exercise will be done with 5 reps each	**Exercises will be given once a day & each exercise will be done with 5 reps each**	**Exercises will be given once a day & each exercise will be done with 5 reps each**	**Exercises will be given once a day & each exercise will be done with 5 reps each**

The Control Group performed conventional exercises without additional interventions. The experimental group followed the Augmented Active Control Exercise Programme , detailed in Table 1. Conventional exercises included back muscle stretching and strengthening, featuring movements such as:

- Spinal extension exercises (e.g., simple back extension, bird dog, prone spinal extension press-ups).
- Spinal flexion exercises (e.g., knee-to-chest stretch, lower back rotational stretch, pelvic tilt, bridge exercise, cat and camel stretch, lumbar crunches).

3. Statistical Analysis

The collected data were analyzed using descriptive and inferential statistics, utilizing the SPSS statistical package 25 for comprehensive evaluation. The variables used in the study were indicated by mean and standard deviation (Std Deviation).

3.1 Results

The study recruited 20 participants, evenly divided into two groups (Experimental Group & Control Group). Baseline demographic characteristics—including **age, height, weight, and BMI**—did not show statistically significant differences ($p > 0.05$), confirming that both groups were comparable before intervention. The absence of baseline discrepancies strengthens the validity of post-intervention findings.

Demographic characteristics of the Experimental and Control Group

	Group	**N**	**Mean**	**Std. Deviation**	**t**	**Sig. (2-tailed)**
Age (yrs)	Exp	10	40.40	5.44	-.283	.781
	Con	10	41.10	5.62	-.283	.781
Height (cms)	Exp	10	168.50	8.08	.000	1.000
	Con	10	168.50	8.08	.000	1.000
Weight (kg)	Exp	10	81.30	3.56	-.199	.844
	Con	10	81.60	3.16	-.199	.845
BMI (h/m^2)	Exp	10	28.70	2.03	-.173	.864
	Con	10	28.86	2.09	-.173	.864

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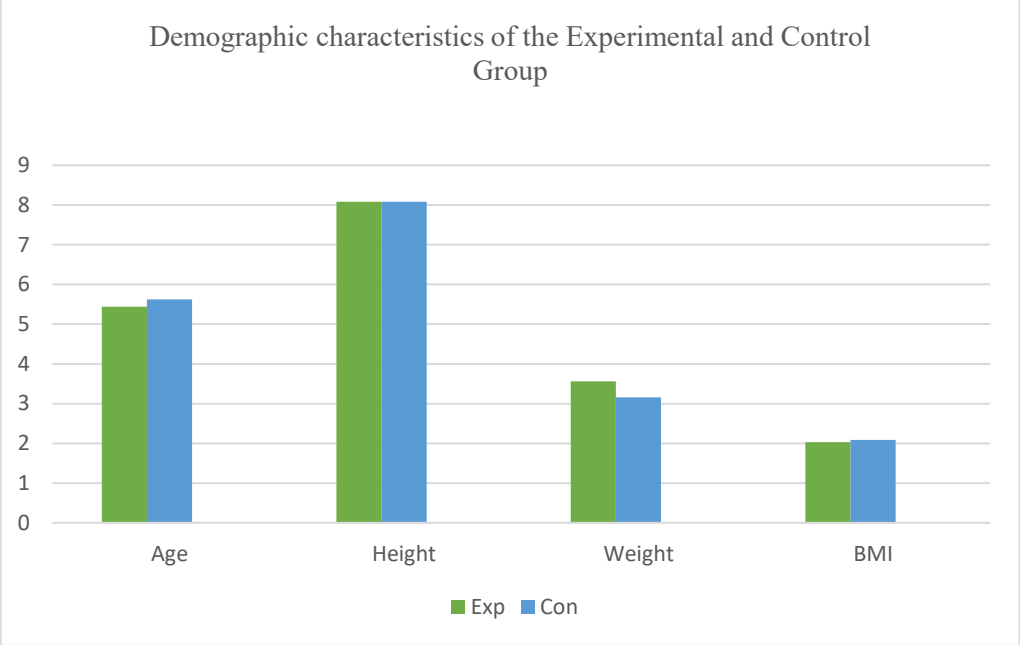

Figure 1. Demographic characteristics of the Experimental and Control Group

When the distribution according to the segments was examined in the Experimental group (n = 10), it was seen that level of involvement were L3-L4 in 1 participants, L4-L5 in 5 participants and L5-S1 in 5 participants. One of the participant had both L3–L4 and L5–S1 involvement, so both were counted. In the Control group (n = 10), the distribution was as follows L3-L4 in 1 participants, L4-L5 in 5 participants and L5-S1 in 5 participants. One of the participant had both L3–L4 and L5–S1 involvement, so both were counted in control group also.

Mean and standard deviation of Range of Motion, Proprioception and Endurance between the Experimental and Control Group

	Group	N	Mean	Std. Deviation	t	Sig. (2-tailed)
Flex Pre	Exp	10	38.0000	2.58199	-1.129	.274
	Con	10	39.9000	4.65355	-1.129	.278
Flex Post	Exp	10	46.5000	3.06413	2.721	.014*
	Con	10	42.6000	3.33999	2.721	.014*
Ext Pre	Exp	10	10.9000	1.66333	1.906	.073
	Con	10	12.5000	2.06828	1.906	.073
Ext Post	Exp	10	15.5000	1.84089	2.092	.051
	Con	10	13.0000	1.95789	-2.677	.015*
SF pre	Exp	10	21.0000	2.30940	4.339	.000***
	Con	10	13.0000	5.35413	4.339	.001
SF post	Exp	10	29.8000	2.61619	7.875	.000***
	Con	10	14.2000	5.69210	7.875	.000
Prop Pre	Exp	10	6.4000	.96609	.000	1.000
	Con	10	6.4000	.96609	.000	1.000
Prop Post	Exp	10	4.1000	.99443	-4.296	.000***
	Con	10	5.9000	.87560	-4.296	.000
End Pre	Exp	10	27.0000	3.85861	.000	1.000
	Con	10	27.0000	3.85861	.000	1.000
End Post	Exp	10	49.6000	7.22957	8.453	.000***
	Con	10	27.4000	4.08792	8.453	.000
Dend Pre	Exp	10	14.9000	2.13177	3.744	1.000
	Con	10	11.9000	1.37032	3.744	1.000
Dend Post	Exp	10	22.8000	3.08401	9.804	.000***
	Con	10	12.2000	1.47573	9.804	.000

Pre-Before Treatment, Post-After treatment, Flex-Flexion, Ext-Extension, SF-Side Flexion, Prop-Proprioception, End-Static Endurance, Dend-Dynamic Endurance, Exp-Experimental Group, Con-Control Group. *- Significant, **- Highly significant, ***- Very highly significant.

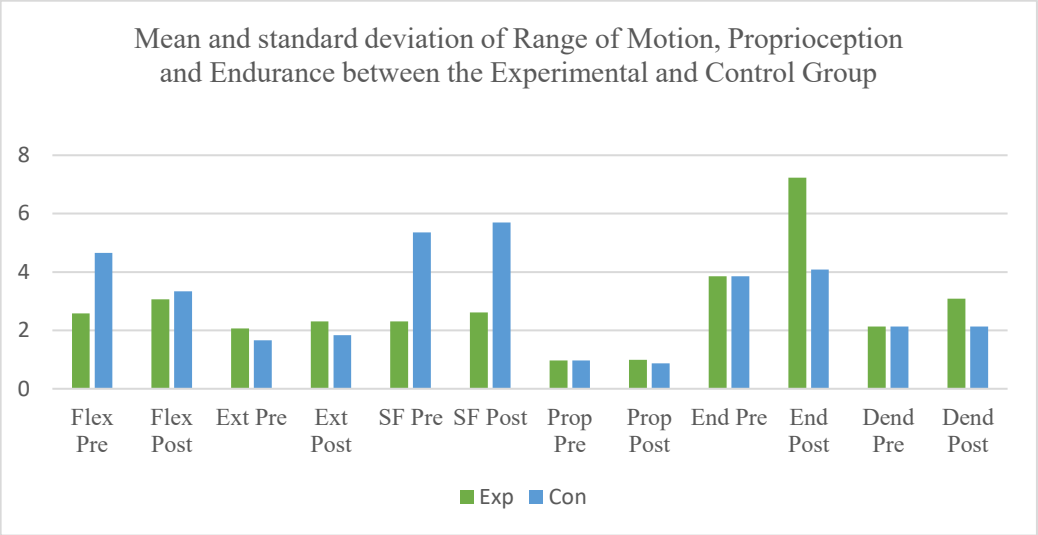

Figure 2. Mean and standard deviation of Range of Motion, Proprioception and Endurance between the Experimental and Control Group

Mean and standard deviation ODI between the Experimental and Control Group

	N	Mean	Std. Deviation
ODI Pre Exp	10	43.0000	4.96655
ODI Pre Con	10	43.0000	4.96655
ODI Post Exp	10	27.3000	5.37587
ODI Post Con	10	42.7000	5.07828

Pre-Before Treatment, Post-After treatment, ODI-Owestry Disability index, Exp-Experimental Group, Con-Control Group.

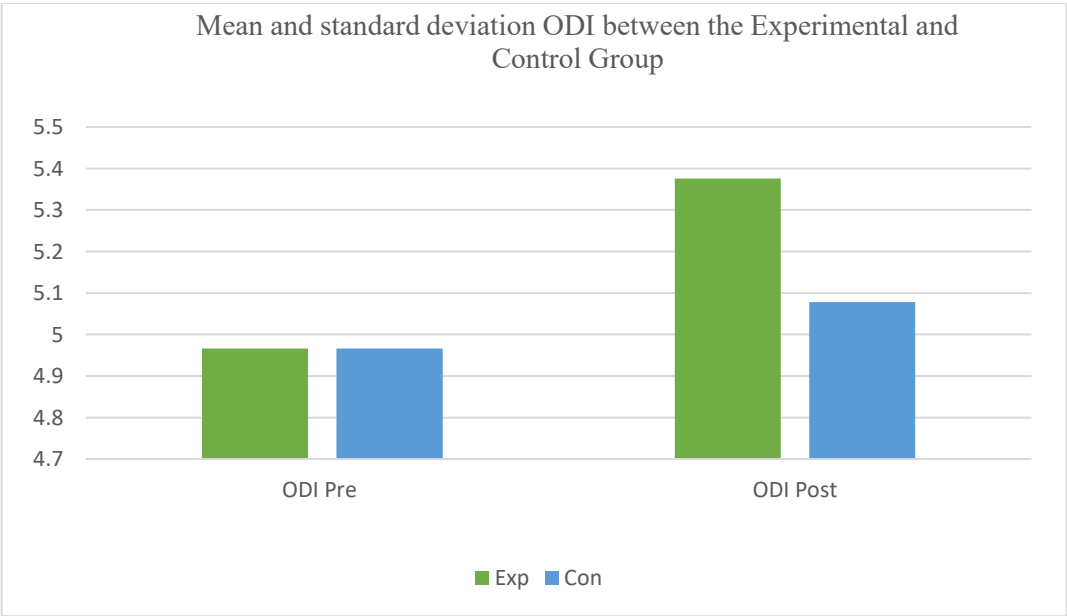

Figure 3. Mean and standard deviation ODI between the Experimental and Control Group

The results show comparisons between the experimental (Exp) and control (Con) groups across various measures, both before (Pre) and after (Post) an intervention. The mean pre-intervention spinal flexion was 38.00° (SD = 2.58) for the experimental group and 39.90° (SD = 4.65) for the control group. The difference was not statistically significant, indicating a comparable baseline between the groups. Post-intervention, the experimental group showed a significant increase in flexion to 46.50° (SD = 3.06), whereas the control group improved to 42.60° (SD = 3.34). The between-group difference was significant (t = 2.721, p = .014), suggesting the intervention had a notable effect on lumbar flexion mobility. Pre-intervention extension was 10.90° (SD = 1.66) for the experimental group and 12.50° (SD = 2.06) for the control group. The difference was not statistically significant, indicating a comparable baseline between the groups. After the intervention, the experimental group's extension slightly improved to 13.00° (SD = 2.31), while the control group rose significantly to 15.50° (SD = 1.84). Though the mean difference approached significance, suggesting borderline significance and the intervention may have enhanced extension ability. The side flexion outcome demonstrated substantial between-group differences. The experimental group had a significantly higher baseline 21.00° (SD = 2.31) compared to the control group 13.00° (SD = 5.35). This discrepancy persisted and expanded post-intervention, with the experimental group achieving a mean of 29.80° (SD = 2.62), compared to 14.20° (SD = 5.69) in the control group thereby suggesting a significant difference between the pre and the post invention values of experimental group. Pre-intervention proprioception measures were identical between groups with a mean of 6.40 (SD = 0.97), indicating perfect baseline parity. After the intervention, the experimental group improved to 4.10 (SD = .99) (lower scores possibly reflecting better proprioceptive accuracy), whereas the control group regressed to 5.90 (SD = .87). The intervention group showed a strong improvement in experimental group. Static endurance showed no baseline differences between the groups with mean of 27.00 (SD = 3.86). However, post-intervention, the experimental group demonstrated a dramatic improvement to 49.60 (SD = 7.23), while the control group remained virtually unchanged at 27.40 (SD = 4.08). Initial dynamic endurance scores favored the experimental group with a mean of 14.90 (SD = 2.13) in experimental group and with a mean of 11.90 (SD = 1.37) in control group. Post-intervention, the experimental group improved to 22.80 (SD = 3.08), while the control group showed minimal change (12.20, SD = 1.48). Showed significant gain post intervention in experimental group. The results revealed a marked reduction in disability among participants who received AACE. The experimental group's ODI decreased from a pre-intervention mean of 43.00 (SD = 4.96) to 27.30 (SD = 5.38) post-intervention, indicating a substantial improvement in functional capacity. In contrast, the control group, which likely received conventional physiotherapy or standard care, showed negligible change, with post-intervention ODI remaining virtually unchanged (43.00 to 42.70, SD = ~5.0). These results provide compelling evidence of the effectiveness of AACE in reducing disability in individuals with disc prolapse.

DISCUSSION

This study aimed to evaluate the efficacy of a targeted intervention—presumably augmented active control exercises—on spinal range of motion (ROM), proprioception, and endurance in individuals with mechanical or discogenic low back pain. The results were analyzed using independent sample t-tests comparing the experimental (Exp) and control (Con) groups pre- and post-intervention across several key outcome measures: flexion (Flex), extension (Ext), side flexion (SF), proprioception (Prop), static endurance (End), and dynamic endurance (Dend). The findings reveal several statistically significant improvements in the experimental group, highlighting the potential benefits of the intervention.

Range of Motion (ROM)

Post-intervention analysis revealed a statistically significant increase in lumbar ROM, indicating that AACEP positively impacted the flexibility and mobility of the lumbar spine. Limited spinal mobility is a hallmark of disc prolapse due to pain, muscle guarding, and stiffness (Waddell, 2004). By facilitating dynamic spinal movement and engaging core musculature actively, AACEP may reduce mechanical stiffness and pain-induced guarding, thus promoting enhanced ROM. These findings align with the work of Akuthota and Nadler (2004), who emphasized the role of active spinal control exercises in restoring segmental mobility in individuals with low back pain. McGill (2001) emphasized the importance of spine-sparing strategies and motor control in restoring functional movement. Similarly, O'Sullivan (2000) highlighted that segmental instability—common in disc pathology—could be addressed by retraining deep stabilizing muscles such as the multifidus and transversus abdominis.

Proprioception

Proprioception, assessed through joint position sense, showed marked improvement post-intervention. Impaired proprioception is commonly observed in individuals with disc-related back pain due to disrupted afferent input from spinal structures (Brumagne et al., 2000). The augmented nature of AACEP, which requires conscious motor control and precise movement execution, likely stimulated neural pathways associated with proprioceptive function. The repeated active engagement of the stabilizing muscles improves sensorimotor control, a finding that has been supported by prior research emphasizing proprioceptive training in spinal rehabilitation (Tsao & Hodges, 2008). Moreover the improvement also aligns with findings from Riemann and Lephart (2002), who emphasized that proprioceptive retraining enhances joint position sense, muscle coordination, and reflex control. AACEP likely involves balance and perturbation elements that stimulate mechanoreceptors and reinforce the neural pathways responsible for lumbar stability.

Improved proprioception not only facilitates better movement control but also reduces the likelihood of maladaptive postures and compensatory strategies that can exacerbate disc pathology. Therefore, integrating proprioceptive tasks into rehabilitation appears to be essential, especially for populations with chronic or recurrent low back pain.

Static and Dynamic Endurance

Both static and dynamic muscular endurance of the lumbar spine improved significantly following the intervention. Static endurance is essential for maintaining postural alignment, while dynamic endurance supports repetitive spinal movement during functional tasks. Low endurance of the deep spinal muscles, particularly the multifidus, is closely linked to recurrent low back pain and spinal instability (Hides et al., 2001). AACEP protocols emphasize sustained and controlled activation of spinal stabilizers, contributing to enhanced muscle performance. This is consistent with findings by McGill (2001), who noted that endurance training of trunk musculature is more relevant than maximal strength training in individuals with spinal disorders. Notably this reflects the findings of Kavcic et al. (2004), who demonstrated that core stabilization exercises effectively increase the endurance of spinal musculature without overloading passive structures. Endurance, as opposed to peak strength, is often more important in preventing spinal fatigue and maintaining posture during functional tasks.

Hodges and Richardson (1999) proposed that individuals with low back pain exhibit delayed activation of deep stabilizing muscles. AACEP likely addresses this neuromuscular deficit by re-educating the motor patterns required for sustained contractions, thereby enhancing both static and dynamic performance.

The improvement in dynamic endurance suggests that AACEP facilitated better neuromuscular coordination, allowing participants to perform repeated functional movements with reduced fatigue. This is particularly relevant in disc prolapse patients, where fatigue of stabilizing musculature can exacerbate symptoms and compromise spinal integrity.

Oswestry Disability Index (ODI)

A significant reduction in ODI scores was observed post-intervention, indicating a decrease in perceived disability and improved functional status. The ODI is a validated tool for quantifying the impact of low back pain on daily living (Fairbank & Pynsent, 2000). The results revealed a marked reduction in disability among participants who received AACEP. The ODI is a ten-item questionnaire assessing the impact of back pain on daily activities such as personal care, lifting, walking, sitting, standing, sleeping, sex life, social life, and traveling. A pre-intervention ODI score of 43% places the participants in the “severe disability” category. After the intervention, the experimental group's score dropped by approximately 15.7 points, shifting them closer to the “moderate disability” range (21–40%) or lower—highlighting meaningful clinical improvement.

This improvement in the experimental group suggests that AACEP effectively targets not just symptom management but also restores function, allowing individuals to better engage in daily tasks with less limitation. The unchanged scores in the control group may indicate that standard physiotherapy modalities, while potentially reducing pain, might be less effective in enhancing functional independence unless specifically designed to address neuromuscular control and postural stability.

AACEP fosters improved spinal control during function, leading to reduced pain-related avoidance behaviours and greater engagement in daily life, thereby lowering disability scores on the ODI.

The multidimensional improvement in mobility, proprioception, and endurance likely contributed to participants’ enhanced ability to perform activities of daily living with less discomfort. These findings support the integration of motor control-based interventions in managing chronic back disorders, as previously

demonstrated by Ferreira et al. (2006), who reported significant ODI improvements in patients undergoing motor control exercise programs.

Clinical Significance

The difference in outcomes between the experimental and control groups highlights several important clinical implications:

1. Targeted, Task-Specific Training Works Better: AACEP, by virtue of its specificity to spinal stability and control, addresses the underlying dysfunction rather than just symptoms.
2. Greater Disability Reduction = Improved Quality of Life: Lower ODI scores translate into greater independence, reduced need for medical visits, and improved work participation.
3. Early Intervention Can Prevent Chronicity: Implementing AACEP early in rehabilitation could prevent the progression to chronic disability, which is often harder to treat.

Strengths of the Intervention

- Functional Relevance: AACEP is task-oriented, training patients to stabilize and control their spine in various postures and movements that mirror real-life demands.
- Neurosensory Engagement: It incorporates proprioceptive and cognitive engagement, which is often missing in traditional exercise protocols.
- Adaptability: It can be customized based on pain levels, movement capabilities, and progression needs.

Limitations and Future Directions

While the results are promising, a few limitations must be considered:

- Sample Size: The study included only 10 participants per group, which limits the statistical power and generalizability.
- Short-Term Follow-Up: The post-intervention assessment appears to be immediate. It remains unknown whether the improvements in ODI would sustain over time.

Future studies should:

- Include larger, randomized controlled trials.
- Investigate long-term effects of AACEP on recurrence rates and quality of life.
- Compare AACE with other interventions such as Pilates, McKenzie therapy, or manual therapy approaches.

CONCLUSION

In conclusion, Augmented Active Control Exercise Program demonstrate significant potential in improving key clinical and functional outcomes in patients with lumbar disc prolapse. Not only do they enhance mobility, proprioception, and muscular endurance, but they also have the potential to reduce disability and improve overall quality of life. By integrating targeted motor control, neuromuscular re-education, and endurance training, AACEP represents a comprehensive and evidence-informed approach to spinal rehabilitation. As the burden of discogenic low back pain continues to rise, such targeted interventions could play a pivotal role in clinical management and preventive care.

Author contributions: Study conception and design Material preparation, data collection were performed by Dr. Snigdha Tiwari. Data analysis was done by Dr. Siddhartha Sen & Dr. Brahma Kumar Tiwari. The first draft of the manuscript was written by Dr. Snigdha Tiwari. All authors read and approved the final manuscript.

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The authors declare no relevant affiliations or financial relationships with any organization or entity that could be perceived as a conflict of interest concerning the subject matter or materials presented in this manuscript. This includes, but is not limited to, employment, consultancy roles, honoraria, stock ownership or options, expert witness engagements, grants or patents (granted or pending), or royalty arrangements. Additionally, no external writing assistance was employed in the preparation of this manuscript.

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