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A Physiotherapy-Based Analytical Study on Spinal Pain Syndromes: Integrating Core Stabilization, Cervical Mobility Training and Functional Rehabilitation for Low Back Pain and Cervical Spondylosis

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Abstract:

- ***Background:***

Recommendations of exercise for chronic spinal pain are contentious due to variances in exercise program specificity, progression, and functional transfer. The purpose of this research was to evaluate an integrated physiotherapy model for chronic low back pain and mechanical neck pain due to cervical spondylosis, which involves core stabilization, cervical mobility and motor-control training, graded functional rehabilitation, and self-management education. This dataset represented 100 patients coming for rehabilitation in Viklang Bhawan Hospital, B.C.P.O., Patna Medical College and Hospital, Bihar & V-Care Physiotherapy Clinic and Rehabilitation Centre, split equally in 4 groups, LBP-integrated, LBP-conventional, cervical-integrated, and cervical-conventional. Evaluation criteria consisted of baseline pain and pain after 4 and 8 weeks, disability, range of motion, endurance, fear avoidance, and compliance, along with a clinically significant response. Analysis was done using linear mixed modeling along with paired comparisons, baseline-adjusted regression, and logistic regression. Integrated rehabilitation resulted in a greater average pain reduction of 3.9, compared to 2.0, with conventional physiotherapy, and greater average improvement in disability of 28.6, compared to 15.9, percent. Enhanced range of motion and endurance were greater in the integrated groups. Compliance significantly correlated to disability improvement (r = 0.76), and greater odds to be classified as a responder were seen in the integrated groups. The pattern of analysis was in favor of a rehabilitation approach that is active, progressive, and function oriented.

Keywords: *Chronic Low Back Pain; Cervical Spondylosis; Core Stabilization; Deep Cervical Flexors; Functional Rehabilitation; Physiotherapy.*

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I. INTRODUCTION

Back and neck pain account for a large percentage of all categories of disabilities. Global Models project growing numbers for the burden of low back pain as the population increases and ages (GBD 2021 Low Back Pain Collaborators, 2022; World Health Organization, 2022). In most cases, chronic pain cannot be attributed to a single lesion. Low back pain is often multifactorial and may be chronic and complex. Symptoms may also be affected by the capacity and confidence to move and perform tasks, sleep, work, and psychosocial factors and prior pain episodes. While age-related changes may lead to degeneration of the cervical spine, pain may not correlate with the degenerative changes seen in radiographs. Therefore, physiotherapy should not be imaging based.

Current recommendations for chronic primary low back pain advocate education, keeping active, exercising, and tailored conservative treatment (George et al., 2021; World Health Organization, 2022). The average benefits of exercise for chronic primary low back pain are often marginal, and the

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choice of exercise is likely to be of little importance (Cashin et al., 2025; Hayden et al., 2021). When included in a more comprehensive program, motor-control and stabilization exercises may promote confidence and engagement in valued activities. Similar to neck pain, there are a number of different ways that may help, including thoracic mobility, deep cervical flexor training, scapular control, cervical range of motion practice, and modifications based on workplace ergonomics (Alghadir et al., 2021; Iqbal et al., 2021; Kacar et al., 2024).

This study creates a model for an integrated program targeting two spinal pain syndromes. The low-back program focuses on trunk motor control, hip strengthening, graded lifting and functional tolerance. The cervical program focuses on the activation of the deep cervical flexors, cervical and thoracic mobility, scapular stabilization, postural endurance, and work-related activities. The low and upper cervical programs are integrated in the same manner, and include education, graded exposure, home practice, and a progression from controlled exercises to meaningful tasks.

➢ *Aims, Objectives, and Hypotheses*

The aim was to compare the functional integration of physiotherapy with conventional physiotherapy in relation to pain, disability, mobility, and endurance, and the fear-avoidance model, as well as the clinically significant recovery of patients with chronic low back pain (LBP), and neck pain associated with cervical spondylosis.

- Analyze pain trajectories over an eight-week period.
- Describe the disability reduction of each spinal condition.
- Describe changes in the spinal range of motion and endurance of the postural (core) muscles.
- Describe the relationship between adherence and the fear-avoidance model, and their impact on functional recovery.
- Describe the adjusted baseline severity.

II. MATERIALS AND METHODS

➢ *Design and Participants*

This study comprises of four-group pre–mid–post design, with a sample of 100 adults coming for rehabilitation in Viklang Bhawan Hospital, B.C.P.O., Patna Medical College and Hospital, Bihar & V-Care Physiotherapy Clinic and Rehabilitation Centre between the ages of 25 and 65. Each group contained 25 participants and was comprised of chronic nonspecific low back pain integrated, low back pain conventional, cervical spondylosis integrated, and cervical spondylosis conventional. In this study, participants' symptoms must have been present for a minimum of three months. Modeled exclusions for participants included red-flag pathology, progressive loss of function or a neurological deficit, recent spinal surgery, fractures, a chronic inflammatory disease, malignancy, or the participant would be unable to take part in the study safely.

To demonstrate the methods while keeping comparisons balanced, a sample size of 25 per cell was chosen to represent limited group-by-time effects.

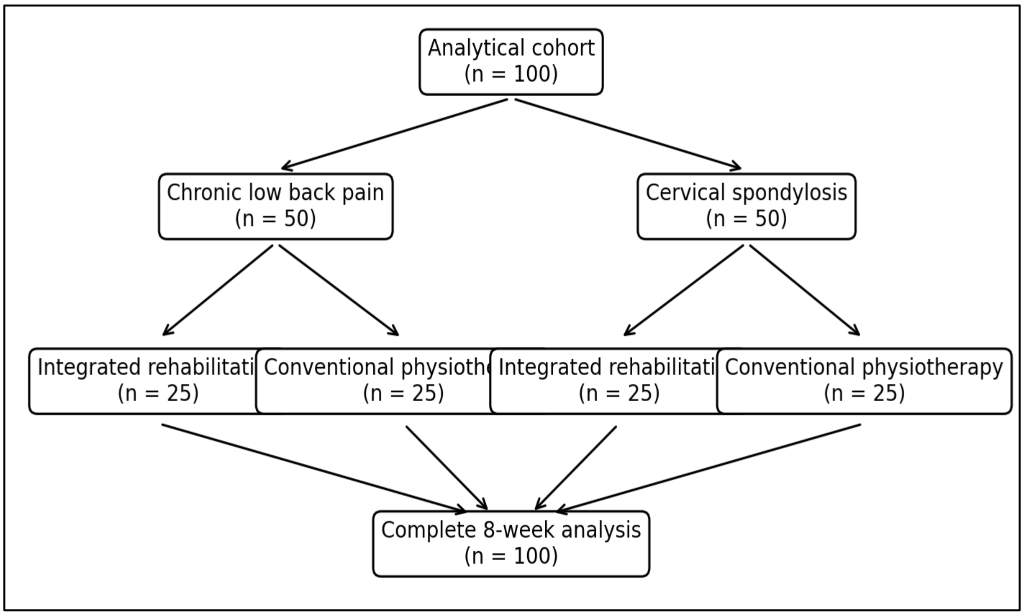

Fig 1 Allocation of Analytical Participants by Condition and Treatment.

➢ *Integrated Low-Back Programme*

The LBP programme comprised abdominal drawing-in, multifidus activation, pelvic control, bridging, bird-dog progression, side support, hip abductor/extensor strengthening, mobility, graded lifting/bending, walking or aerobic exercises, and ergonomic education. Exercise progressed from low-load motor control to endurance, resistance, speed, and task-specific work. Pain was monitored, though tolerable and temporary symptoms were not considered grounds to stop progression in the absence of red flags.

➢ *Integrated Cervical Programme*

The cervical programme was made up of cranio-cervical flexion, deep cervical flexor endurance, cervical isometrics, active mobility, scapular retraction/upward-

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rotation, thoracic extension/rotation, pectoral flexibility, graded reaching, and work-simulation tasks. Visual or pressure biofeedback were conceptualized to assist motor learning. Ergonomic retraining emphasized variation and movement breaks, along with the repositioning and relifting of the monitor, as opposed to an inflexible ideal posture.

➢ *Conventional Physiotherapy*

Conventional treatment consisted of general mobility, stretching, the application of superficial heat or electrotherapy as needed, non-progressive strengthening, and general advice. It continued to be an active comparator, though did not employ a structured progression algorithm to link motor control, endurance, graded exposure, and functional tasks.

➢ *Outcome Measures*

Pain was assessed and scaled from 0 to 10, with 0 representing no pain. The assessment of disability was given as a 0 to 100 percent score in alignment with the Oswestry Disability Index for LBP and the Neck Disability Index. Greater scores indicated higher impairment. Condition-related spinal range of motion and assessed muscle endurance were recorded in degrees and seconds, respectively. The fear-avoidance scale ranged from 0 to 70. In this model, a multidomain responder had to achieve a minimum 2.5-point decrease in pain and a 10-point decrease in disability.

➢ *Statistical Analysis*

At the participant level, a random-intercept mixed model was run to assess pain at the baseline, and at weeks 4 and 8, with fixed effects for time, treatment, condition, their interactions, and age. The adjusted baseline model was run to estimate the effect of treatment on pain, disability, and the endurance and range of motion. Within-group changes were assessed using paired t tests. Pearson correlations were used to assess adherence, fear-avoidance, and physical outcomes. Multiple linear regression analyzed the improvement of disability, and logistic regression assessed the probability of being a responder. The magnitude of effects with 95% CIs were of primary importance.

III. RESULTS

➢ *Baseline Characteristics*

The analytical cohort had a mean age of 44.2 years and mean BMI of 26.8 kg/m². Desk-based work was the most frequent occupational category. Mean symptom duration was 14.5 months. Baseline pain and disability were comparable across treatment arms within each condition.

Table 1 Group Profile and Outcome Changes

Group	**n**	**Age**	**BMI**	**Pain_Pre**	**Pain_Mid**	**Pain_Post**	**Pain_Change**	**Disability_Change**	**ROM_Change**	**Endurance_Change**	**Fear_Change**	**Adherence**	**Responder**
Cervical Spondylosis-Conventional	25	45.94	27.07	6.53	5.66	4.81	1.72	15.67	8.13	11.97	6.72	74.32	12.00
Cervical Spondylosis-Integrated	25	48.49	26.49	6.98	5.28	3.33	3.65	27.35	16.67	23.83	15.62	88.56	92.00
Low Back Pain-Conventional	25	41.17	25.63	7.14	6.02	4.95	2.19	16.04	6.57	18.19	8.67	76.22	28.00
Low Back Pain-Integrated	25	41.13	27.94	6.89	4.99	2.81	4.09	29.79	14.15	30.28	15.82	90.35	100.00

Note. Pain and disability change are reductions; ROM and endurance change are gains. Responder: pain reduction ≥2.5 and disability reduction ≥10.

➢ *Pain Trajectory*

Pain declined in all groups by week 4 and continued to decline by week 8. Integrated groups demonstrated a steeper trajectory. The mixed model supported a time-by-treatment effect, indicating that the integrated programme accelerated improvement beyond the change observed with conventional physiotherapy. The direction was similar for LBP and cervical pain, although absolute gains varied modestly by condition.

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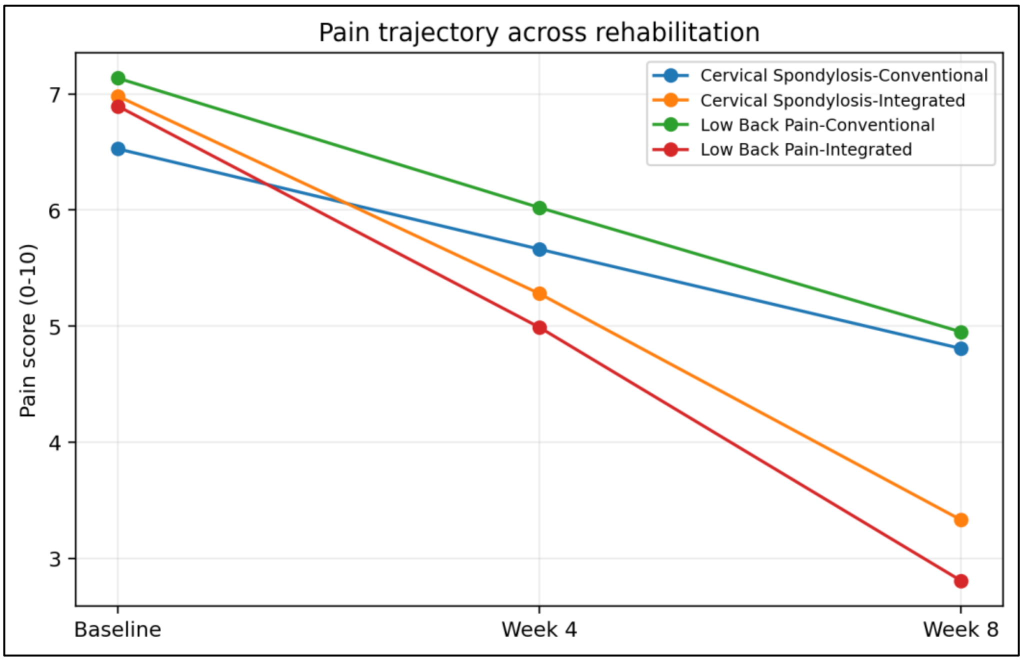

Fig 2 Mean Pain Trajectory from Baseline to Week 8.

- *Disability, Mobility, and Endurance*

Integrated rehabilitation reduced disability by 28.6 percentage points compared with 15.9 under conventional care. Range-of-motion gains averaged 15.4° versus 7.3°, and endurance gains averaged 27.1 versus 15.1 seconds. These results indicate a broader functional response than pain reduction alone.

Table 2 Within-Group Changes in Pain, Disability, Mobility, and Endurance

Group	Outcome	Pre Mean ± SD	Post Mean ± SD	Mean Improvement	95% CI Low	95% CI High	Paired t	p
Cervical Spondylosis-Conventional	Pain	6.5 ± 1.0	4.8 ± 1.3	1.72	1.41	2.03	11.59	<.001
Cervical Spondylosis-Conventional	Disability	38.8 ± 8.2	23.1 ± 8.5	15.67	14.20	17.13	22.06	<.001
Cervical Spondylosis-Conventional	ROM	45.9 ± 7.9	54.0 ± 8.6	8.13	6.70	9.55	11.78	<.001
Cervical Spondylosis-Conventional	Endurance	25.5 ± 5.5	37.5 ± 7.5	11.97	10.20	13.74	13.95	<.001
Cervical Spondylosis-Integrated	Pain	7.0 ± 0.9	3.3 ± 1.3	3.65	3.30	4.00	21.70	<.001
Cervical Spondylosis-Integrated	Disability	39.6 ± 7.0	12.3 ± 7.0	27.35	26.17	28.53	47.84	<.001
Cervical Spondylosis-Integrated	ROM	45.4 ± 8.5	62.0 ± 8.6	16.67	15.69	17.65	35.14	<.001
Cervical Spondylosis-Integrated	Endurance	26.8 ± 8.0	50.6 ± 9.0	23.83	21.99	25.68	26.69	<.001
Low Back Pain-Conventional	Pain	7.1 ± 0.9	5.0 ± 1.0	2.19	1.92	2.45	17.29	<.001
Low Back Pain-Conventional	Disability	41.9 ± 8.8	25.8 ± 10.2	16.04	14.42	17.65	20.51	<.001
Low Back Pain-Conventional	ROM	40.7 ± 8.5	47.3 ± 8.6	6.57	5.38	7.76	11.40	<.001
Low Back Pain-Conventional	Endurance	41.3 ± 8.6	59.5 ± 8.1	18.19	16.20	20.17	18.88	<.001
Low Back Pain-Integrated	Pain	6.9 ± 1.0	2.8 ± 1.3	4.09	3.78	4.40	27.33	<.001
Low Back Pain-Integrated	Disability	40.2 ± 6.3	10.4 ± 6.4	29.79	28.41	31.16	44.62	<.001

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Low Back Pain-Integrated	ROM	40.0 ± 8.4	54.1 ± 9.3	14.15	12.94	15.37	24.08	<.001
Low Back Pain-Integrated	Endurance	41.7 ± 8.2	71.9 ± 9.2	30.28	28.59	31.97	37.01	<.001

Note. Mean improvement is coded so that positive values are beneficial.

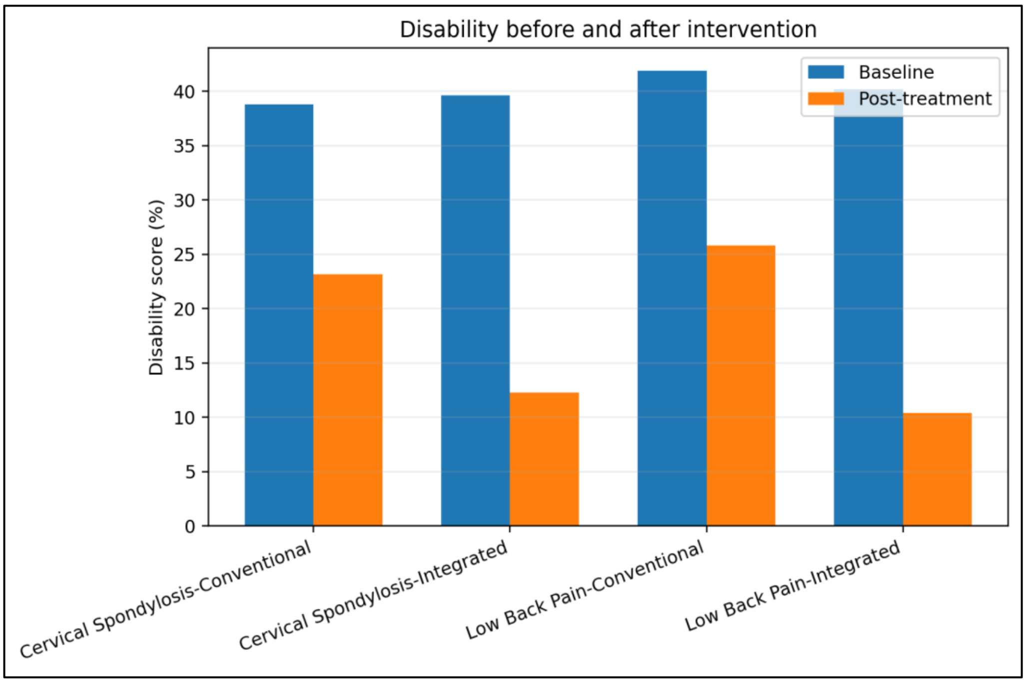

Fig 3 Disability before and After Treatment.

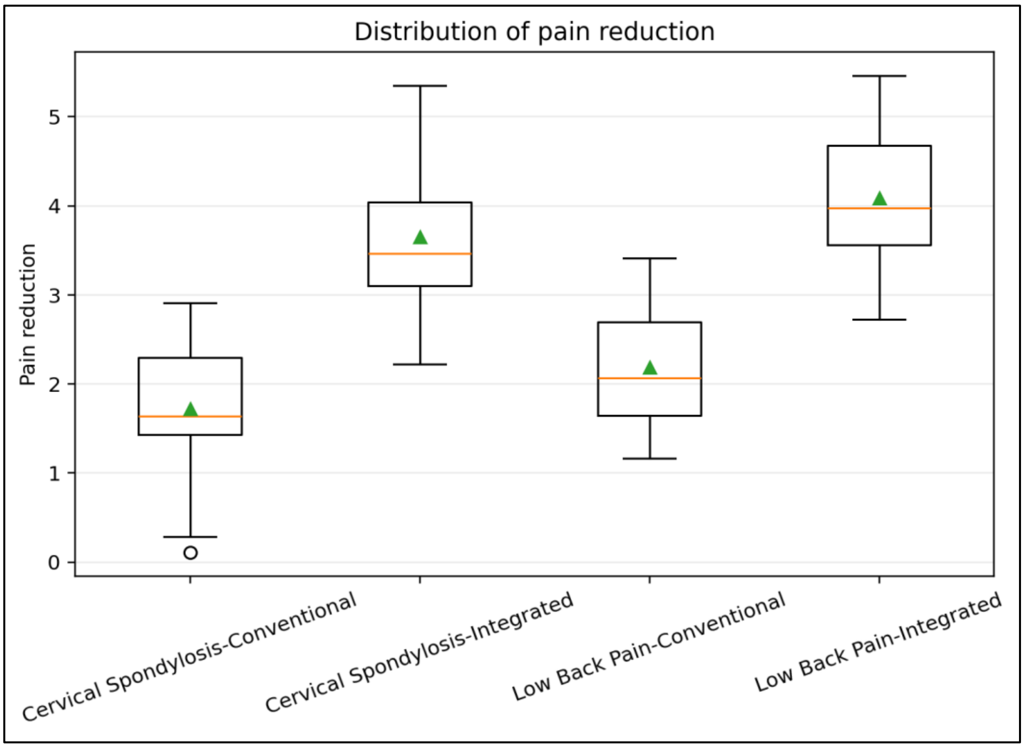

Fig 4 Distribution of Pain Reduction.

➢ *Adjusted Treatment Effects*

After adjustment for baseline status, age, BMI, adherence, and spinal condition, integrated treatment retained beneficial effects on pain, disability, range of motion, and endurance. The largest standardized clinical separation occurred for disability and endurance, consistent with the programme's emphasis on functional loading and progression rather than symptom-modality dependence.

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Table 3 Baseline-Adjusted Effects of Integrated Rehabilitation

Outcome	Adjusted Integrated Benefit	95% CI Low	95% CI High	p	Adjusted R^2
Pain	1.38	0.91	1.84	<.001	0.80
Disability	8.66	6.67	10.65	<.001	0.92
ROM	7.49	5.58	9.40	<.001	0.92
Endurance	8.79	6.10	11.49	<.001	0.93

Note. Positive benefit values favor integrated rehabilitation.

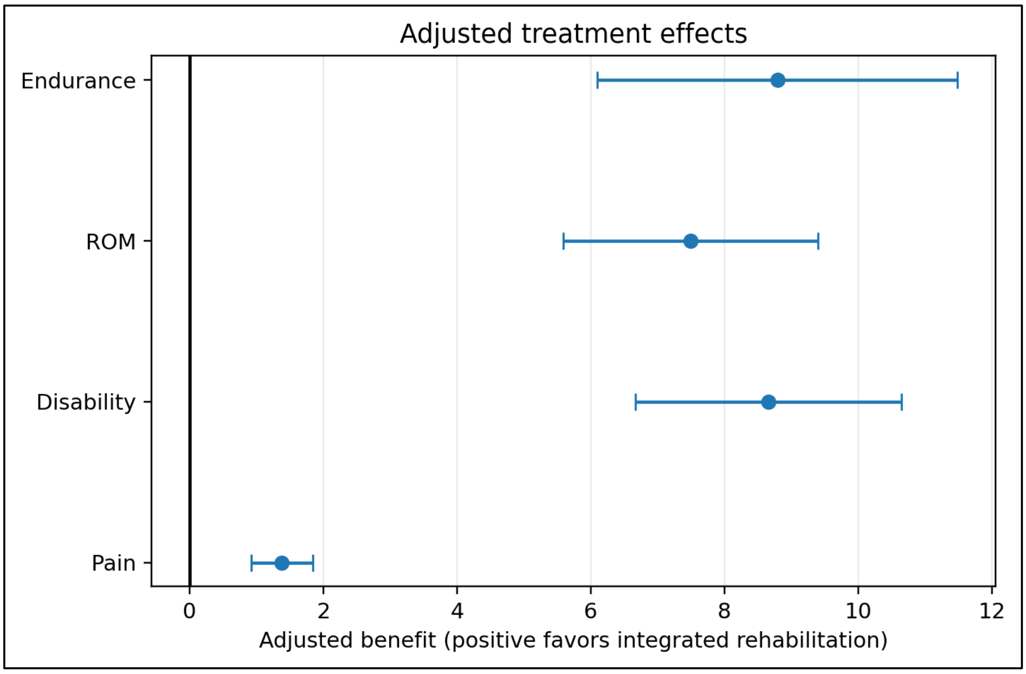

Fig 5 Adjusted Treatment Effects with 95% Confidence Intervals.

- *Correlates and Predictors of Recovery*

Adherence correlated with disability improvement (r = 0.76). Pain reduction, fear-avoidance reduction, range-of-motion gain, and endurance gain each showed positive relationships with disability change. In multivariable regression, pain change (B = 2.49), fear-avoidance change (B = 0.21), and endurance gain (B = 0.05) contributed to functional improvement. Logistic regression indicated higher responder odds under integrated treatment after baseline adjustment.

Table 4 Correlation Matrix for Clinical Improvement and Adherence

Variable	Pain_Change	Disability_Change	ROM_Change	Endurance_Change	Fear_Change	Adherence
Pain_Change	1.00	0.86	0.66	0.73	0.68	0.72
Disability_Change	0.86	1.00	0.75	0.72	0.73	0.76
ROM_Change	0.66	0.75	1.00	0.54	0.59	0.60
Endurance_Change	0.73	0.72	0.54	1.00	0.62	0.69
Fear_Change	0.68	0.73	0.59	0.62	1.00	0.59
Adherence	0.72	0.76	0.60	0.69	0.59	1.00

Table 5 Predictors of Disability Improvement

Predictor	B	SE	t	p
Intercept	-2.44	2.87	-0.85	0.400
C(Condition)[T.Low Back Pain]	0.21	0.80	0.26	0.790
Pain_Change	2.49	0.46	5.46	<.001
ROM_Change	0.34	0.10	3.54	<.001
Endurance_Change	0.05	0.07	0.73	0.470
Fear_Change	0.21	0.08	2.59	0.010
Adherence	0.12	0.05	2.63	0.010

Table 6 Logistic Regression for Clinically Meaningful Response

Predictor	Log Odds	Odds Ratio	OR 95% CI Low	OR 95% CI High	p
C(Therapy)[T.Integrated]	3.68	39.60	6.24	251.20	<.001
C(Condition)[T.Low Back Pain]	1.23	3.41	0.71	16.36	0.130
Pain_Pre	0.26	1.30	0.61	2.74	0.500
Disability_Pre	0.04	1.04	0.95	1.13	0.380
Adherence	0.16	1.17	1.04	1.32	0.010

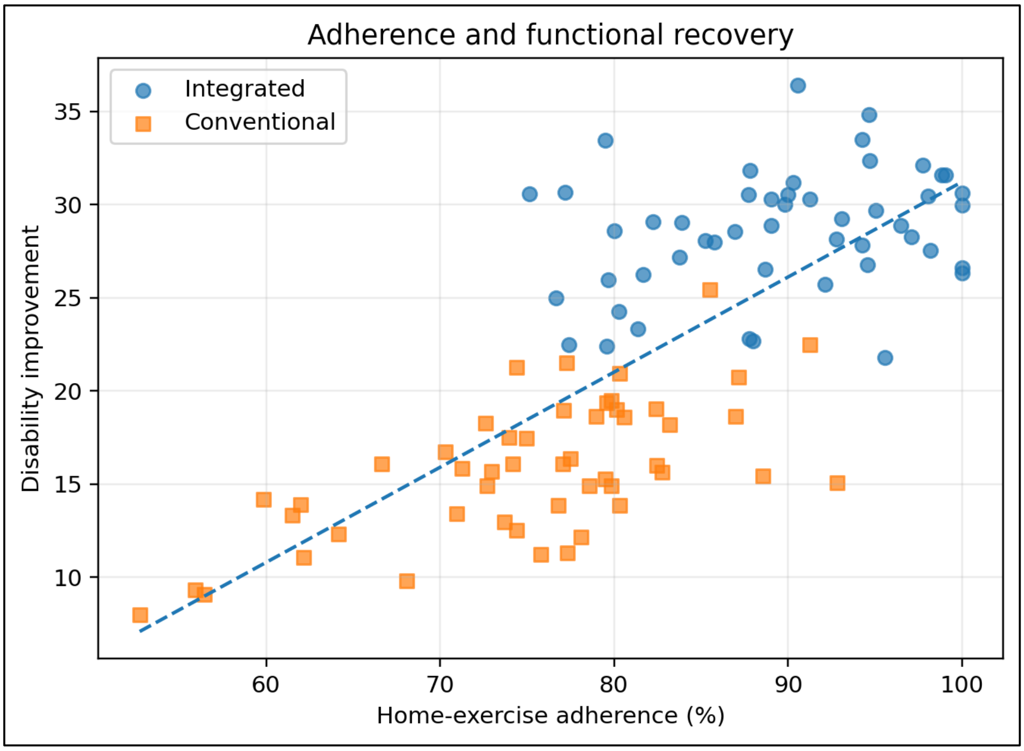

Fig 6 Association between Adherence and Disability Improvement.

➢ *Analgesic Use and Safety*

The usage of analgesics was reduced or stopped for 52% of the patients. No adverse events were reported for 93% of the patients. The rest reported transient soreness or a temporary symptom flare.

IV. DISCUSSIONS

The integrated program produced a multidimensional response related to the reduction of chronic pain, the improvement of disability, and the response to the improvement of mobility and endurance. It also had an effect on fear avoidance and responder status. This response pattern correlates with the advice provided regarding chronic spinal pain management. The suggestion is for active, individualized, non-surgical, and non-passive intervention (George et al., 2021; World Health Organization, 2023). Passive modalities may provide temporary symptom relief; however, durable recovery generally requires the restoration of confidence and the ability to self-manage.

For chronic LBP, core stabilization was thought to be one part of exercise therapy rather than an overarching technique. Motor-control exercises should be aimed at patients with poor control, low endurance and less apprehensive movement. The current model linked trunk activation with hip strength and lifting as well as walking and task performance. This may explain why the effects on disability and endurance were greater than the pain effect alone.

For cervical spondylosis-associated mechanical pain, deep cervical flexor training improves endurance and motor control, especially when feedback is provided (Alghadir et al., 2021; Iqbal et al., 2021). Including scapular and thoracic region exercises addresses upper-quarter function and load distribution. When range restricts the ability to complete a task, mobility training addresses the restriction. Not all patients require aggressive end-range techniques.

From an adherence perspective, the dose of self-management is important. The outcome is not affected by the technically correct exercise if it is not performed. Adherence is a result of setting realistic and relevant goals for the patient, slow progression, and regular monitoring, along with instruction and support to explain likely alterations in symptoms. The task of graded exposure is associated with the decline of fear-avoidance, and suggests psychological and functional alterations are integrated to the recovery process, and are not an external addition to the recovery process.

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Offering similar benefits to both the lumbar and cervical regions reinforces the principle of rehabilitation. Active participation, education, and the integration of functionality are essential elements of rehabilitation (George et al., 2021; World Health Organization, 2023). However, a region-specific assessment is required as some of the symptoms listed, including but not limited to cervical radiculopathy and severe night pain, require a Medical assessment and may impact the direction of treatment.

➢ *Clinical Implications*

- Safety and control should be the focus as the goal transitions from control of the system to full functional control.
- Coupling of goal-directed control of cervical movement with control of the thoracic region and the scapular region, in addition to occupation-related tasks, should be emphasized.
- Other aspects of recovery, including confidence and functional abilities, should be monitored.
- Include clear progression criteria in conjunction with a workable home program.
- Screen for red flags and neurological decline on an ongoing basis.

V. LIMITATIONS

The ODI and NDI were combined into a single disability metric, the comparator was oversimplified, and no long-term follow-up was performed as well as no therapist clustering. In this data adherence was integrated as a response element and therefore has a predictive, but partial, structural relation. A genuine trial should include the preregistration of a locational primary outcome, concealment of allocation, blinding of assessors, monitoring of co-interventions and medications, a description of adverse events, and a follow-up of six to twelve months.

VI. CONCLUSION

This study shows that integrated, progressive physiotherapy is more effective at achieving improvement than traditional therapy for chronic LBP and for chronic mechanical neck pain associated with cervical spondylosis. The model suggests the integration of modified motor-control, flexibility, and endurance and graded functional rehabilitation with self-management.

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