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Post-Operative Physiotherapy for Lumbar Spine Decompression Surgery: A Tailored Approach to Minimize Disability and Maximize Quality of Life

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ABSTRACT:

Background: Lumbar spinal stenosis (LSS) is a leading cause of disability in older adults. Surgical decompression is among the commonest spinal procedures performed in patients aged 65 years or older. Although decompression provides anatomical relief, structured post-operative rehabilitation is critical for reducing residual disability and restoring health-related quality of life. **Objective:** To evaluate the effectiveness of a tailored 4-week post-operative physiotherapy programme on pain, disability and quality of life in patients undergoing lumbar spine decompression surgery. **Methods:** A single-group pre–post quasi-experimental study was conducted at the Department of Community Physiotherapy, Dr. APJ Abdul Kalam College of Physiotherapy, PIMS, Loni. Twenty post-operative patients were enrolled and nineteen completed the intervention. Outcome measures were the Numeric Pain Rating Scale (NPRS), Oswestry Disability Index (ODI) and Short Form-36 Health Survey (SF-36). All measures were administered before and after a 4-week structured rehabilitation protocol incorporating cryotherapy, early mobilisation, lumbopelvic stabilisation, progressive resistance training and functional re-education. The paired-samples t-test with Cohen's d was used for analysis. **Results:** Statistically significant improvements were observed across all outcomes. NPRS decreased from 7.95 ± 0.91 to 5.32 ± 1.16 ($t(18) = 8.82$, $p < 0.001$, $d = 2.02$), a 33.11% reduction. ODI fell from 44.6% ± 6.9 to 27.3% ± 10.7 ($t(18) = 11.65$, $p < 0.001$, $d = 2.67$), a 38.84% reduction. SF-36 composite scores improved from 36.4 ± 6.8 to 44.5 ± 7.9 ($t(18) = 8.48$, $p < 0.001$, $d = 1.95$), a 22.25% increase. **Conclusion:** A tailored 4-week post-operative physiotherapy programme produced clinically meaningful and statistically significant improvements in pain, disability and quality of life following lumbar decompression surgery. The findings support individualised rehabilitation as an integral component of post-decompression care.

1. INTRODUCTION:

Lumbar spinal stenosis (LSS) is a degenerative narrowing of the spinal canal, lateral recess or neural foramina. It produces mechanical and inflammatory compression of the cauda equina or nerve roots, and typically presents with neurogenic claudication, low back pain and lower-limb radicular symptoms. [1] LSS is one of the most prevalent musculoskeletal conditions of older adults. It affects an estimated 103 million people globally and accounts for the single largest indication for spinal surgery in patients aged 65 years or older. [1] A systematic review pooling data from 41 studies reported that the clinical prevalence of LSS in the general adult population is 11%. The prevalence rises to 39% in mixed primary and secondary care populations. [2] In a population-based Japanese cohort, the symptomatic prevalence of LSS was 9.3%, with significant decrement in physical performance compared with unaffected individuals. [3] With population ageing, the absolute disease burden is expected to grow further over the next two decades, particularly in low- and middle-income countries. [2]

First-line management of LSS is conservative and comprises activity modification, analgesia and supervised exercise. A recent network meta-analysis confirmed that targeted exercise approaches outperform usual care for chronic low back pain. [4] When symptoms persist despite an adequate trial of conservative management, surgical decompression is indicated. Reported procedures include simple decompression by lateral fenestration, [5] microscopic partial pediculectomy, [6] posterior lumbar interbody fusion (PLIF) [7] and microendoscopic decompression. [8] Each technique aims to relieve nerve-root compression while balancing the risk of iatrogenic instability, surgical-site infection and implant-related complications. [9,10] The recently published five-year follow-up of the NORDSTEN-DS randomised controlled trial demonstrated that decompression alone is non-inferior to decompression with fusion for degenerative lumbar spondylolisthesis. This provides strong contemporary support for less-invasive surgical strategies. [11]

Despite anatomical decompression, residual back pain, weakness, deconditioning and fear-avoidance behaviour persist in 10–40% of patients post-operatively. [12,13] The eight-year results of the Spine Patient Outcomes Research Trial (SPORT) showed that operative outcomes plateau and may regress without active rehabilitation. [14] A Cochrane review of post-decompression rehabilitation reported that active rehabilitation improves back-related functional status in both the short and long term. A contemporary meta-analysis confirmed that supervised exercise therapy yields better disability and pain outcomes than usual care. [15,16] Despite this evidence base, post-operative rehabilitation in routine practice is often inconsistent, generic and not titrated to the patient's specific impairments, comorbidities or surgical procedure. [17] Enhanced Recovery After Surgery (ERAS) consensus recommendations advocate early mobilisation and structured physiotherapy following spinal procedures, although Level-1 evidence remains limited. [18,19]

A tailored physiotherapy programme has been theorised to optimise post-decompression recovery. Such a programme progresses with biological healing, addresses each patient's individual impairments, and integrates pain education, neuromuscular control, progressive resistance and functional retraining. [20] Early initiation of strength-based rehabilitation has been shown to enhance core muscle strength and walking distance after lumbar fusion. Core stabilisation training is a recurring active ingredient of effective post-operative rehabilitation programmes. [21] However, evidence specifically addressing tailored post-decompression rehabilitation in Indian community-based practice settings, using validated patient-reported outcome measures, is sparse.

The present study was therefore designed to evaluate the effectiveness of a tailored 4-week post-operative physiotherapy programme on pain, disability and health-related quality of life in adults who had undergone lumbar spine decompression surgery. We hypothesised that the programme would produce statistically significant and clinically meaningful improvements across the Numeric Pain Rating Scale (NPRS), Oswestry Disability Index (ODI) and Short Form-36 Health Survey (SF-36). The findings would inform the development of context-specific rehabilitation pathways for this patient population.

2. MATERIALS AND METHODS

2.1 Study Design and Setting

A single-group pre–post quasi-experimental study was conducted in the Department of Community Physiotherapy, Dr. APJ Abdul Kalam College of Physiotherapy, PIMS, Loni, Maharashtra, India. The investigation followed the principles of the Declaration of Helsinki. Ethical clearance was obtained from the Institutional Ethics Committee prior to participant enrolment. Written informed consent was obtained from every participant. Outcome measures were recorded before and after the 4-week intervention period.

2.2 Participants
Patients of either sex, referred for post-operative physiotherapy after surgical decompression of the lumbar spine, were screened for eligibility. Inclusion criteria were: (i) confirmed lumbar decompression surgery with surgical clearance to commence rehabilitation; (ii) conscious patient able to follow verbal commands; and (iii) willingness to provide written informed consent. Exclusion criteria were: (i) concurrent participation in another clinical trial; (ii) inability to attend follow-up appointments or complete outcome assessments; and (iii) any medical or psychological condition that, in the opinion of the investigator, was likely to interfere with the intervention or assessment. As this was a pilot exploratory study, a convenience sample of 20 participants was recruited. One was lost to follow-up, leaving nineteen for the final analysis.

2.3 Outcome Measures
Three validated patient-reported outcome instruments were administered at baseline (within 48–72 hours of surgical clearance) and on completion of the 4-week programme:
(i) Numeric Pain Rating Scale (NPRS): an 11-point self-report scale (0 = no pain; 10 = worst imaginable pain). The NPRS demonstrates strong concurrent validity with the visual analogue scale, satisfactory test–retest reliability, and a minimum clinically important difference (MCID) of approximately 2 points or 30% in patients with low back pain. [22,23]

(ii) Oswestry Disability Index (ODI): a condition-specific 10-item questionnaire scored from 0% (no disability) to 100% (maximum disability). It comprises domains of pain intensity, personal care, lifting, walking, sitting, standing, sleeping, sex life, social life and travelling. The ODI has excellent internal consistency (Cronbach's α = 0.85–0.87), strong construct validity and high responsiveness in surgical and non-surgical low back pain populations. [24,25]

(iii) Short Form-36 Health Survey (SF-36): a generic 36-item measure of health-related quality of life across eight domains (physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional and mental health). The SF-36 has been validated in spine disease. The Physical Function and Bodily Pain domains show strong convergent validity against condition-specific measures and acceptable responsiveness. [26,27]

2.4 Intervention: Tailored 4-Week Physiotherapy Protocol
All participants received an individualised programme delivered by qualified physiotherapists. The protocol was tailored to each participant's pre-operative status, surgical procedure, pain level and functional ability. It progressed weekly under direct physiotherapist supervision, in accordance with ERAS principles. [18,19]

Week 1 (days 1–7): Pain and oedema management with intermittent cryotherapy applied around the operative site (15-minute sessions, 2–3 times daily); supine ankle pumping; isometric quadriceps and gluteal contractions; supported short-distance ambulation with assistive device; respiratory exercises; and education in log-rolling, neutral spine and lifting precautions. [19]

Week 2: Progressive bed mobility, supine pelvic tilts, single knee-to-chest stretches within pain tolerance, transverse abdominis activation drills, sit-to-stand training, and incremental walking distance. Education emphasised pacing, body mechanics and avoidance of forward flexion under load. [20,21]

Week 3: Lumbopelvic stabilisation exercises (bridging, dead-bug, modified bird-dog), graded resistance training for hip abductors and extensors using elastic bands, partial squats within pain-free range, and treadmill walking with monitored speed and incline. [21]

Week 4: Endurance and functional retraining—stair climbing, light activities of daily living, low-impact aerobic conditioning (10–15 minutes), advanced core stability progressions, and prescription of a written home-exercise programme. [20,21]

Cognitive elements—reassurance, pain neuroscience education and graded exposure to feared movements—were embedded throughout. These addressed kinesiophobia and catastrophising. [28] Representative exercises performed by participants are illustrated in Figure 1.

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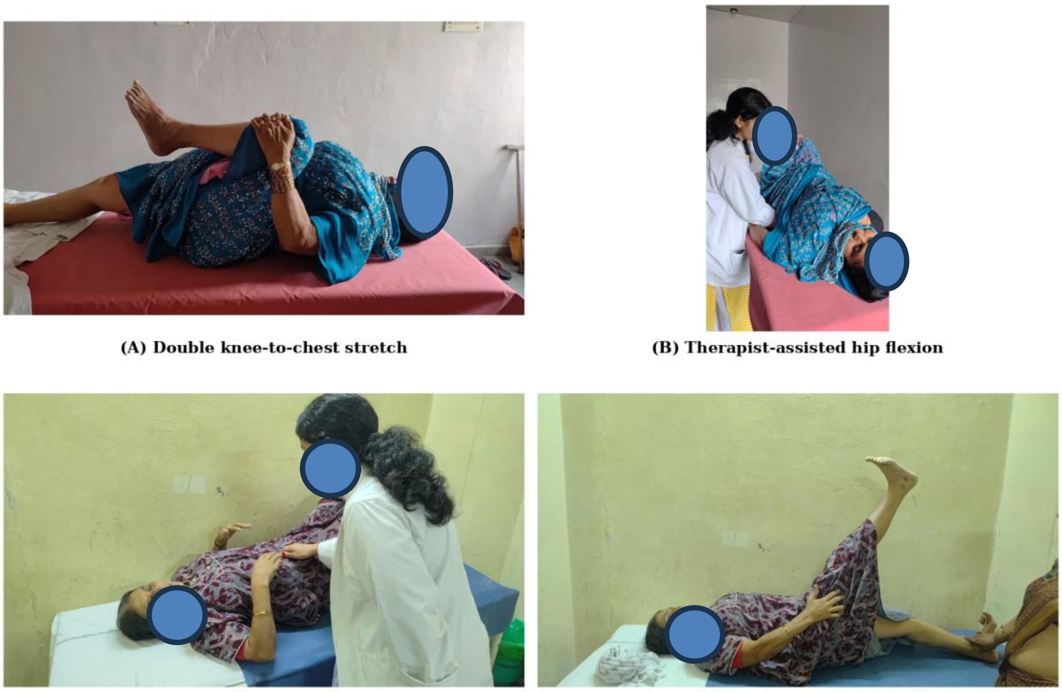

(A) Double knee-to-chest stretch

(B) Therapist-assisted hip flexion

(C) Lumbar palpation and assessment

(D) Active straight leg raise

Figure 1. Representative exercises performed during the tailored 4-week post-operative physiotherapy programme. (A) Double knee-to-chest stretch for gentle lumbar flexion mobility within pain tolerance; (B) therapist-assisted hip flexion stretch with neutral-spine cueing; (C) lumbar palpation and segmental assessment guiding individualised progression; (D) active straight leg raise for hip-flexor and quadriceps activation.

2.5 Statistical Analysis

Analyses were performed using JASP (version 0.18). Continuous variables are presented as mean ± standard deviation. Normality of difference scores was assessed using the Shapiro–Wilk test. As assumptions of normality were satisfied for all outcomes ($p > 0.05$), the paired-samples t-test was used to compare pre- and post-intervention scores. Cohen's d was calculated for each comparison and interpreted using conventional benchmarks (small = 0.2; medium = 0.5; large = 0.8). [29] Statistical significance was set at $\alpha = 0.05$ (two-tailed). Percentage change from baseline was computed for each outcome to facilitate cross-instrument comparison.

3. RESULTS

Of the 20 participants enrolled, 19 (95%) completed the 4-week programme and were included in the final analysis; one withdrew because of inability to attend follow-up. Pre- and post-intervention descriptive statistics for all outcomes are presented in Table 1. The Shapiro–Wilk test confirmed that difference scores were normally distributed (NPRS: $W = 0.947$, $p = 0.356$; ODI: $W = 0.912$, $p = 0.080$), justifying the use of the parametric paired-samples t-test.

Table 1. Descriptive statistics and paired-samples t-test results for all outcome measures (n = 19).

Measure	n	Pre, Mean ± SD	Post, Mean ± SD	Mean Diff.	t (df = 18)	p	Cohen's d
NPRS	19	7.95 ± 0.91	5.32 ± 1.16	2.63	8.82	< 0.001	2.02
ODI (%)	19	44.6 ± 6.9	27.3 ± 10.7	17.3	11.65	< 0.001	2.67
SF-36	19	36.4 ± 6.8	44.5 ± 7.9	8.1	8.48	< 0.001	1.95

NPRS = Numeric Pain Rating Scale; ODI = Oswestry Disability Index; SF-36 = Short Form-36 Health Survey.

3.1 Numeric Pain Rating Scale (NPRS)

Mean NPRS decreased from 7.95 ± 0.91 at baseline to 5.32 ± 1.16 post-intervention. The within-participant mean difference was 2.63 points. The reduction was statistically significant, $t(18) = 8.82$, $p < 0.001$, with an extremely large effect size (Cohen's d = 2.02). The mean change of 2.63 points exceeds the established MCID of 2 points for patients with low back pain. [22,23] Pre- and post-intervention values are illustrated in Figure 2A. Individual participant trajectories are shown as a raincloud plot in Figure 3. The reduction was consistent across the cohort, with virtually all participants showing a downward shift from pre- to post-intervention.

3.2 Oswestry Disability Index (ODI)

ODI scores fell from 44.6% ± 6.9 (moderate-to-severe disability) at baseline to 27.3% ± 10.7 (moderate disability) post-intervention. This represents a 38.84% relative reduction. The change was statistically significant, $t(18) = 11.65$, $p < 0.001$, with a Cohen's d of 2.67. Eighteen of the nineteen participants moved at least one ODI severity category. Pre- and post-intervention ODI values are presented in Figure 2B.

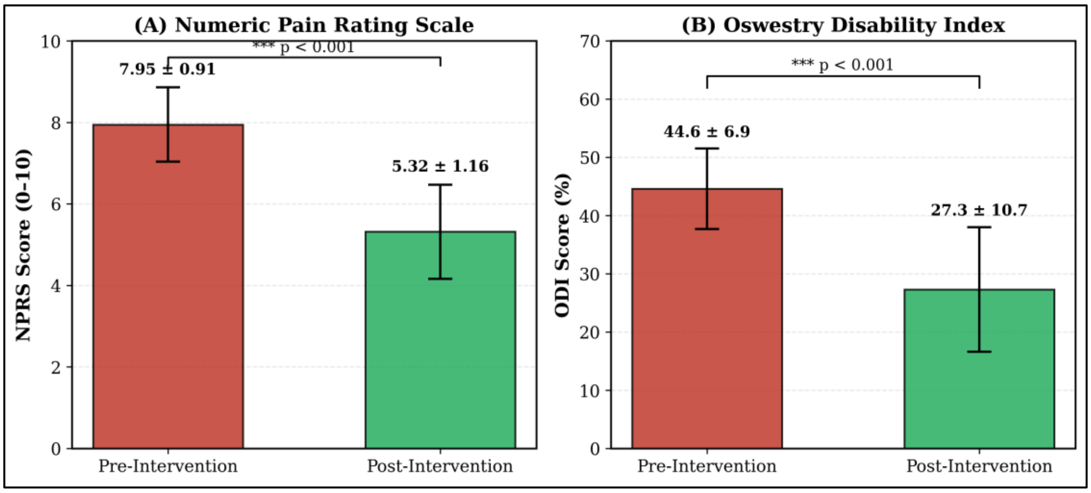

Figure 2. Pre- and post-intervention scores for (A) Numeric Pain Rating Scale (NPRS) and (B) Oswestry Disability Index (ODI). Bars represent group means; error bars represent ±1 SD. Both reductions were statistically significant (paired-samples t-test; ***p < 0.001).

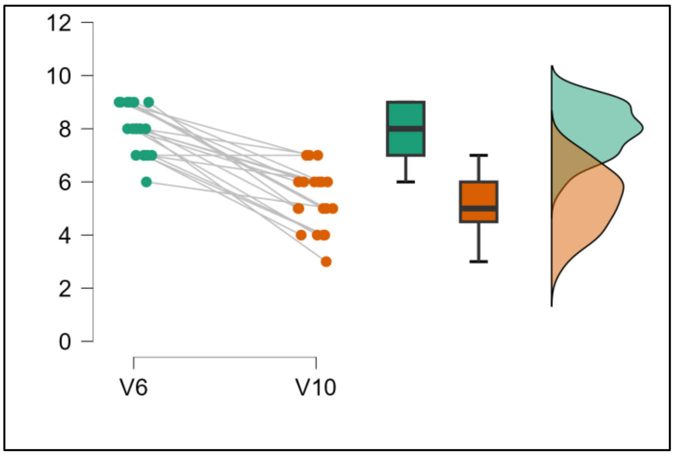

Figure 3. Individual-participant Numeric Pain Rating Scale (NPRS) scores before (V6, pre-intervention) and after (V10, post-intervention) the 4-week tailored physiotherapy programme. Linked dots show paired trajectories for each participant; box plots and density curves illustrate the shift in distribution. Pain scores decreased consistently across the cohort, with no participant showing a worsening of symptoms.

3.3 Short Form-36 Health Survey (SF-36)

SF-36 composite scores improved from 36.4 ± 6.8 at baseline to 44.5 ± 7.9 post-intervention. The within-participant mean difference was 8.1 points, equating to a 22.25% relative improvement. The change was statistically significant, $t(18) = 8.48$, $p < 0.001$, with a large effect size (Cohen's $d = 1.95$). The largest gains were noted in the Physical Function, Bodily Pain and Role-Physical domains. While smaller in magnitude than the disability and pain reductions, the change is consistent with a meaningful improvement in patients' perceived physical and psychosocial well-being.

3.4 Comparative Magnitude of Change

Figure 4 displays the percentage change from baseline across all three outcome measures. Disability (ODI: 38.84% reduction) showed the greatest relative change, followed by pain (NPRS: 33.11% reduction) and quality of life (SF-36: 22.25% improvement). Standardised effect sizes were extremely large for both NPRS (Cohen's d = 2.02) and ODI (d = 2.67), and large for SF-36 (d = 1.95). All values substantially exceed Cohen's threshold for a "large" effect (d = 0.8). [29] Together, the findings support rejection of the null hypothesis across all three measured domains.

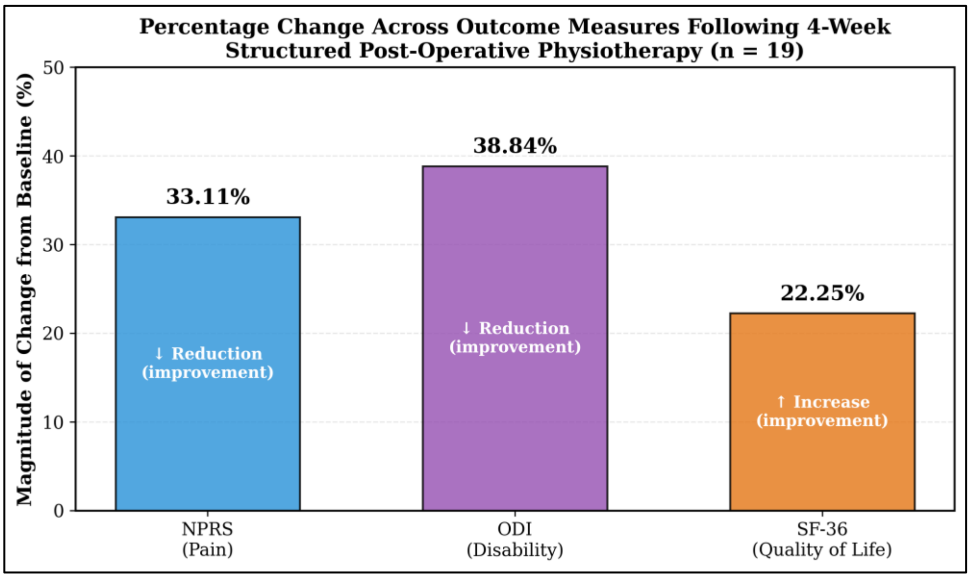

Figure 4. Percentage change from baseline across the three outcome measures following the 4-week structured physiotherapy programme. Reductions for NPRS and ODI represent improvement; the SF-36 represents an increase that also represents improvement.

4. DISCUSSION

The present study demonstrated that a tailored 4-week post-operative physiotherapy programme produced statistically significant and clinically meaningful improvements in pain, disability and quality of life. All participants had undergone lumbar spine decompression surgery. The reductions of 33.11% in NPRS and 38.84% in ODI, alongside a 22.25% improvement in SF-36, together with extremely large effect sizes (Cohen's d > 1.9), suggest that individualised early rehabilitation can substantially augment the benefits of surgical decompression.

The pain reduction of 2.63 NPRS points exceeds the MCID of approximately 2 points (or 30%) reported by Childs and colleagues for patients with low back pain. [22,23] This magnitude of analgesic benefit is consistent with the randomised trial of Amjad et al. They reported significantly greater pain reductions when non-surgical spinal decompression was combined with routine physiotherapy than with routine physiotherapy alone. [30] Apfel et al. similarly observed decreased discogenic pain following non-surgical decompression, attributing the effect partly to restoration of disc height. [31] In the post-surgical context, McIntyre et al. concluded in their systematic review that multimodal rehabilitation reduces both pain and pain-related fear after lumbar surgery. This rehabilitation integrates exercise, education and cognitive elements. [32] Plausible mechanisms include resolution of mechanical nerve-root insult by the surgery itself. Physiotherapy addresses residual paraspinal deconditioning, kinesiophobia and protective muscle guarding that frequently persist after the operation. [20,28]

The 38.84% reduction in ODI is consistent with—and at the upper end of—improvements reported in larger surgical cohorts. Parker et al. observed clinically meaningful ODI improvement two years after lumbar decompression in patients receiving structured care. [33] Lee et al. similarly reported significant ODI gains at 3, 6 and 12 months post-operatively. [34] The substantial functional improvement seen in our cohort likely reflects the integrated progression from pain control through lumbopelvic stabilisation to graded resistance and functional retraining. Tarnanen et al. showed that these components enhance trunk strength and disability outcomes when commenced early after lumbar surgery. [21] The systematic review by Aydemir et al. concluded that exercise therapy produces consistent benefits for disability after lumbar surgery, particularly when combined with cognitive elements. [20] The Cochrane review by McGregor et al. and a recent meta-analysis by Ferrari et al. corroborate the importance of structured active rehabilitation post-decompression. [15,13]

The 22.25% improvement in SF-36 is clinically meaningful, although smaller than the disability and pain gains. The 8-year SPORT data of Lurie et al. demonstrated durable physical-component gains following surgical management of LSS, especially when accompanied by structured rehabilitation. [14] Grevitt et al. previously validated SF-36 as a responsive instrument in spinal surgery, with the Physical Function and Bodily Pain subscales showing the greatest sensitivity to change. [26] The relatively smaller percentage improvement in SF-36 in our cohort is in keeping with the recognised time-course of quality-of-life recovery. Quality-of-life recovery typically lags behind objective pain and disability changes and is influenced by comorbidity, psychosocial context and return-to-work trajectories. [35]

Several mechanisms likely underlie the observed effects. First, the tailored progression—from cryotherapy and gentle mobility in week 1 through lumbopelvic stabilisation and resistance training in weeks 3–4—matches the physiological timeline of post-surgical tissue healing while preventing deconditioning. [18,19] Second, neuromuscular re-education of the deep trunk musculature (transverse abdominis, multifidus) addresses the segmental instability that decompression alone does not correct. [21] Third, the embedded cognitive components, including pain neuroscience education and reassurance, target catastrophising and fear-avoidance beliefs. These beliefs are well-recognised predictors of poor surgical outcome. [28,36] Fourth, supervised, structured rehabilitation in line with ERAS recommendations is associated with reduced length of stay, fewer complications and improved patient-reported outcomes following spinal surgery. [18,19]

4.1 Clinical Implications

The findings have direct relevance to clinical practice in resource-constrained settings. A 4-week, supervised, individualised physiotherapy protocol is feasible, low-cost and produces large effects across pain, disability and quality-of-life domains. Embedding such a tailored pathway within standard post-operative orthopaedic care may bridge the well-documented gap between surgical anatomical correction and functional recovery. The pathway should ideally begin in the inpatient phase and continue through community physiotherapy. [17] The protocol's emphasis on graded progression, neuromuscular re-education and patient education provides a replicable template suitable for adaptation in similar settings.

4.2 Strengths and Limitations

Strengths of the study include the use of three complementary, validated outcome measures, structured weekly progression of the protocol, and adherence to ERAS principles. [18] Limitations must, however, be acknowledged. First, the absence of a control group and the single-group pre–post design preclude causal inference. Observed improvements may, in part, reflect natural post-operative recovery, regression to the mean, or placebo effects. Second, the small sample size ($n = 19$) limits generalisability and statistical power for subgroup analysis. Third, the 4-week follow-up is short; longer-term durability of benefits remains untested. Fourth, blinded outcome assessment was not feasible in this open design. Future research should employ randomised controlled designs with larger samples, blinded assessment, longer follow-up (≥12 months) and inclusion of objective performance measures (e.g., 6-minute walk test, timed up-and-go) to confirm and extend these findings. [37,38]

5. CONCLUSION

A tailored 4-week post-operative physiotherapy programme produced statistically significant and clinically meaningful improvements across all measured outcomes. Pain (NPRS) decreased by 33.11% and disability (ODI) decreased by 38.84%. Health-related quality of life (SF-36) improved by 22.25%. The extremely large effect sizes (Cohen's $d > 1.9$ for all outcomes) underscore the clinical relevance of individualising rehabilitation to patient-specific impairments. The protocol progresses systematically from pain control through neuromuscular re-education to functional retraining. These findings reinforce that surgical decompression should not be viewed as the end-point of care but as the beginning of a structured rehabilitation continuum. Although the absence of a control group and the short follow-up limit definitive causal inference, the magnitude and consistency of the findings support the integration of tailored physiotherapy as a routine component of post-decompression care. Larger randomised controlled trials with extended follow-up are warranted to validate and extend these results.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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