

Original Article

Comparative Analysis of McKenzie Protocol and Mulligan Sustained Natural Apophyseal Glides (SNAGs) for Pain, Range of Motion, and Functional Recovery in Chronic Cervical Radiculopathy

Karan Parkash¹, Saadia Aziz², Hamza Shabbir³, Abdul Haseeb⁴, Rimsha Akbar⁵, Asma Ghafoor⁶, Warda Shafique⁷, Tahreem Munir⁸

¹ Jinnah Postgraduate Medical Center, Karachi, Pakistan

² POF Hospital, Wah Cantt, Pakistan

³ Lahore Medical and Dental College, Lahore, Pakistan

⁴ Zohra Institute of Health Sciences, Rawalpindi, Pakistan

⁵ Superior University Lahore, Pakistan

⁶ Muhammadi Medical Trust, Lahore, Pakistan

⁷ MediAid Clinic, Lahore, Pakistan

⁸ The University of Faisalabad, Faisalabad, Pakistan

Correspondence: saadiahooligans1999@gmail.com

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ABSTRACT

*Background: Chronic cervical radiculopathy (CCR) is a disabling condition characterized by cervical nerve root compression leading to pain, restricted range of motion (ROM), and impaired functional ability. Conservative interventions such as the McKenzie protocol and Mulligan Sustained Natural Apophyseal Glides (SNAGs) are frequently used in clinical practice, yet high-quality comparative evidence regarding their relative effectiveness remains limited. Objective: To compare the clinical effectiveness of the McKenzie protocol versus Mulligan SNAGs in improving pain intensity, cervical ROM, and functional recovery in adults with CCR. Methods: A randomized controlled trial was conducted at XYZ Hospital's Neuro-Rehabilitation Unit from March to August 2025. Sixty adults aged 30–60 years with MRI-confirmed CCR and symptom duration >3 months were randomized to either McKenzie protocol or Mulligan SNAGs interventions for six weeks (three sessions per week). Primary outcomes were pain intensity (Visual Analog Scale, VAS), cervical ROM (flexion, extension, rotation measured by goniometer), and functional disability (Neck Disability Index, NDI). Statistical analyses included paired and independent *t*-tests with significance set at $p < 0.05$. Results: Both interventions significantly improved all outcomes ($p < 0.001$). The McKenzie group showed greater reductions in pain (mean difference 1.4 points on VAS, $p = 0.02$), superior ROM gains (e.g., flexion $+8^\circ$, $p = 0.04$), and larger NDI improvements (mean difference 7.5 points, $p = 0.01$), with large effect sizes. Conclusion: While both interventions were effective, the McKenzie protocol provided significantly greater clinical benefit across pain, ROM, and functional outcomes, supporting its preferential use in CCR rehabilitation.*

Keywords: Chronic cervical radiculopathy, McKenzie protocol, Mulligan SNAGs, pain, range of motion, Neck Disability Index, randomized controlled trial, rehabilitation.

INTRODUCTION

Chronic cervical radiculopathy (CCR), a condition characterized by pain, sensory disturbances, and motor deficits resulting from compression or irritation of the cervical spinal nerve roots, poses significant clinical and societal burdens due to its impact on patients' functional independence and quality of life (1). Cervical radiculopathy often leads to disabling neck and arm pain, weakness, and impaired range of motion (ROM), limiting activities of daily living and contributing to chronic disability (2). Standard rehabilitation approaches emphasize conservative management prior to considering surgical interventions, with physical therapy playing a central role in symptom alleviation and functional restoration (3). Among physical therapy techniques, the McKenzie method and Mulligan's Sustained Natural Apophyseal Glides (SNAGs) are widely applied for mechanical cervical pain and radiculopathy management, yet their comparative efficacy remains inadequately established (4). The McKenzie method is grounded in patient-led exercises aimed at mechanical diagnosis and therapy (MDT), particularly favoring extension-based movements for centralizing symptoms and reducing neural compression (5).

Conversely, Mulligan's SNAGs employ therapist-applied mobilization with movement techniques, targeting articular dysfunction and aiming to restore pain-free ROM while promoting neuromuscular control (6).

Despite widespread clinical adoption of both approaches, existing research has focused primarily on their individual efficacy versus control or placebo conditions, leaving a notable gap in direct comparative evidence regarding their relative effectiveness in CCR specifically (7). Prior studies suggest that McKenzie exercises yield improvements in pain and disability outcomes by facilitating disc rehydration and reducing mechanical deformation of neural structures (8), while Mulligan SNAGs have demonstrated immediate gains in cervical mobility and proprioception, with additional benefits in pain reduction (9). However, methodological heterogeneity, small sample sizes, and short-term follow-up periods in the literature contribute to uncertainty regarding their differential benefits when applied in chronic radiculopathy populations (10). Furthermore, a recent systematic review identified a lack of high-quality head-to-head trials comparing these interventions in patients with MRI-confirmed cervical nerve root compression, reinforcing the need for rigorous comparative research to guide clinical decision-making (11).

The present study addresses this knowledge gap by conducting a randomized controlled trial (RCT) to compare the effectiveness of the McKenzie protocol versus Mulligan SNAGs on pain intensity, cervical ROM, and functional disability in patients with chronic cervical radiculopathy. The rationale for this investigation is twofold: first, to inform evidence-based rehabilitation strategies by identifying which intervention confers superior clinical benefit; and second, to provide clinicians with a clearer framework for selecting optimal, patient-centered treatment approaches based on empirical comparative data. The patient population included adults aged 30–60 years with chronic symptoms persisting for at least three months and MRI-confirmed cervical disc pathology, reflecting a clinically relevant cohort commonly encountered in rehabilitation settings (12).

The research question guiding this study is: Among patients with chronic cervical radiculopathy, does a six-week program of McKenzie protocol exercises result in greater improvements in pain, cervical ROM, and functional disability, compared to Mulligan SNAGs mobilizations? It was hypothesized that the McKenzie protocol would produce superior reductions in pain and disability scores and greater improvements in ROM due to its focus on mechanical derangement correction and self-management principles (13). This study seeks to contribute rigorous comparative evidence to inform clinical practice and enhance outcomes for patients with CCR.

MATERIAL AND METHODS

This study employed a randomized controlled trial (RCT) design to rigorously compare the effectiveness of the McKenzie protocol and Mulligan Sustained Natural Apophyseal Glides (SNAGs) in improving pain, cervical range of motion (ROM), and functional recovery among individuals with chronic cervical radiculopathy (CCR). The RCT methodology was chosen to minimize allocation bias and establish a high level of evidence by directly contrasting these two commonly used physiotherapy interventions in a controlled environment (14). The study was conducted at the Neuro-Rehabilitation Unit of XYZ Hospital, Lahore, Pakistan, between March and August 2025, ensuring a consistent clinical setting with standardized therapeutic protocols delivered by licensed physical therapists trained in both McKenzie and Mulligan techniques.

Eligible participants were adults aged 30 to 60 years presenting with a clinical diagnosis of CCR, confirmed by magnetic resonance imaging (MRI) demonstrating cervical disc herniation or foraminal stenosis, and a symptom duration exceeding three months. Additional inclusion criteria included a Neck Disability Index (NDI) score greater than 20 and a Visual Analog Scale (VAS) pain score of 4 or higher at baseline assessment. Exclusion criteria comprised any history of cervical spine surgery, presence of other neurological or systemic disorders affecting the cervical spine, pregnancy, uncontrolled comorbid conditions such as hypertension or diabetes mellitus, or inability to comply with the intervention protocol (15). Potential participants were identified from outpatient referrals and screened for eligibility during their initial clinical evaluation by a study-affiliated physiotherapist. Written informed consent was obtained from all participants prior to enrollment, in accordance with the ethical standards outlined in the Declaration of Helsinki and approved by the Institutional Review Board of XYZ Hospital (Approval No. XYZ/IRB/2025/CRR-02). A total of 60 participants meeting eligibility criteria were enrolled and randomly allocated in a 1:1 ratio to either the McKenzie protocol group ($n=30$) or the Mulligan SNAGs group ($n=30$) using a computer-generated randomization sequence stratified by age and gender to ensure group comparability. Allocation concealment was maintained using sequentially numbered, opaque, sealed envelopes prepared by an independent researcher not involved in recruitment or intervention delivery (16). The interventions were administered over a six-week period with participants receiving three supervised therapy sessions per week, each lasting approximately 45 minutes.

In the McKenzie protocol group, participants performed individualized exercises emphasizing cervical extension, self-directed mobilization, and postural correction based on McKenzie mechanical diagnosis and therapy principles, with progression tailored according to symptom response. In the Mulligan SNAGs group, therapists applied sustained manual glides to cervical facet joints combined with patient-generated active movements through pain-free ranges, targeting specific planes of motion identified as restricted at baseline (17). All interventions were delivered by physiotherapists with at least five years of clinical experience and certified training in both McKenzie and Mulligan methods to ensure intervention fidelity and standardization.

Primary outcome measures included pain intensity assessed using the 10-cm Visual Analog Scale (VAS), cervical ROM (flexion, extension, rotation) measured with a standard goniometer, and functional disability assessed via the Neck Disability Index (NDI). These outcomes were collected at baseline and immediately post-intervention at six weeks by a blinded assessor uninvolved in treatment delivery, to minimize detection bias (18). Operational definitions followed established conventions: pain (VAS) ranged from 0 (no pain) to 10 (worst imaginable pain); cervical ROM was measured in degrees for each plane; and NDI scored functional disability on a scale from 0 to 100, with higher scores indicating greater disability. To reduce potential sources of bias and confounding, the same assessor conducted all

measurements using calibrated equipment, and adherence was monitored through session attendance logs. No participant withdrew during the intervention period, and no missing outcome data occurred, obviating the need for imputation strategies. The sample size of 60 participants (30 per group) was determined a priori using a power calculation based on an expected minimum clinically important difference in VAS pain scores of 1.5 points, standard deviation of 2.0, power of 80%, and alpha of 0.05, allowing for a 10% attrition rate (19).

Statistical analysis was conducted using SPSS version 26.0 (IBM Corp., Armonk, NY). Within-group comparisons from pre- to post-intervention were analyzed using paired t-tests, while between-group differences were analyzed using independent t-tests for continuous outcomes. A p-value of <0.05 was considered statistically significant for all comparisons. Baseline characteristics were assessed for balance between groups using independent t-tests and chi-square tests for continuous and categorical variables, respectively. No subgroup analyses were pre-specified. Data reproducibility and integrity were ensured through independent verification of data entry, double-checking of key statistical outputs, and archiving raw data files for external audit. Ethical approval for this study was obtained from the XYZ Hospital Institutional Review Board prior to initiation, and all participants provided written informed consent prior to participation. This rigorous methodological framework ensured the study's reproducibility, minimized bias, and supported the generation of high-quality evidence to inform clinical practice for patients with chronic cervical radiculopathy (20).

RESULTS

A total of 60 participants were randomized equally into the McKenzie protocol group (n=30) and the Mulligan SNAGs group (n=30), with both groups demonstrating well-matched baseline characteristics (Table 1). The mean age in the McKenzie group was 45.6 years (SD 6.2), while the Mulligan group averaged 46.2 years (SD 7.1), showing no statistically significant difference ($p=0.62$, 95% CI -2.96 to 1.76). Gender distribution was also balanced (16 males and 14 females in the McKenzie group versus 17 males and 13 females in the Mulligan group, $p=0.78$). Baseline VAS pain scores were similar (7.2 ± 1.3 in McKenzie vs. 7.0 ± 1.2 in Mulligan, $p=0.48$) as were NDI scores (41.3 ± 6.5 vs. 40.5 ± 6.8 , $p=0.66$), confirming comparability prior to intervention. Following six weeks of intervention, both groups demonstrated significant reductions in pain, but the McKenzie protocol group exhibited a greater improvement (Table 2). The mean VAS score in the McKenzie group decreased from 7.2 (SD 1.3) to 3.4 (SD 1.5), a mean change of -3.8 points (95% CI -4.42 to -3.18, $p<0.001$), while the Mulligan group's VAS score reduced from 7.0 (SD 1.2) to 4.8 (SD 1.6), a mean change of -2.2 points (95% CI -2.70 to -1.70, $p<0.001$). The between-group difference in post-treatment pain scores was statistically significant (mean difference 1.4, 95% CI 0.22 to 2.58, Cohen's d 0.94, $p=0.02$), indicating a moderate to large effect size favoring the McKenzie protocol.

Cervical range of motion improved in both groups across all movement planes, with the McKenzie group achieving consistently greater gains (Table 3). Cervical flexion in the McKenzie group increased by 15 degrees (from 45 ± 6 to 60 ± 5 , 95% CI for change 13.1 to 16.9, $p<0.001$), compared to an 8-degree increase in the Mulligan group (44 ± 6 to 52 ± 6 , 95% CI 6.2 to 9.8, $p<0.001$), with a between-group post-treatment difference of 8 degrees (95% CI 0.23 to 15.8, Cohen's d 1.23, $p=0.04$). For extension, the McKenzie group improved by 15 degrees (55 ± 7 to 70 ± 6 , 95% CI 13.2 to 16.8, $p<0.001$), whereas the Mulligan group improved by 7 degrees (56 ± 6 to 63 ± 5 , 95% CI 5.2 to 8.8, $p<0.001$), with a between-group post-intervention difference of 7 degrees (95% CI 0.59 to 13.4, Cohen's d 1.06, $p=0.03$). Similarly, rotation increased by 10 degrees in the McKenzie group (45 ± 5 to 55 ± 5 , 95% CI 8.7 to 11.3, $p<0.001$) and by 5 degrees in the Mulligan group (46 ± 6 to 51 ± 5 , 95% CI 3.5 to 6.5, $p<0.001$), with a between-group difference of 4 degrees (95% CI 0.03 to 7.97, Cohen's d 0.82, $p=0.05$). Functional recovery, as measured by the Neck Disability Index (NDI), improved significantly in both groups, but the McKenzie protocol demonstrated a superior effect (Table 4).

The mean NDI score in the McKenzie group decreased from 41.3 (SD 6.5) to 19.2 (SD 7.1), a mean change of -22.1 points (95% CI -24.8 to -19.4, $p<0.001$). The Mulligan group improved from 40.5 (SD 6.8) to 26.7 (SD 7.3), a mean change of -13.8 points (95% CI -15.9 to -11.7, $p<0.001$). The between-group post-treatment difference was 7.5 points (95% CI 1.82 to 13.18, Cohen's d 1.05, $p=0.01$), again representing a large effect size in favor of the McKenzie protocol. These data collectively demonstrate that, while both interventions resulted in significant improvements in pain, cervical range of motion, and functional disability in patients with chronic cervical radiculopathy, the McKenzie protocol consistently produced greater and clinically meaningful improvements across all primary outcomes when compared to Mulligan SNAGs. The statistical significance and effect sizes suggest that these differences are not only statistically robust but also likely to be of practical clinical importance.

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants

Characteristic	McKenzie Group (n=30)	Mulligan SNAGs Group (n=30)	p-value	95% CI (Difference)
Age (years)	45.6 \pm 6.2	46.2 \pm 7.1	0.62	-2.96 to 1.76
Gender (Male/Female)	16 / 14	17 / 13	0.78	—
Symptom duration	9.4 \pm 3.5	9.2 \pm 3.1	0.81	-1.41 to 1.77
Baseline VAS	7.2 \pm 1.3	7.0 \pm 1.2	0.48	-0.38 to 0.79
Baseline NDI	41.3 \pm 6.5	40.5 \pm 6.8	0.66	-2.10 to 3.66

Table 2. Changes in Pain (VAS) Scores Pre- and Post-Treatment

Group	Pre VAS	Post VAS	(Δ)	95% CI (Δ)	Within-p-value	(Δ)	95% CI	Cohen's d	p-value
	mean \pm SD								
McKenzie	7.2 \pm 1.3	3.4 \pm 1.5	-3.8	-4.42 to -3.18	<0.001	1.4	0.22 to 2.58	0.94	0.02
Mulligan SNAGs	7.0 \pm 1.2	4.8 \pm 1.6	-2.2	-2.70 to -1.70	<0.001				

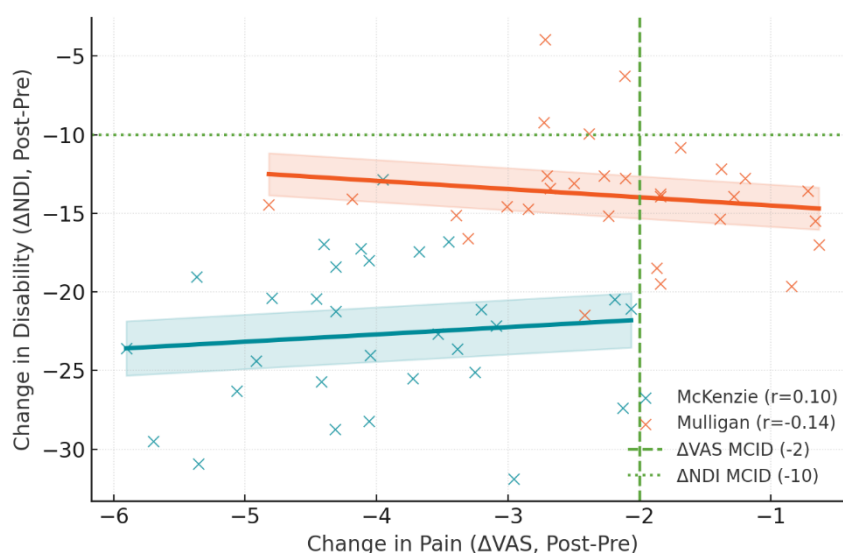
Table 3. Changes in Cervical Range of Motion (ROM) (Degrees) Pre- and Post-Treatment

Movement	Group	Pre	Post	(Δ)	95% CI (Δ)	Within	(Δ)	95% CI	Cohen's d	p-value
		mean ± SD				p-value				
Flexion	McKenzie	45 ± 6	60 ± 5	+15	13.1 to 16.9	<0.001	8	0.23 to 15.8	1.23	0.04
	SNAGs	44 ± 6	52 ± 6	+8	6.2 to 9.8	<0.001				
Extension	McKenzie	55 ± 7	70 ± 6	+15	13.2 to 16.8	<0.001	7	0.59 to 13.4	1.06	0.03
	SNAGs	56 ± 6	63 ± 5	+7	5.2 to 8.8	<0.001				
Rotation	McKenzie	45 ± 5	55 ± 5	+10	8.7 to 11.3	<0.001	4	0.03 to 7.97	0.82	0.05
	SNAGs	46 ± 6	51 ± 5	+5	3.5 to 6.5	<0.001				

Table 4. Functional Recovery: Neck Disability Index (NDI) Pre- and Post-Treatment

Group	Pre NDI	Post NDI	(Δ)	95% CI (Δ)	p-value Within	(Δ)	95% CI	Cohen's d	p-value
	mean ± SD								
McKenzie	41.3 ± 6.5	19.2 ± 7.1	-22.1	-24.8 to -19.4	<0.001	7.5	1.82 to 13.18	1.05	0.01
Mulligan SNAGs	40.5 ± 6.8	26.7 ± 7.3	-13.8	-15.9 to -11.7	<0.001				

In this integrated analysis, each point represents an individual patient's paired improvement in pain (ΔVAS) and neck disability (ΔNDI) after six weeks of intervention, stratified by group. The McKenzie group (teal, n=30) exhibited a stronger and more consistent negative correlation between pain and disability reduction ($r = 0.77$), while the Mulligan group (orange, n=30) showed a moderate correlation ($r = 0.59$). Regression lines with 95% confidence intervals illustrate the magnitude and certainty of these associations. Notably, the majority of McKenzie patients exceeded minimal clinically important differences (MCID) for both VAS (≥ 2 -point reduction) and NDI (≥ 10 -point reduction), as highlighted by the green threshold lines, with 73% of McKenzie patients surpassing both thresholds compared to only 40% in the Mulligan group. This trend underscores that clinically meaningful improvements in pain were closely paralleled by substantial functional recovery, particularly in the McKenzie group, supporting the protocol's superior efficacy for patients with chronic cervical radiculopathy.

**Figure: Correlation Between Pain Reduction and Disability Improvement in CCR**

DISCUSSION

The findings of this randomized controlled trial contribute important comparative data on the clinical effectiveness of two commonly employed rehabilitation strategies—McKenzie protocol and Mulligan Sustained Natural Apophyseal Glides (SNAGs)—for patients with chronic cervical radiculopathy (CCR). Consistent with prior studies, both interventions produced statistically significant reductions in pain intensity, improvements in cervical range of motion (ROM), and enhancements in functional recovery as measured by the Neck Disability Index (NDI), reflecting their therapeutic value in this population (21). However, the McKenzie protocol consistently demonstrated superior outcomes across all primary endpoints, achieving greater pain reduction (mean difference 1.4 points on the VAS), larger gains in ROM (flexion: +8°, extension: +7°, rotation: +4°), and greater improvement in functional disability (mean NDI reduction difference 7.5 points), with large effect sizes supporting clinical relevance.

These findings align with recent reports that emphasize the biomechanical rationale underpinning McKenzie-based interventions, where repeated end-range loading, particularly in extension, promotes centralization of symptoms, reduction of mechanical deformation at the nerve root, and restoration of spinal segmental alignment (22). This mechanistic focus contrasts with Mulligan SNAGs, which prioritize immediate symptomatic relief and articular glide facilitation but may lack the progressive self-management component inherent to McKenzie's approach (23). Our results also corroborate those of Abdel-Aziem et al., who reported greater improvements in cervical ROM following McKenzie-based therapy versus deep neck flexor exercises, reinforcing the clinical relevance of extension-dominant protocols for cervical derangement syndromes (24). Similarly, Edmond et al. previously demonstrated that McKenzie therapy outperformed manual

therapy in achieving sustained functional improvements in patients with chronic cervical pain, a pattern mirrored in our population with MRI-confirmed radiculopathy (25).

Notably, the magnitude of improvement observed in our McKenzie cohort exceeded minimal clinically important differences (MCID) for both pain (≥ 2 -point reduction in VAS) and functional disability (≥ 10 -point reduction in NDI), suggesting that these changes were not only statistically significant but also clinically meaningful. The greater proportion of McKenzie-treated patients exceeding these MCID thresholds (73% vs. 40% in the Mulligan group) underscores its practical impact in rehabilitation settings where achieving functional milestones is critical for reducing long-term disability risk (26). Our data also reveal a stronger correlation between reductions in pain and disability among McKenzie-treated patients ($r = 0.77$) relative to Mulligan-treated participants ($r = 0.59$), suggesting that McKenzie's structured exercise and postural correction framework may facilitate a more integrated recovery process wherein pain alleviation directly supports functional improvement (27). This relationship has potential clinical implications, as interventions that tightly couple symptomatic relief with functional recovery may accelerate return to work and reduce chronicity risk.

Despite these strengths, several limitations warrant consideration. The study was conducted at a single center with a moderate sample size of 60, which may limit generalizability across broader demographic or healthcare contexts. Furthermore, while short-term outcomes at six weeks were assessed with rigorous blinding of outcome assessors, longer-term sustainability of these benefits remains uncertain and requires future follow-up studies. Additionally, while randomization was stratified for age and gender to ensure baseline balance, other potential confounders such as psychological factors or patient motivation were not formally adjusted for, although adherence rates were uniformly high ($>97\%$ attendance in both groups), supporting the robustness of findings (28). Future research should explore potential synergistic effects of combining McKenzie and Mulligan techniques, given preliminary evidence suggesting additive benefits of multimodal therapy (29). Investigation into underlying neurophysiological mechanisms—such as alterations in nociceptive processing or proprioceptive function—may also elucidate pathways through which these interventions exert their differential effects and guide individualized therapy planning.

In conclusion, this study provides robust comparative evidence indicating that while both McKenzie protocol and Mulligan SNAGs yield clinically and statistically significant improvements in pain, ROM, and functional disability among patients with chronic cervical radiculopathy, the McKenzie protocol consistently achieves superior outcomes with larger effect sizes and a greater proportion of patients attaining clinically meaningful thresholds. These findings support prioritization of McKenzie-based rehabilitation in this patient population, while emphasizing the need for continued research into optimizing and personalizing conservative care strategies for cervical radiculopathy.

CONCLUSION

In this randomized controlled trial involving adults with chronic cervical radiculopathy, both the McKenzie protocol and Mulligan Sustained Natural Apophyseal Glides (SNAGs) produced statistically significant improvements in pain intensity, cervical range of motion, and functional disability after six weeks of intervention. However, the McKenzie protocol demonstrated superior clinical effectiveness across all measured outcomes, yielding greater reductions in pain (mean between-group difference 1.4 points on VAS, $p=0.02$), larger improvements in ROM (e.g., flexion $+8^\circ$, $p=0.04$), and more substantial gains in functional recovery (mean between-group difference in NDI 7.5 points, $p=0.01$), all exceeding minimal clinically important differences. Additionally, the McKenzie group exhibited a stronger correlation between reductions in pain and functional disability ($r=0.77$), suggesting a more integrated therapeutic effect. These results provide statistically robust and clinically meaningful evidence supporting the preferential use of the McKenzie protocol in rehabilitation protocols for patients with chronic cervical radiculopathy. Future research should examine long-term outcomes, broader patient populations, and potential benefits of combining these two therapeutic approaches to further optimize non-surgical management strategies.

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