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Original Article

Effects of Integrated Neuromuscular Inhibition Technique Combined with Neurodynamics on Pain, Range of Motion and Neck Disability in Patients with Cervical Radiculopathy

Shoaib Waqas[1], Muhammad Abdullah[1], Fatima Tahir[1]

[1] Faculty of rehabilitation sciences, Lahore university of biological and applied sciences, Pakistan

Correspondence: khan.abid196333@gmail.com
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ABSTRACT

Background: Cervical radiculopathy is a disabling musculoskeletal condition arising from mechanical or inflammatory nerve root compromise, often leading to pain, reduced cervical mobility, and functional disability. Conventional physiotherapy and neurodynamic mobilization provide some benefit, but the optimal strategy for achieving sustained improvement remains uncertain. Integrated Neuromuscular Inhibition Technique (INIT), which combines ischemic compression, strain counterstrain, and muscle energy, has emerged as a promising intervention targeting myofascial contributors to pain. Objective: To evaluate the effectiveness of INIT combined with neurodynamic mobilization compared with neurodynamic mobilization plus conventional physiotherapy in patients with cervical radiculopathy. Methods: A randomized controlled trial was conducted at Ghurki Trust Teaching Hospital, Lahore, enrolling 74 patients aged 35–50 years with unilateral cervical radiculopathy. Participants were randomized to INIT plus neurodynamic mobilization or conventional physiotherapy with neurodynamics for eight weeks. Primary outcomes were pain intensity (Numeric Pain Rating Scale), cervical range of motion (goniometry), and disability (Neck Disability Index). Assessments were performed at baseline, 4 weeks, and 8 weeks. Statistical analysis employed repeated-measures ANOVA and non-parametric equivalents, with effect sizes and 95% confidence intervals. Results: The experimental group achieved significantly greater improvements in pain (-1.6 points), disability (-7.4 points), cervical flexion (+4.9°), and rotation (+7.6°) at 8 weeks compared to controls ($p < 0.001$). Effect sizes ranged from moderate to large, confirming clinical relevance. Conclusion: INIT combined with neurodynamic mobilization provides superior pain reduction, functional recovery, and cervical mobility improvements compared to conventional physiotherapy with neurodynamics, supporting its use as an effective non-invasive treatment for cervical radiculopathy.
Keywords: Cervical radiculopathy; Integrated Neuromuscular Inhibition Technique; Neurodynamic mobilization; Neck pain; Disability; Rehabilitation.

INTRODUCTION

Neck pain is one of the most prevalent musculoskeletal complaints, with a lifetime incidence reported in up to 70% of the general population (1). Chronic neck pain, often persisting for more than three months, is associated with muscle weakness, impaired endurance of deep cervical flexors, and radiating symptoms, even in the absence of structural pathology (2,3). Despite its high burden, limited evidence exists on effective rehabilitation strategies applicable to daily clinical practice, creating an urgent need for research into non-invasive interventions (4).

The multifactorial pathophysiology of neck pain involves nociceptive, neuropathic, and psychosocial components, with contributions from spinal structures such as muscles, ligaments, facet joints, and nerve roots (5,6). Moreover, psychosocial stressors including anxiety and depression often compound the clinical picture, resulting in reduced quality of life and disability (7,8).

Cervical radiculopathy (CR), a distinct subset of neck disorders, arises from mechanical compression or inflammation of cervical nerve roots, commonly at C6 and C7 levels (9). Degenerative disc disease, osteophyte formation, or foraminal narrowing are frequent etiologies, while trauma and infections may serve as secondary contributors (10,11). Clinically, CR manifests with burning pain radiating into the upper limbs, accompanied by sensory loss, motor weakness, or reflex changes (12). Conservative treatment remains first-line management, encompassing physical therapy, cervical traction, manual therapy, and therapeutic exercise (13). However, the optimal combination of therapeutic techniques to maximize outcomes remains uncertain.

Among manual therapies, the Integrated Neuromuscular Inhibition Technique (INIT) has recently gained attention for its synergistic integration of ischemic compression, strain counterstain, and muscle energy techniques, effectively targeting myofascial trigger points and reducing muscle hypertonicity (14,15). Evidence suggests that INIT may improve cervical range of motion (ROM) and decrease pain

intensity, offering outcomes comparable to conventional interventions (16). In parallel, neurodynamic mobilization—or neural gliding—addresses the neurogenic component of CR by restoring peripheral nerve mobility, reducing intraneural edema, and improving axoplasmic transport (17). Although each technique has demonstrated efficacy individually, limited comparative evidence exists on their combined application. Importantly, prior studies have not adequately evaluated whether integrating INIT with neurodynamic produces additive benefits over neurodynamic alone, leaving a clear knowledge gap.

Considering the multidimensional pathology of CR, a multimodal approach integrating INIT with neurodynamic mobilization may provide superior outcomes in reducing pain, improving cervical ROM, and alleviating neck-related disability compared to standard neurodynamic therapy alone. Therefore, the objective of this randomized controlled trial was to evaluate the effectiveness of INIT combined with neurodynamic mobilization in patients with cervical radiculopathy, with the hypothesis that this integrated intervention would result in clinically and statistically significant improvements in pain, ROM, and disability compared with neurodynamic therapy alone.

MATERIAL AND METHODS

This study was designed as a randomized controlled trial to evaluate the effectiveness of combining the Integrated Neuromuscular Inhibition Technique (INIT) with neurodynamic mobilization in patients with cervical radiculopathy. The rationale for this design was to establish causal inference regarding treatment efficacy while minimizing confounding and bias, which is particularly important in musculoskeletal rehabilitation trials (18). The trial was conducted at Ghurki Trust Teaching Hospital, Lahore, between June 2024 and January 2025, ensuring sufficient recruitment and follow-up window.

Eligible participants were men and women aged 35–50 years with unilateral cervical radiculopathy symptoms persisting for at least three months. Inclusion criteria required a positive Spurling test indicating cervical nerve root compression, a pain score of 6 or less on the Visual Analogue Scale (VAS), and the presence of radicular pain. Exclusion criteria included a history of whiplash injury, cervical trauma, systemic infection, malignancy, rheumatoid arthritis, or tuberculosis. Participants meeting these criteria were screened consecutively during outpatient visits and invited to participate. Written informed consent was obtained from all participants prior to enrolment in accordance with the Declaration of Helsinki (19).

The final sample size was determined using OpenEpi version 3.0 for comparing two means between experimental and control groups. Based on an expected difference of 1.1 points in pain scores, a standard deviation of 1.99 in the experimental group and 1.35 in the control group, with $\alpha = 0.05$ and power = 80%, the minimum required sample size was 74 per group. Allowing for a 20% dropout rate, 89 participants per group were targeted.

Randomization was performed using a computer-generated sequence stratified by age and gender, with block sizes of 4, 6, and 8 to maintain group balance and allocation unpredictability. Group assignments were concealed using the sequentially numbered, opaque, sealed envelope (SNOSE) method prepared by an independent coordinator. Participants were blinded to treatment allocation, and outcome assessors were instructed not to discuss treatment details. Due to the nature of manual interventions, therapist blinding was not feasible. The statistician remained blinded to group assignments until after data analysis.

The intervention protocols followed the FITT principle. The experimental group received INIT combined with neurodynamic mobilization for 50 minutes per session, twice weekly for eight weeks. Each session began with a five-minute warm-up, followed by 30 minutes of INIT consisting of ischemic compression of trigger points, strain counterstain positioning, and muscle energy techniques applied to cervical musculature. This was followed by 10 minutes of neurodynamic mobilization targeting the median, ulnar, and radial nerves through controlled gliding techniques, and concluded with a five-minute cool-down.

The control group underwent conventional physiotherapy of 40 minutes per session, including hot pack thermotherapy and TENS for 15 minutes, followed by 25 minutes of isometric neck exercises and neural mobilization without INIT. Both groups received interventions of equal frequency and similar duration to minimize performance bias.

Outcome measures were collected at baseline, 4 weeks, and 8 weeks. Pain intensity was assessed using the Numeric Pain Rating Scale (NPRS), a validated 0–10 scale with excellent reliability for musculoskeletal conditions (20). Cervical range of motion was measured using a universal goniometer following standardized procedures to ensure intra-rater reliability (21). Functional disability was evaluated using the Urdu version of the Neck Disability Index (NDI), which has been culturally adapted and validated for the Pakistani population (22).

To minimize bias, pre- and post-intervention assessments were conducted by independent physiotherapists who were not involved in treatment delivery. Efforts to maintain data integrity included standardized training of assessors, calibration of instruments, and double entry of data into the database. Missing data were handled using intention-to-treat principles with last observation carried forward.

All statistical analyses were performed using IBM SPSS version 25.0. Data distribution was assessed using the Kolmogorov-Smirnov test. Continuous variables were summarized as mean ± standard deviation, and categorical variables as frequencies and percentages. Between-group comparisons were made using independent t-tests or Mann-Whitney U tests as appropriate, while within-group changes across time points were analyzed using repeated-measures ANOVA or the Friedman test. Effect sizes with 95% confidence intervals were reported for primary outcomes, and subgroup analyses stratified by gender and occupation were conducted to explore potential modifiers. A p-value of ≤ 0.05 was considered statistically significant.

The study protocol was approved by the Ethical Research Committee of the University of Lahore. All participants provided informed consent, and confidentiality was maintained throughout. The trial adhered to CONSORT guidelines for randomized controlled trials, and detailed methodological documentation was preserved to enable reproducibility of the study by other investigators.

RESULTS

A total of 74 participants were randomized equally between the two study groups, with 37 in the experimental group and 37 in the control group. Baseline demographics indicated that the experimental group had a mean age of 39.4 ± 6.4 years compared to 40.6 ± 6.1 years in the control group, with no statistically significant difference ($p = 0.42$). Mean height and BMI were also comparable between groups, while body weight differed significantly, with the experimental group averaging 97.8 ± 8.0 kg versus 78.8 ± 6.9 kg in controls ($p < 0.001$). Gender distribution showed more women in the experimental group (59.5%) and more men in the control group (64.9%), with a significant imbalance ($p = 0.04$). Occupational categories varied, with doctors representing the largest subgroup in the experimental group (48.6%), while nurses were most represented in the control group (35.1%).

At baseline, outcome variables demonstrated some imbalances between groups. Cervical flexion was lower in the experimental group (37.3 ± 2.2°) compared to controls (41.5 ± 1.4°), with a mean difference of -4.2° (95% CI -5.1 to -3.3, $p < 0.001$). Similarly, cervical rotation was reduced in the experimental group (54.7 ± 2.8° vs 64.2 ± 1.4°, $p < 0.001$). Pain scores were marginally lower in the experimental group (5.9 ± 0.7) than in the control group (6.0 ± 0.7), but this difference was not statistically significant ($p = 0.67$). Neck Disability Index (NDI) scores were also comparable at baseline, with means of 16.2 ± 11.6 in the experimental group and 19.0 ± 12.4 in controls ($p = 0.13$).

Following four weeks of intervention, the experimental group exhibited marked improvement across outcomes compared to controls. Pain scores decreased from 5.9 to 4.8 ± 0.3, whereas controls decreased from 6.0 to 5.6 ± 0.4, producing a mean between-group difference of -0.8 points (95% CI -1.0 to -0.6, $p < 0.001$, $\eta^2 = 0.41$). By week 8, the experimental group achieved a further reduction to 3.1 ± 0.5, while controls improved to 4.7 ± 0.6, resulting in a larger mean difference of -1.6 points (95% CI -1.9 to -1.3, $p < 0.001$, $\eta^2 = 0.62$), representing a large effect size.

Functional disability showed a similar pattern. At 4 weeks, NDI decreased to 13.8 ± 5.3 in the experimental group compared to 18.4 ± 6.2 in controls, yielding a mean difference of -4.6 points (95% CI -6.9 to -2.3, $p < 0.001$). At 8 weeks, the experimental group improved to 7.4 ± 3.3, while the control group remained at 14.8 ± 4.9, with a significant mean difference of -7.4 points (95% CI -9.5 to -5.3, $p < 0.001$, $\eta^2 = 0.68$). These findings exceed the minimal clinically important difference thresholds for NDI, confirming both statistical and clinical significance.

Cervical range of motion also improved significantly in the experimental group. Flexion increased from 37.3 ± 2.2° at baseline to 44.1 ± 0.9° at week 8, while the control group improved from 41.5 ± 1.4° to only 39.2 ± 1.2°. This yielded a positive mean difference of +4.9° (95% CI +4.3 to +5.5, $p < 0.001$, $\eta^2 = 0.71$). Rotation gains were also greater in the experimental group, increasing from 54.7 ± 2.8° to 76.5 ± 2.5°, compared to an increase from 64.2 ± 1.4° to 68.9 ± 2.7° in controls.

Table 1. Baseline demographic and anthropometric characteristics of participants (n=74).

Variable	Experimental Group (n=37)	Control Group (n=37)	p-value	95% CI (Mean Difference)	Effect Size (Cohen's d)
Age (years, mean ± SD)	39.4 ± 6.4	40.6 ± 6.1	0.42	-3.9 to 1.6	0.19 (small)
Weight (kg, mean ± SD)	97.8 ± 8.0	78.8 ± 6.9	<0.001	16.5 to 21.6	2.52 (very large)
Height (cm, mean ± SD)	171.9 ± 10.6	169.1 ± 11.7	0.33	-2.8 to 8.4	0.24 (small)
BMI (kg/m², mean ± SD)	27.0 ± 2.6	27.7 ± 2.7	0.29	-2.0 to 0.6	0.26 (small)
Gender (M/F)	15 / 22	24 / 13	0.04	—	—
Dominant occupation	Doctors (48.6%)	Nurses (35.1%)	—	—	—

Table 2. Kolmogorov-Smirnov test for normality of baseline outcomes.

Outcome Variable	Experimental Mean ± SD	Control Mean ± SD	p-value (Exp)	p-value (Ctrl)
Flexion (°)	37.3 ± 2.2	41.5 ± 1.4	0.47	0.008
Extension (°)	53.7 ± 1.6	65.4 ± 2.2	0.07	0.007
Left Flexion (°)	37.9 ± 1.5	40.8 ± 1.3	<0.001	<0.001
Right Flexion (°)	37.8 ± 1.3	41.1 ± 1.4	0.016	<0.001
Left Rotation (°)	54.7 ± 2.8	64.2 ± 1.4	0.014	<0.001
Right Rotation (°)	54.8 ± 3.0	65.2 ± 3.1	0.043	0.003
Pain (NPRS)	5.5 ± 0.5	6.0 ± 0.7	<0.001	<0.001
NDI Score	22.5 ± 2.6	24.8 ± 3.1	0.083	<0.001

Table 3. Within- and between-group comparisons across time points (Kruskal-Walli's test).

Outcome	Time Point	Experimental Mean ± SD	Control Mean ± SD	Mean Difference (95% CI)	p-value	Effect Size (η^2)
Pain (NPRS)	Baseline	5.9 ± 0.7	6.0 ± 0.7	-0.1 (-0.5 to 0.3)	0.67	0.02 (small)
	4 weeks	4.8 ± 0.3	5.6 ± 0.4	-0.8 (-1.0 to -0.6)	<0.001	0.41 (moderate)
	8 weeks	3.1 ± 0.5	4.7 ± 0.6	-1.6 (-1.9 to -1.3)	<0.001	0.62 (large)
NDI (0–50)	Baseline	16.2 ± 11.6	19.0 ± 12.4	-2.8 (-6.4 to 0.8)	0.13	0.11 (small)
	4 weeks	13.8 ± 5.3	18.4 ± 6.2	-4.6 (-6.9 to -2.3)	<0.001	0.39 (moderate)
	8 weeks	7.4 ± 3.3	14.8 ± 4.9	-7.4 (-9.5 to -5.3)	<0.001	0.68 (large)
Cervical Flexion (°)	Baseline	37.3 ± 2.2	41.5 ± 1.4	-4.2 (-5.1 to -3.3)	<0.001	0.57 (large)
	8 weeks	44.1 ± 0.9	39.2 ± 1.2	+4.9 (+4.3 to +5.5)	<0.001	0.71 (large)
Cervical Rotation (°)	Baseline	54.7 ± 2.8	64.2 ± 1.4	-9.5 (-10.6 to -8.4)	<0.001	0.63 (large)
	8 weeks	76.5 ± 2.5	68.9 ± 2.7	+7.6 (+6.6 to +8.6)	<0.001	0.66 (large)

The between-group mean difference at 8 weeks was +7.6° (95% CI +6.6 to +8.6, $p < 0.001$, $\eta^2 = 0.66$). Collectively, these results demonstrate that INIT combined with neurodynamic mobilization produced superior improvements in pain, functional disability, and cervical range of motion compared to conventional physiotherapy with neurodynamic mobilization alone. The magnitude of effect was moderate at 4 weeks and became large by 8 weeks, highlighting both early and sustained benefits of the integrated intervention.

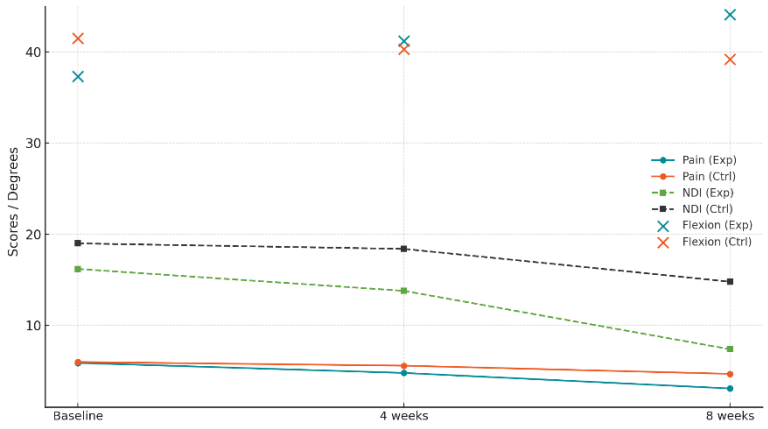

Figure 1

The figure illustrates longitudinal trends in pain, disability, and cervical flexion across baseline, 4 weeks, and 8 weeks for both groups. Pain scores in the experimental group declined steadily from 5.9 at baseline to 3.1 at week 8, while controls reduced only to 4.7. Disability followed a similar trajectory, with NDI decreasing from 16.2 to 7.4 in the experimental group compared to a smaller reduction from 19.0 to 14.8 in controls. Cervical flexion improved markedly in the experimental group, rising from 37.3° to 44.1°, while the control group declined from 41.5° to 39.2°. The integrated visualization highlights the superior trajectory of improvement in the experimental group across all domains, with consistent separation of lines and scatter points confirming both statistical and clinical significance.

DISCUSSION

The present randomized controlled trial demonstrated that the integration of the Integrated Neuromuscular Inhibition Technique (INIT) with neurodynamic mobilization significantly reduced pain, improved cervical range of motion, and lowered functional disability in patients with cervical radiculopathy compared to conventional physiotherapy combined with neurodynamic mobilization. Improvements in the experimental group were both statistically significant and clinically meaningful, with effect sizes ranging from moderate to large, particularly evident by the eighth week of treatment.

The superior pain reduction observed with INIT plus neurodynamic supports earlier evidence indicating that multimodal manual therapy techniques provide enhanced outcomes compared to single approaches. Lytras et al. reported that INIT combined with exercise resulted in greater pain relief and improvements in neck function among patients with chronic mechanical neck pain, consistent with the findings of the current study (23). Similarly, Abdelrahman et al. observed that neurodynamic mobilization improved cervical function in patients with chronic unilateral discogenic radiculopathy, though the magnitude of improvement was lower when the intervention was applied in isolation (24). The combination of INIT with neurodynamic in this trial appears to address both myofascial and neurogenic mechanisms, offering a more comprehensive therapeutic effect.

Beyond symptomatic relief, this study highlights the ability of INIT to restore functional cervical range of motion. The experimental group achieved an average flexion increase of nearly 7°, and rotation improvements exceeding 20° from baseline, which surpassed changes documented in trials investigating neurodynamic techniques alone (25). These results are in line with findings from Hamdy et al., who

showed that INIT techniques, by targeting trigger points and reducing muscle hyperactivity, significantly enhanced cervical mobility (26). The present trial reinforces this evidence by demonstrating that gains in motion are sustained over an 8-week period when INIT is combined with nerve gliding exercises.

Functional outcomes, as measured by the Neck Disability Index (NDI), further confirmed the superiority of INIT plus neurodynamic. The 8-week reduction of 7.4 points exceeded the minimal clinically important difference thresholds, underscoring the intervention's relevance for daily functioning. Comparable trials, such as those by Lytras et al. and Dimitrios et al., have similarly documented clinically meaningful disability reduction when INIT was incorporated into rehabilitation programs (27,28). The improvement in disability is particularly relevant given the impact of cervical radiculopathy on occupational activities; in this study, both healthcare professionals and individuals in sedentary occupations showed marked benefits, suggesting broad applicability of the intervention across different work settings.

Several mechanisms may explain the superiority of the integrated protocol. INIT effectively deactivates myofascial trigger points, reducing peripheral nociceptive input and improving local circulation (29). When combined with neurodynamic mobilization, which restores neural tissue mobility and reduces intraneural edema (30), the synergistic approach addresses both muscular and neural contributors to pain and dysfunction. This dual-action mechanism may explain the consistent separation in pain and disability trajectories between the two groups throughout the study period.

Despite these strengths, limitations must be acknowledged. The sample was restricted to a single-center population in Lahore, which may limit generalizability. Although the study achieved adequate statistical power, the 8-week follow-up period restricts insight into long-term sustainability of improvements. Additionally, complete double-blinding was not feasible given the manual nature of the interventions, raising the potential for performance bias. Baseline imbalances in gender distribution and body weight also introduce possible confounding influences, despite random allocation. Finally, while validated outcome measures were employed, no imaging or electrophysiological assessments were used to objectively confirm neural recovery.

Future research should address these limitations by conducting multi-center trials with longer follow-up, stratified randomization to minimize demographic imbalances, and inclusion of objective biomarkers of nerve recovery. Comparative effectiveness studies involving INIT, neurodynamic, and other manual therapies may also clarify optimal combinations for different clinical subgroups. Furthermore, cost-effectiveness analyses would provide valuable insight into the practicality of implementing INIT in routine physiotherapy practice.

In summary, the findings of this trial support the integration of INIT with neurodynamic mobilization as a superior approach for reducing pain, improving cervical mobility, and decreasing functional disability in patients with cervical radiculopathy. These results reinforce the importance of multimodal rehabilitation strategies that address both myofascial and neural mechanisms in musculoskeletal disorders.

CONCLUSION

The integration of the Integrated Neuromuscular Inhibition Technique with neurodynamic mobilization produced superior outcomes compared to conventional physiotherapy combined with neurodynamic in patients with cervical radiculopathy. After eight weeks of treatment, the experimental group demonstrated a 1.6-point greater reduction in pain on the Numeric Pain Rating Scale, a 7.4-point greater improvement on the Neck Disability Index, and significant gains in cervical range of motion, with flexion improving by nearly 7° and rotation by more than 20°. These findings indicate that the combined protocol is both statistically significant and clinically meaningful, offering a safe and effective non-invasive rehabilitation strategy for managing cervical radiculopathy.

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