RESEARCH PAPER

Effects of Active versus Passive Upper Extremity Neural Mobilization Combined with Mechanical Traction and Joint Mobilization in Females with Cervical Radiculopathy: A Randomized Controlled Trial

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Abstract

Background: Cervical radiculopathy, arising from compression or irritation of a cervical nerve root, produces neck pain, radiating arm pain, sensory disturbance and motor weakness. It disproportionately affects females, who often present with greater pain intensity and disability than males. Conservative management commonly combines neural mobilization, mechanical traction and joint mobilization, but comparative, female-specific evidence on active versus passive neural mobilization protocols remains limited.

Objective: To compare the effects of active versus passive upper extremity neural mobilization, each combined with mechanical traction and joint mobilization, on pain intensity, functional disability and cervical range of motion (ROM) in females with cervical radiculopathy.

Methods: In this randomized controlled trial, 44 females with a clinical diagnosis of cervical radiculopathy were allocated by simple random sampling and computer-generated randomization to an active upper extremity neural mobilization group (Group A, n = 21) or a passive upper extremity neural mobilization group (Group B, n = 23); both groups received 12 treatment sessions over four weeks. The Numeric Pain Rating Scale (NPRS), Neck Disability Index (NDI) and cervical ROM (goniometry) were recorded at baseline and after the intervention period and compared between groups using the independent-samples t-test ($\alpha = 0.05$).

Results: The two groups were equivalent at baseline for NPRS, NDI and ROM (all $p > 0.05$). Across the full sample (N = 44), mean NPRS fell from 7.00 ± 0.81 to 4.18 ± 1.35, NDI fell from 38.77 ± 1.78 to 22.84 ± 3.29, and cervical ROM rose from 50.02 ± 2.16° to 66.05 ± 5.60°. Post-intervention, Group A showed significantly greater improvement than Group B on every outcome: NPRS 3.10 ± 0.77 vs. 5.17 ± 0.94 (mean difference −2.08, $t(42) = -8.00$, $p < 0.001$, $d \approx 2.40$); NDI 19.90 ± 1.45 vs. 25.52 ± 1.88 (mean difference −5.62, $t(42) = -11.03$, $p < 0.001$, $d \approx 3.33$); and cervical ROM 71.29 ± 1.98° vs. 61.26 ± 2.77° (mean difference +10.03, $t(42) = 13.70$, $p < 0.001$, $d \approx 4.13$).

Conclusion: Both active and passive upper extremity neural mobilization combined with mechanical traction and joint mobilization reduced pain and disability and increased cervical ROM in females with cervical radiculopathy over four weeks, with substantially and consistently larger gains in the active-mobilization group across all three outcome domains.

Keywords: cervical radiculopathy; neural mobilization; cervical traction; joint mobilization; Neck Disability Index; women's health; randomized controlled trial

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Introduction

Cervical radiculopathy is a neurological condition arising from compression, irritation or inflammation of one or more cervical nerve roots, typically at the C5–C7 levels, most often secondary to disc herniation, uncovertebral or facet joint spondylosis, or foraminal stenosis.[1,2] The clinical picture includes axial neck pain, pain radiating into the shoulder, arm or hand in a dermatomal pattern, paraesthesia, sensory loss, and in more advanced cases, myotomal weakness and reduced deep tendon reflexes.[1,6] Population-based estimates place the annual incidence of cervical radiculopathy at roughly 83 per 100,000, with peak occurrence in the fifth decade of life, and the condition accounts for a substantial share of work absenteeism and healthcare utilization related to neck and arm pain.[1]

Mechanistically, nerve root compression produces a combination of direct mechanical deformation and a secondary inflammatory cascade: compressed and irritated nerve roots release and are exposed to pro-

inflammatory mediators such as cytokines, prostaglandins and phospholipase A2, which sensitize nociceptors and amplify radicular pain independent of the degree of mechanical compression alone.[3,4] Head posture also modulates symptoms — combined neck extension, lateral flexion and rotation toward the symptomatic side narrows the intervertebral foramen and can reproduce or worsen radicular pain, a relationship exploited clinically in provocation testing.[3] Over time, unaddressed nerve root irritation can lead to adaptive shortening and reduced mobility of the neural tissue itself, which is the physiological rationale underlying neural mobilization as a treatment strategy.[8,9]

Neck and upper-limb musculoskeletal symptoms are increasingly common in adults who spend long periods in flexed postures using computers and mobile devices, and cervical radiculopathy has been reported to disproportionately affect females, who tend to present with higher pain intensity, greater functional disability, and more associated comorbidity than males, at times accompanied by delayed diagnosis and treatment initiation.[2] Despite this disparity, the majority of conservative-treatment trials for cervical radiculopathy have not analyzed or reported outcomes separately by sex, leaving a gap in sex-specific evidence to guide clinical decision-making in this population.

Management of cervical radiculopathy spans a spectrum from pharmacotherapy and structured physical therapy to, in refractory cases, epidural corticosteroid injection or surgical decompression.[5,6] Non-steroidal anti-inflammatory drugs are frequently used for symptomatic relief but carry recognized gastrointestinal, renal and cardiovascular risk with limited evidence of durable long-term benefit, which strengthens the rationale for effective, non-pharmacological conservative approaches.[12] Among these, three modalities feature prominently in the physiotherapy literature. Neural mobilization comprises a family of techniques — delivered either actively by the patient or passively by the therapist — that move the limb and cervical spine through defined sequences intended to restore normal excursion, gliding and vascularity of neural tissue and to reduce mechanical or chemical irritation of the affected nerve root.[8,9] Mechanical cervical traction applies a controlled longitudinal distraction force to the cervical spine, with the aims of enlarging the intervertebral foramen, reducing intradiscal pressure, and relieving compressive load on the nerve root; subgroup analyses of traction for spinal radicular pain suggest it is most effective in patients with a clear radicular component, which supports its use in cervical radiculopathy specifically.[7,10] Joint mobilization uses graded, passive oscillatory or sustained pressure applied to spinal segments to restore accessory joint motion, reduce mechanically-driven pain, and normalize segmental biomechanics.[8,14]

Evidence supporting each of these modalities in isolation is inconsistent, in part because diagnostic criteria for cervical radiculopathy are not standardized across studies, complicating comparison of trial populations and pooling of results.[13] Randomized evidence directly comparing an active, patient-performed neural mobilization protocol against a passive, therapist-delivered protocol — with both combined with traction and joint mobilization, and both restricted to a female cohort — is limited.[9,10] This is a clinically important gap: active and passive neural mobilization differ substantially in treatment cost, therapist contact time, and reliance on correct patient self-administration, so evidence on their comparative effectiveness has direct implications for how conservative care for cervical radiculopathy is structured in practice.

We therefore conducted a randomized controlled trial to compare active versus passive upper extremity neural mobilization, each combined with mechanical traction and joint mobilization, on three outcome domains — pain intensity (Numeric Pain Rating Scale), functional disability (Neck Disability Index) and cervical range of motion — in females with cervical radiculopathy. We hypothesized (alternate hypothesis) that the two treatment approaches would differ in effectiveness on these outcomes, against a null hypothesis of no difference between groups.

Materials and Methods

Study design and setting

This was a prospective, two-arm, parallel-group randomized controlled trial conducted at the Institute of Applied Medicines & Research, Duhai, Ghaziabad, Uttar Pradesh, India. The trial compared two structured, multi-week conservative treatment protocols delivered under the supervision of qualified physiotherapy staff.

Participants

Forty-four females with a clinical diagnosis of cervical radiculopathy were enrolled in the study. Participants were recruited from those presenting for physiotherapy evaluation and management of neck and radiating upper-limb symptoms consistent with cervical nerve root involvement. Diagnosis was based on clinical history and physical examination findings consistent with cervical radiculopathy, in keeping with the diagnostic approach described in the wider literature on the condition.[1,6] Written informed consent was obtained from every participant before enrolment, using a structured consent form that explained the purpose of the study, the procedures involved, the voluntary nature of participation, the right to withdraw at any time without penalty, and the

confidentiality of collected data. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Sampling and randomization

Eligible participants were selected using simple random sampling from among females presenting with cervical radiculopathy at the study site. Selected participants were then allocated to one of the two treatment arms — Group A (active upper extremity neural mobilization) or Group B (passive upper extremity neural mobilization) — using a computer-generated randomization sequence, yielding a final allocation of 21 participants to Group A and 23 participants to Group B.

Operational definitions

- Cervical radiculopathy: a clinical syndrome of neck and radiating upper-limb pain, with or without associated sensory or motor deficit, resulting from compression or irritation of a cervical nerve root.
- Active upper extremity neural mobilization: nerve-gliding movements of the upper limb performed independently by the participant, following instruction and supervision, intended to restore neural tissue excursion and reduce nerve root irritation.
- Passive upper extremity neural mobilization: controlled, therapist-applied movements of the upper limb, performed without active participant effort, intended to achieve the same neural mobilization goal through externally guided motion.
- Mechanical traction: application of a controlled longitudinal distraction force to the cervical spine using a traction unit, intended to decompress neural and articular structures and enlarge the intervertebral foramen.
- Joint mobilization: graded, passive accessory movement applied to cervical spinal segments to restore normal joint mechanics and reduce mechanically mediated pain.

Intervention protocol

Both groups received a total of 12 treatment sessions delivered over a period of four weeks, combining upper extremity neural mobilization (active in Group A, passive in Group B) with mechanical cervical traction and joint mobilization, consistent with the operational definitions above.

Group A — Active upper extremity neural mobilization (n = 21)

Each session for Group A followed a structured four-part format:

- Warm-up (5–10 minutes): general warm-up activity such as stationary cycling or brisk walking, intended to increase local blood flow and prepare soft tissue for mobilization.
- Active upper extremity neural mobilization (15–20 minutes, 3 sessions/week): patient-performed nerve-gliding exercises targeting the affected upper extremity, carried out for 2–3 sets of 10–15 repetitions per session.
- Strength training (15–20 minutes, 3 sessions/week): resistance exercises for the upper extremity musculature, carried out for 2–3 sets of 8–12 repetitions per session, intended to support functional recovery alongside the neural mobilization component.
- Cool-down (5–10 minutes): stretching of the upper extremity musculature to conclude each session.

Group B — Passive upper extremity neural mobilization (n = 23)

Group B received passive upper extremity neural mobilization across the same 12-session, four-week schedule. Therapist-applied controlled movements were used to mobilize the upper limb and affected neural structures without active participant effort, in combination with mechanical traction and joint mobilization applied to the cervical spine, consistent with the operational definitions above.

Outcome measures

- Numeric Pain Rating Scale (NPRS) — an 11-point self-reported scale of pain intensity, anchored at 0 (no pain) and 10 (worst pain imaginable); a widely used, simple and responsive measure of musculoskeletal pain, and the primary outcome of this trial.
- Neck Disability Index (NDI) — a 10-item, self-administered questionnaire covering pain intensity and its impact on personal care, lifting, reading, headache, concentration, work, driving, sleep and recreation; each item is scored 0–5, giving a total range of 0–50, with higher scores indicating greater neck-related disability.
- Cervical range of motion (ROM) — active cervical ROM measured with a goniometer/inclinometer and recorded in degrees, used here as a composite indicator of cervical mobility across the treatment period.

Data collection procedure

All three outcome measures were recorded for every participant at two time points: at baseline, immediately before the first treatment session, and at post-intervention, immediately after completion of the twelfth and final session at the end of the four-week protocol. Data were collected and tabulated for all 44 randomized participants, with no losses to follow-up reported.

Statistical analysis

Descriptive statistics (mean, standard deviation, minimum and maximum) were calculated for NPRS, NDI and ROM at baseline and post-intervention, for the total sample and separately by group. Between-group comparisons at each time point were performed using the independent-samples t-test, with Levene's test used to assess the equality of variances between groups. Statistical significance was set at $\alpha = 0.05$, and analyses were consistent with output conventions of SPSS-style independent-samples t-test reporting (Levene's F and significance, t, degrees of freedom, two-tailed significance, and mean difference).

Results

Forty-four females diagnosed with cervical radiculopathy were randomized: 21 to Group A (active upper extremity neural mobilization) and 23 to Group B (passive upper extremity neural mobilization). All 44 participants completed the full four-week, 12-session intervention and were included in the final analysis.

Pain intensity (NPRS)

Table 1 shows the descriptive statistics for NPRS scores across the full sample (N = 44). Mean NPRS fell from 7.00 ± 0.81 (range 6–8) at baseline to 4.18 ± 1.35 (range 2–6) post-intervention, a reduction of 2.82 points on the 11-point scale across the combined sample.

Table 1. Descriptive statistics for NPRS scores, pre- and post-intervention (N = 44)

Variable	N	Minimum	Maximum	Mean	SD
NPRS Pre	44	6	8	7.00	0.807
NPRS Post	44	2	6	4.18	1.352

Functional disability (NDI)

Table 2 shows NDI scores decreased from 38.77 ± 1.78 (range 35–42) at baseline to 22.84 ± 3.29 (range 18–28) post-intervention, a mean reduction of 15.93 points on the 50-point index.

Table 2. Descriptive statistics for NDI scores, pre- and post-intervention (N = 44)

Variable	N	Minimum	Maximum	Mean	SD
NDI Pre	44	35	42	38.77	1.777
NDI Post	44	18	28	22.84	3.292

Cervical range of motion (ROM)

Table 3 shows cervical ROM increased from 50.02 ± 2.16° (range 45–54°) at baseline to 66.05 ± 5.60° (range 58–75°) post-intervention, a mean gain of 16.03° across the combined sample.

Table 3. Descriptive statistics for cervical range of motion, pre- and post-intervention (N = 44)

Variable	N	Minimum	Maximum	Mean	SD
ROM Pre	44	45	54	50.02	2.162
ROM Post	44	58	75	66.05	5.603

Group-wise comparison

Table 4 presents group-wise descriptive statistics for Group A and Group B at both time points. At baseline, the two groups were closely matched on all three outcomes, consistent with successful randomization. Post-intervention, Group A showed lower pain scores, lower disability scores and greater cervical ROM than Group B on every measure.

Table 4. Group-wise descriptive statistics, pre- and post-intervention

Outcome	Group A (n = 21) Mean ± SD	Group B (n = 23) Mean ± SD
NPRS Pre	7.00 ± 0.84	7.00 ± 0.80
NPRS Post	3.10 ± 0.77	5.17 ± 0.94
NDI Pre	39.00 ± 2.07	38.57 ± 1.47
NDI Post	19.90 ± 1.45	25.52 ± 1.88
ROM Pre (°)	49.76 ± 2.51	50.26 ± 1.81
ROM Post (°)	71.29 ± 1.98	61.26 ± 2.77

Independent-samples t-tests confirmed no significant between-group difference at baseline for any outcome (Tables 5–7, “Pre” rows), but significant differences favoring Group A at post-intervention across all three outcomes (Tables 5–7, “Post” rows). The magnitude of these post-intervention differences was large by conventional standards: the between-group effect size (Cohen's d, calculated from the group means and standard deviations in Table 4) was approximately 2.4 for NPRS, 3.3 for NDI and 4.1 for cervical ROM, all well above the threshold of 0.8 typically used to denote a large effect.

Table 5. Independent-samples t-test for NPRS scores (Group A vs. Group B)

Comparison	Levene's F	Levene's Sig.	t	df	Sig. (2-tailed)	Mean difference
NPRS Pre	0.153	0.698	0.000	42	1.000	0.000
NPRS Post	0.062	0.804	−8.002	42	0.000	−2.079

Table 6. Independent-samples t-test for NDI scores (Group A vs. Group B)

Comparison	Levene's F	Levene's Sig.	t	df	Sig. (2-tailed)	Mean difference
NDI	1.55	0.21	0.80	4	0.4	0.435

Comparison	Levene's F	Levene's Sig.	t	df	Sig. (2-tailed)	Mean difference
Pre	4	9	8	2	24	
NDI Post	0.226	0.637	−11.031	42	0.000	−5.617

Table 7. Independent-samples t-test for cervical ROM (Group A vs. Group B)

Comparison	Levene's F	Levene's Sig.	t	df	Sig. (2-tailed)	Mean difference
ROM Pre	1.535	0.222	−0.761	42	0.451	−0.499
ROM Post	0.264	0.610	13.704	42	0.000	10.025

Note: Table 4 group-wise means/SDs and the Cohen's d estimates above were calculated directly from the participant-level dataset underlying this study; all other reported values (Tables 1–3 and 5–7) are descriptive and inferential statistics as computed for the trial.

Discussion

In this randomized controlled trial, both active and passive upper extremity neural mobilization, each combined with mechanical traction and joint mobilization, were associated with clinically evident reductions in pain intensity and neck disability and increases in cervical range of motion over four weeks in females with cervical radiculopathy. This pattern is consistent with prior reports that neural mobilization techniques can reduce symptoms and improve function across a range of musculoskeletal conditions involving nerve root or peripheral nerve irritation.[9,10] The magnitude of within-sample change was substantial across all three domains: pain fell by nearly three points on an 11-point scale, disability fell by roughly 16 points on the 50-point NDI, and cervical ROM increased by approximately 16° on average, suggesting that the combined treatment package — irrespective of whether the neural mobilization component was active or passive — produced changes that are likely to be clinically, and not merely statistically, meaningful.

Several complementary mechanisms plausibly underlie this improvement. Neural mobilization is thought to restore normal excursion and vascularity of neural tissue and to reduce mechanical or inflammatory irritation of the nerve root itself;[3,4,9] mechanical traction decompresses cervical structures, reduces intradiscal pressure and widens the intervertebral foramen, directly addressing the compressive component of radiculopathy;[7,10] and joint mobilization restores segmental joint mechanics and reduces mechanically driven pain arising from adjacent facet and uncovertebral structures.[8,14] Because these three mechanisms act on distinct but interacting contributors to radicular symptoms — neural tissue mobility, foraminal space, and segmental joint mechanics — their combination in both arms of this trial may explain why even the passive-mobilization group achieved a clear and significant improvement from baseline.

The between-group analysis, however, showed that Group A (active neural mobilization) achieved a substantially and consistently greater improvement than Group B (passive neural mobilization) on all three outcomes, with large effect sizes for pain, disability and ROM alike. This is broadly consistent with case-series evidence that adding neural mobilization to cervical traction improves pain and disability outcomes in cervical radiculopathy,[33] and it parallels findings from other regional musculoskeletal conditions — for example, shoulder impingement syndrome — where structured, active exercise-based interventions such as scapular stabilization training have produced comparable or greater functional gains than passive treatment approaches.[30,31] A plausible explanation for the advantage seen in Group A is dosage: active, patient-performed nerve-gliding exercise can be repeated frequently by the patient throughout the day, whereas a passive technique is necessarily limited to the therapist's direct contact time during a scheduled session, so the cumulative “dose” of neural mobilization delivered to Group A over the four-week protocol was likely considerably higher than that delivered to Group B. A second, complementary explanation is the additional strength-training component included in the Group A protocol, which may have contributed independently to functional gains in disability and range of motion, over and above the neural mobilization technique itself.

These findings are consistent with the study's alternate hypothesis that active and passive upper extremity neural mobilization would differ in effectiveness when combined with traction and joint mobilization, and they argue against the null hypothesis of no difference between the two approaches. Clinically, both protocols in this trial appear to be safe, well-tolerated, non-invasive options that can be incorporated into physical therapy practice for females with cervical radiculopathy, and either represents a reasonable conservative alternative to pharmacotherapy or more invasive management for appropriately selected patients.[5,6,12] Where feasible, however, prioritizing an active, patient-performed protocol may offer a materially larger benefit based on the present results, while still accounting for individual patient preference, capacity to self-administer nerve-gliding exercise with correct technique, and overall clinician judgment regarding the most appropriate approach for a given

patient.

Limitations

- Small, single-sex, single-center sample (N = 44), which may limit the generalizability of findings to broader or more diverse populations, including males and older or younger age groups.
- Short intervention duration (four weeks / 12 sessions), with no long-term follow-up to assess the durability of treatment effects or the rate of symptom recurrence beyond the immediate post-intervention period.
- Outcomes were assessed only at baseline and post-intervention, without interim measurement points that could have characterized the trajectory of improvement over the four-week period.
- Blinding of outcome assessors to group allocation was not described, which may introduce a degree of assessment bias, particularly for the goniometric ROM measurements.
- The unequal group sizes (21 in Group A vs. 23 in Group B) were a product of the randomization process rather than a fixed 1:1 allocation ratio.

Clinical and Research Implications

Both interventions evaluated in this trial are simple, low-cost, non-invasive additions to conservative care for cervical radiculopathy in women and can readily be incorporated into routine outpatient physiotherapy practice without specialized equipment beyond a standard cervical traction unit. Given the substantially larger effect associated with the active protocol across all three outcome domains, clinicians may reasonably consider prioritizing patient-performed nerve-gliding exercise — combined with mechanical traction and joint mobilization — as a first-line conservative approach where patients demonstrate the ability to perform the technique correctly and consistently, reserving passive mobilization for patients who are unable to safely self-administer active neural mobilization. From a research standpoint, these findings support the design of larger, multicenter, adequately powered trials to confirm the comparative effectiveness observed here, ideally incorporating blinded outcome assessment, longer follow-up to evaluate durability of effect, and direct measurement of home-exercise adherence to clarify the contribution of treatment "dose" to the between-group difference identified in this study.

Conclusion

In females with cervical radiculopathy, both active and passive upper extremity neural mobilization combined with mechanical traction and joint mobilization reduced pain and disability and improved cervical range of motion over a four-week treatment period. The active protocol produced significantly and substantially greater improvement than the passive protocol across all three outcomes, with large effect sizes for pain, disability and range of motion alike, suggesting that active, patient-performed neural mobilization may be the preferable first-line component of this combined conservative treatment package in appropriately selected patients.

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