

“ADDITIONAL EFFECT OF NEURAL TISSUE MOBILIZATION ALONG WITH CERVICAL STABILIZATION EXERCISES ON PAIN, FUNCTION, AND DISABILITY IN PATIENTS WITH C6–C7 CERVICAL RADICULOPATHY: A COMPARATIVE EXPERIMENTAL STUDY”

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ABSTRACT

Background

Cervical radiculopathy is a clinically important disorder characterized by cervical nerve-root irritation or compression, frequently resulting in neck and upper-extremity pain, sensory disturbances, weakness, functional limitation, and disability. Exercise-based rehabilitation, particularly cervical stabilization exercise, is commonly incorporated into conservative management. Neural tissue mobilization may additionally address neural mechanosensitivity and impaired neural excursion. However, the additional contribution of neural tissue mobilization when combined with cervical stabilization exercise requires further clinical evaluation.

Objective

To determine the additional effect of neural tissue mobilization combined with cervical stabilization exercises on pain, functional ability, and disability in patients with C6–C7 cervical radiculopathy.

Methods

A comparative experimental pre–post study was conducted in 40 patients aged 30–50 years with unilateral C6–C7 cervical radiculopathy. Participants were allocated into two groups of 20 using a simple lottery method.

Group A received neural tissue mobilization in addition to cervical stabilization exercises, whereas Group B received cervical stabilization exercises alone. Both groups received treatment five days per week for four weeks. Pain, disability, and patient-specific functional ability were assessed using the Numeric Pain Rating Scale (NPRS), Neck Disability Index (NDI), and Patient-Specific Functional Scale (PSFS), respectively. Within-group changes were assessed using paired t-tests and between-group comparisons using independent-samples t-tests. The source study reports assessment of distributional assumptions using the Shapiro–Wilk test.

Results

Both groups demonstrated statistically significant improvements following the four-week intervention. In the NTM+CSE group, mean NDI decreased from 40.65 ± 3.45 to 21.30 ± 2.95 , PSFS increased from 2.65 ± 1.18 to 7.00 ± 1.52 , and NPRS decreased from 7.75 ± 0.91 to 3.75 ± 1.11 ($p < 0.001$ for all comparisons). In the CSE-only group, NDI decreased from 40.40 ± 3.67 to 33.90 ± 4.35 , PSFS increased from 2.65 ± 1.18 to 5.65 ± 1.30 , and NPRS decreased from 7.75 ± 0.91 to 5.50 ± 1.23 ($p < 0.001$ for all comparisons). Between-group post-intervention comparisons demonstrated statistically significant differences for NDI ($p = 0.001$), PSFS ($p = 0.005$), and NPRS ($p = 0.001$), with greater improvement observed in the combined NTM+CSE group.

Conclusion

The addition of neural tissue mobilization to cervical stabilization exercise was associated with greater improvements in pain, patient-specific function, and neck-related disability than cervical stabilization exercise alone in patients with C6–C7 cervical radiculopathy. The findings support further investigation of combined neurodynamic and stabilization-based rehabilitation using larger samples, standardized protocols, and longer-term follow-up.

Keywords

Cervical radiculopathy; C6–C7; neural tissue mobilization; neural mobilization; cervical stabilization exercise; neck disability; pain; patient-specific functional scale; NPRS; NDI.

INTRODUCTION

Cervical radiculopathy is a clinical syndrome resulting from irritation, inflammation, or compression of a cervical spinal nerve root and is commonly characterized by neck pain radiating into the upper extremity, sensory disturbances, motor weakness, and altered reflexes. Cervical disc pathology and degenerative changes such as spondylosis and foraminal narrowing are among the principal structural contributors.^{1,2}

The clinical presentation varies according to the affected nerve root. C6 involvement may produce symptoms extending toward the lateral forearm and thumb, whereas C7 involvement commonly produces posterior arm and forearm symptoms with involvement of the middle finger and possible triceps weakness or reduced triceps reflex.^{1,2} Accurate diagnosis therefore requires integration of history, neurological examination, provocative testing, and, when clinically indicated, imaging and other investigations.^{1,3}

Conservative management remains an important component of care for patients without progressive neurological compromise or other indications for surgical intervention. Physical therapy may include

therapeutic exercise, cervical stabilization, manual therapy, traction, and neural mobilization.^{4–6} Exercise-based interventions have demonstrated beneficial effects on pain, disability, and physical function in patients with cervical radiculopathy.^{7,8}

Cervical stabilization exercises are designed to improve the strength, endurance, neuromuscular control, and functional contribution of the cervical musculature. Stabilization training may improve cervical alignment and sensorimotor control while reducing excessive mechanical loading of cervical structures. Previous research has demonstrated improvements in pain and functional status following stabilization-based rehabilitation.⁹

Neural tissue mobilization is a neurodynamic intervention intended to facilitate neural excursion and reduce abnormal neural mechanosensitivity. Neural mobilization has been proposed to influence nerve mobility, intraneural fluid dynamics, mechanosensitivity, and the ability of neural tissues to tolerate mechanical loading.^{10,11} Clinical studies have reported improvements in pain, disability, and selected functional outcomes following neural mobilization in cervical radiculopathy.^{12–14}

Evidence also suggests that combining manual or neural interventions with therapeutic exercise may provide additional benefits compared with exercise alone. Savva et al. reported beneficial effects of combining cervical traction with neural mobilization in cervical radiculopathy, while other studies have demonstrated improvements following stabilization exercise and multimodal physiotherapy.^{15–18}

Despite these findings, there remains a clinical rationale for evaluating whether adding neural tissue mobilization specifically to a cervical stabilization program provides additional benefit over stabilization exercise alone. The present study therefore examined the effects of neural tissue mobilization combined with cervical stabilization exercises compared with cervical stabilization exercises alone in individuals with C6–C7 cervical radiculopathy.

NEED FOR THE STUDY

Cervical radiculopathy may substantially interfere with activities of daily living because of pain, radiating symptoms, sensory disturbance, weakness, and functional limitation. Although both cervical stabilization exercise and neural mobilization have individually demonstrated therapeutic benefits, comparatively fewer studies have specifically examined their combined application within a structured rehabilitation program for C6–C7 cervical radiculopathy.

The present investigation was therefore undertaken to determine whether the addition of neural tissue mobilization to cervical stabilization exercises could produce greater improvements in pain, patient-specific function, and disability than cervical stabilization exercises alone.

AIM

To determine the additional effect of neural tissue mobilization combined with cervical stabilization exercises on pain, function, and disability in patients with C6–C7 cervical radiculopathy.

OBJECTIVES

1. To determine the effect of cervical stabilization exercises on pain, function, and disability in patients with C6–C7 cervical radiculopathy.
2. To determine whether adding neural tissue mobilization to cervical stabilization exercises produces additional improvement in pain, function, and disability.

HYPOTHESES

Null Hypothesis

There is no significant difference between neural tissue mobilization combined with cervical stabilization exercises and cervical stabilization exercises alone in improving pain, function, and disability in patients with C6–C7 cervical radiculopathy.

Alternative Hypothesis

There is a significant difference between neural tissue mobilization combined with cervical stabilization exercises and cervical stabilization exercises alone in improving pain, function, and disability in patients with C6–C7 cervical radiculopathy.

MATERIALS AND METHODS

Study Design

A comparative experimental pre–post study design was employed.

Study Setting

The study was conducted in the Physiotherapy Department, Career College, Bhopal, Madhya Pradesh, India.

Study Population

The target population comprised patients diagnosed with C6–C7 cervical radiculopathy.

Sample Size

A total of 40 participants meeting the specified eligibility criteria were included.

Participants were divided into:

- **Group A:** NTM + CSE, n=20
- **Group B:** CSE alone, n=20

The source thesis reports that 53 individuals initially volunteered, of whom 40 fulfilled the stated inclusion and exclusion criteria.

Sampling and Allocation

Simple random allocation using a lottery method was reported.

Study Duration

The study duration was reported as 13 months, with an intervention period of four weeks.

ELIGIBILITY CRITERIA

Inclusion Criteria

Participants were included when they fulfilled the following criteria:

- Diagnosed with C6–C7 cervical radiculopathy.
- Age between 30 and 50 years.
- Symptoms present for more than three months.
- Both male and female participants.
- Unilateral upper-extremity radiating pain.
- Positive upper-limb tension test.
- Positive Spurling's compression test.
- Sensory changes corresponding to the involved dermatome.

Exclusion Criteria

Participants were excluded in the presence of:

- Markedly restricted cervical range of motion.
- Cervical myelopathy.
- Cervical fracture or instability.
- Previous cervical surgery.
- Thoracic outlet syndrome.
- Gross neurological deficit.
- Significant psychological/cognitive conditions specified in the original protocol.
- Uncontrolled systemic hypertension.
- Vertebrobasilar insufficiency.
- Cognitive deficits.

INTERVENTION PROTOCOL

Group A: Neural Tissue Mobilization + Cervical Stabilization Exercise

Participants in Group A received neural tissue mobilization in addition to cervical stabilization exercises.

Neural Tissue Mobilization

Neural tissue mobilization primarily targeted the median nerve pathway, with the intervention designed to address neural mobility and mechanosensitivity associated with cervical radiculopathy.

Participants were positioned supine. The affected shoulder was initially maintained in a relatively neutral position to minimize neural strain. Progression toward shoulder abduction and external rotation was undertaken according to participant tolerance.

Controlled elbow, wrist, and finger movements were performed to facilitate neural sliding rather than sustained neural tension. The technique was progressed within a symptom-tolerable range.

The protocol described in the source thesis used median-nerve neurodynamic positioning and repeated distal joint movements to facilitate neural excursion.

Cervical Stabilization Exercises

Cervical stabilization exercises were designed to activate and strengthen the cervical musculature and improve neuromuscular control.

Isometric contractions were performed in:

- Cervical flexion
- Cervical extension
- Right lateral flexion
- Left lateral flexion
- Right rotation
- Left rotation

Each contraction was maintained for approximately 6–10 seconds and repeated 10 times in each direction. Resistance-band progression was used according to tolerance and improvement in strength.

Group B: Cervical Stabilization Exercise Alone

Participants in Group B received the cervical stabilization exercise protocol without neural tissue mobilization.

The same cervical stabilization program was delivered, consisting of isometric contractions in flexion, extension, lateral flexion, and rotation.

Treatment Frequency

Both groups received treatment:

5 sessions/week × 4 weeks = 20 treatment sessions.

OUTCOME MEASURES

Numeric Pain Rating Scale

Pain intensity was evaluated using the Numeric Pain Rating Scale (NPRS), ranging from 0 to 10:

- 0 = no pain
- 10 = worst possible pain

The NPRS has established reliability and clinical utility for pain assessment in neck disorders.^{19, 20}

Neck Disability Index

The Neck Disability Index (NDI) was used to evaluate neck-related functional disability. The questionnaire consists of 10 functional domains, with each item scored from 0 to 5, producing a maximum score of 50.

Higher scores represent greater disability.

The NDI is a widely used and validated outcome measure for patients with neck pain and cervical radiculopathy.^{21–23}

Patient-Specific Functional Scale

The Patient-Specific Functional Scale (PSFS) was used to evaluate patient-identified functional limitations.

Scores range from 0 to 10:

- 0 = unable to perform the activity
- 10 = able to perform the activity at the previous level

The PSFS has demonstrated reliability and construct validity in patients with cervical radiculopathy.^{23, 24}

STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS version 21 according to the original study protocol.

Descriptive statistics were used to summarize participant characteristics and outcome measures.

The Shapiro–Wilk test was used to assess distributional assumptions. Because the data were reported as normally distributed, parametric tests were subsequently used.

The following statistical procedures were applied:

- Paired t-test for within-group pre–post comparisons.
- Independent-samples t-test for between-group comparisons.
- Statistical significance was established at **p<0.05**.

The source thesis specifically reports that paired t-tests were used for within-group comparisons and independent t-tests for between-group comparisons.

RESULTS

Participant Characteristics

Forty participants completed the study, with 20 participants in each group.

Table 1. Baseline demographic characteristics

Characteristic	NTM + CSE (n=20)	CSE (n=20)
Mean age (years)	39.65 ± 4.69	40.25 ± 4.88
Male	10 (50%)	11 (55%)
Female	10 (50%)	9 (45%)

The groups were broadly comparable with respect to age and sex distribution.

Within-Group Changes: NTM + CSE Group

Table 2. Pre- and post-intervention outcome measures in the NTM + CSE group

Outcome	Pre-intervention Mean ± SD	Post-intervention Mean ± SD	t	p
NDI	40.65 ± 3.45	21.30 ± 2.95	51.07	<0.001
PSFS	2.65 ± 1.18	7.00 ± 1.52	-26.10	<0.001
NPRS	7.75 ± 0.91	3.75 ± 1.11	27.56	<0.001

Participants receiving the combined intervention demonstrated statistically significant improvement in all three outcome measures.

Mean NDI decreased by **19.35 points**, indicating a substantial reduction in disability.

Mean PSFS increased by **4.35 points**, indicating improved patient-specific functional performance.

Mean NPRS decreased by **4.00 points**, indicating a clinically meaningful reduction in reported pain intensity.

The source thesis reports $p=0.001$ for all three within-group comparisons.

Within-Group Changes: CSE Group

Table 3. Pre- and post-intervention outcome measures in the CSE-only group

Outcome	Pre-intervention Mean $\pm$ SD	Post-intervention Mean $\pm$ SD	t	p
NDI	40.40 $\pm$ 3.67	33.90 $\pm$ 4.35	12.36	<0.001
PSFS	2.65 $\pm$ 1.18	5.65 $\pm$ 1.30	-18.49	<0.001
NPRS	7.75 $\pm$ 0.91	5.50 $\pm$ 1.23	15.75	<0.001

The CSE-only group also demonstrated statistically significant improvement in pain, function, and disability following the four-week intervention.

BETWEEN-GROUP COMPARISON

Table 4. Between-group comparison of post-intervention outcomes

Outcome	NTM + CSE Post Mean $\pm$ SD	CSE Post Mean $\pm$ SD	p
NDI	21.30 $\pm$ 2.95	33.90 $\pm$ 4.35	0.001
PSFS	7.00 $\pm$ 1.52	5.65 $\pm$ 1.31	0.005
NPRS	3.75 $\pm$ 1.11	5.50 $\pm$ 1.23	0.001

The source analysis demonstrated statistically significant between-group differences following treatment for NDI, PSFS, and NPRS.

The combined NTM+CSE group had lower post-treatment disability and pain scores and higher functional scores than the CSE-only group.

MAGNITUDE OF CHANGE

Table 5. Mean change from baseline to post-intervention

Outcome	NTM + CSE	CSE alone	Difference in mean change
NDI	-19.35	-6.50	12.85
PSFS	+4.35	+3.00	1.35
NPRS	-4.00	-2.25	1.75

The combined intervention produced greater absolute improvement across all three outcomes.

For NDI, disability decreased by approximately **47.6%** from baseline in the NTM+CSE group compared with approximately **16.1%** in the CSE group.

For NPRS, pain decreased by approximately **51.6%** in the NTM+CSE group compared with approximately **29.0%** in the CSE group.

For PSFS, functional scores increased by approximately **164.2%** in the NTM+CSE group compared with approximately **113.2%** in the CSE group.

These percentage calculations are descriptive and should not be interpreted as percentage treatment effects.

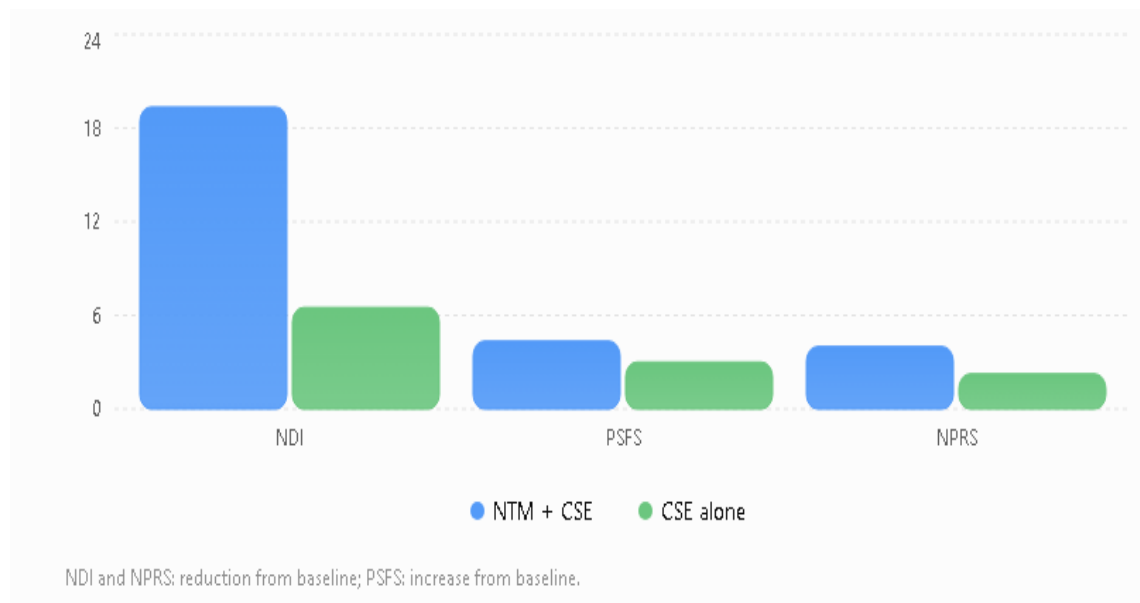


Figure 1. Comparison of mean improvement in NDI, PSFS, and NPRS following the 4-week intervention.

DISCUSSION

The present study investigated whether adding neural tissue mobilization to cervical stabilization exercises produced additional benefits in patients with C6–C7 cervical radiculopathy. The principal finding was that both interventions were associated with significant improvement; however, participants receiving the combined NTM+CSE intervention demonstrated greater post-treatment improvements in pain, patient-specific function, and disability.

The combined group demonstrated a reduction in mean NPRS from 7.75 to 3.75, whereas the CSE-only group demonstrated a reduction from 7.75 to 5.50. Similarly, NDI decreased from 40.65 to 21.30 in the combined group compared with 40.40 to 33.90 in the CSE-only group. PSFS increased from 2.65 to 7.00 in the combined group compared with 2.65 to 5.65 in the CSE group.

These findings are consistent with previous literature suggesting that neural mobilization may provide beneficial effects in individuals with cervical radiculopathy. Kim et al. reported improvements in pain, disability, cervical range of motion, and deep-flexor endurance following neural mobilization in patients with

cervical radiculopathy.¹³ Similarly, Rafiq et al. reported significant improvements in pain and disability following neural mobilization compared with conservative treatment.¹⁴

The findings are also consistent with evidence supporting cervical stabilization exercise. Akkan and Gelecek reported improvements in pain and functional status following stabilization exercise in individuals with cervical radiculopathy.⁹ Exercise-based rehabilitation has also been associated with reductions in pain and disability across studies of cervical radiculopathy.^{7,8}

An important finding of the present study is that cervical stabilization alone was beneficial, but the addition of neural tissue mobilization was associated with greater improvement. This observation is compatible with the concept that cervical radiculopathy involves both mechanical and neural components. Stabilization exercises may improve cervical muscle performance, postural control, and neuromuscular coordination, whereas neural mobilization may address neural mechanosensitivity and impaired neural excursion.

Savva et al. demonstrated beneficial effects of combining neural mobilization with intermittent cervical traction in cervical radiculopathy, reporting improvements in pain, disability, and functional outcomes.¹⁵ Their findings support the potential value of incorporating neurodynamic techniques within multimodal rehabilitation.

The present findings are also compatible with the work of Efstathiou et al., who described several proposed mechanisms through which neural mobilization may influence symptoms, including improvement in neural mobility, reduction in mechanosensitivity, and restoration of normal neural movement.¹⁰ However, these mechanisms should be interpreted as proposed physiological explanations rather than directly demonstrated mechanisms in the present study.

The improvement observed in the CSE-only group is clinically relevant. Cervical stabilization exercises may improve activation and endurance of cervical musculature and contribute to improved control of cervical movement. The present findings therefore do not suggest that stabilization exercise is ineffective; rather, the between-group findings indicate that the addition of neural tissue mobilization was associated with greater improvement within this study population.

Previous systematic reviews and clinical trials have also emphasized the potential value of multimodal physiotherapy for cervical radiculopathy. Manual therapy and therapeutic exercise have been associated with improvements in pain and disability, although heterogeneity in diagnostic criteria, treatment protocols, and outcome measures limits direct comparison between studies.^{16,25}

A possible clinical interpretation is that addressing both cervical neuromuscular control and neural mechanosensitivity may provide complementary therapeutic effects. Stabilization exercises target the muscular and sensorimotor component of cervical dysfunction, while neural mobilization specifically addresses neural tissue mobility. The combination may therefore provide a broader rehabilitation stimulus than either approach alone.

Nevertheless, the present results should be interpreted within the methodological limitations of the study. The sample consisted of only 40 participants from a single clinical setting, and outcomes were evaluated immediately following a four-week intervention without longer-term follow-up. Furthermore, outcomes were primarily based on patient-reported measures, and objective electrophysiological measures were not included.

Consequently, the findings should be regarded as evidence of short-term clinical improvement rather than proof of long-term neural recovery.

CLINICAL IMPLICATIONS

The findings indicate that a rehabilitation program incorporating both cervical stabilization exercise and neural tissue mobilization may be useful for patients presenting with appropriately assessed C6–C7 cervical radiculopathy.

From a physiotherapy perspective, the intervention may be particularly relevant when patients demonstrate:

- Radicular upper-extremity symptoms;
- Neural mechanosensitivity;
- Functional limitation;
- Cervical muscular weakness or impaired endurance; and
- Pain associated with cervical and upper-limb movement.

Clinical application should nevertheless be individualized according to symptom irritability, neurological status, contraindications, and patient tolerance.

LIMITATIONS

The following limitations should be considered:

1. The sample size was relatively small (n=40), which limits statistical precision and generalizability.
2. Participants were recruited from a single clinical setting, potentially limiting external validity.
3. Outcomes were assessed only immediately after the four-week intervention.
4. No medium- or long-term follow-up was available to determine whether treatment effects were maintained.
5. The principal outcome measures were self-reported instruments.
6. Objective neurological, electrophysiological, imaging, or quantitative muscle-strength measures were not incorporated.
7. The study did not provide sufficient information to determine whether treatment adherence, therapist effects, or other potential confounding variables influenced outcomes.

FUTURE RESEARCH

Future investigations should:

- Include larger multicenter samples.
- Use standardized neurodynamic and stabilization protocols.
- Include longer follow-up periods.
- Incorporate objective neurological and strength assessments.

- Consider electrophysiological outcomes where clinically appropriate.
- Examine different cervical nerve-root levels.
- Compare combined NTM+CSE with other multimodal rehabilitation approaches.
- Evaluate clinically important between-group changes using prespecified minimal clinically important difference thresholds.
- Report effect sizes and confidence intervals alongside p-values.

CONCLUSION

In this comparative experimental study of patients with C6–C7 cervical radiculopathy, both cervical stabilization exercise alone and neural tissue mobilization combined with cervical stabilization exercise were associated with significant improvements in pain, patient-specific function, and disability after four weeks.

The combined NTM+CSE intervention demonstrated greater post-intervention improvement than cervical stabilization exercise alone across NPRS, PSFS, and NDI outcomes. The findings suggest that incorporating neural tissue mobilization into a cervical stabilization program may provide additional short-term clinical benefits for appropriately selected patients with C6–C7 cervical radiculopathy.

Larger, multicenter studies with standardized treatment protocols, objective neurological measures, and longer follow-up are warranted to establish the reproducibility and durability of these findings.

DECLARATIONS

Informed Consent

Written informed consent was obtained from participants before their participation in the study, according to the study documentation.

Funding

No external funding was received for this study.

Conflict of Interest

The authors declare that they have no conflict of interest.

Data Availability

The underlying participant-level data were collected as part of the study. Data availability should be stated according to the institutional policy and the requirements of the target journal.

Author Contributions

Dr. Kartik Chhonker: Conceptualization, supervision, study methodology, interpretation of findings, and manuscript development.

Dr. Namrata Srivastava: Academic supervision, methodological review, interpretation, and critical revision of the manuscript.

Dr. Kalpana Jain: Academic support, interpretation of findings, critical review, and manuscript revision.

Dr. Gunjan Shukla: Academic contribution, literature review, interpretation, and critical revision.

All authors: Reviewed and approved the final manuscript and agree to be accountable for the work.

The exact contribution statement should be confirmed by all authors before submission.

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KEY MESSAGE

The addition of neural tissue mobilization to cervical stabilization exercises was associated with greater short-term improvements in pain, patient-specific function, and disability than cervical stabilization exercises alone in patients with C6–C7 cervical radiculopathy.

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