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# Comparative Effectiveness of Neural Mobilization with and without Breathing Re-education on Strength and Endurance of Deep Neck Flexors in Cervical Radiculopathy

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## KEYWORDS

Breathing re-education
Neurodynamics
Neurological dysfunction
Pinched nerve
Radiating pain

## DECLARATIONS

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## ABSTRACT

**Background:** Cervical radiculopathy is a condition of the cervical spine characterized by compression or irritation of the cervical nerve roots due to various pathological causes. It commonly results in radicular symptoms such as pain, numbness, paresthesia, and muscle weakness in the upper limbs. The condition often leads to functional limitations, psychological distress, and decreased quality of life. **Objective:** To evaluate the comparative effectiveness of neural mobilization combined with breathing reeducation versus neural mobilization alone on improving the strength and endurance of deep neck flexor muscles in individuals diagnosed with cervical radiculopathy. **Methodology:** A quasi-experimental study was conducted in the department of physiotherapy, Allied Hospital, Faisalabad, for three months from December 2024 to February 2025. About 40 participants having positive spurling test and Grade 2 strength of cervical flexors, were included in this trial. The participants who had hypertension, malignancy, cervical ribs and those who underwent cervical surgery were excluded. Pain intensity, range of motion, strength of cervical flexors and endurance were assessed through neck disability index, goniometer, manual muscle testing and deep neck flexors endurance test respectively, for pre and post-intervention. Group A received neural mobilization in addition to breathing re-education, while Group B received only neural mobilization. Mean and standard deviation of all variables were calculated. The obtained data were analyzed using a paired-sample t-test. **Results:** Group A demonstrated statistically significant improvements, with p-values <0.00 for visual analogue scale, manual muscle testing, range of motion, and deep neck flexor endurance. In contrast, Group B showed significant improvement only in pain score and deep neck flexor endurance (p=0.04), while changes in manual muscle testing (p=0.08) and range of motion (p=0.16) were not statistically significant. **Conclusion:** The combination of neural mobilization with breathing re-education is more effective than neural mobilization alone in enhancing pain relief, muscle strength, range of motion, and endurance of deep neck flexors in patients with cervical radiculopathy.

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## INTRODUCTION

Cervical radiculopathy is a neurological condition caused by the compression and irritation of one or more nerve roots in the cervical spine[1], leading to symptoms that typically include neck discomfort, radiating pain into the arms, altered sensation, and muscular weakness along the distribution of the affected nerve. This condition is most often linked to degenerative changes in the cervical spine, such as intervertebral disc herniation or cervical spondylosis, but it may also result from trauma or other space-occupying lesions. This disorder can provoke both mechanical compression and biochemical irritation of the cervical nerve roots, contributing to various pathological responses such as neural inflammation, edema, ischemia, fibrosis, hypoxia, and decreased mobility of the nerve tissue.[2] While the exact pathophysiological mechanism behind nerve root irritation is not entirely understood, it is widely believed that inflammatory chemical mediators play a more prominent role in producing radiculopathy symptoms than direct mechanical compression alone.[3]

The annual incidence rate of cervical radiculopathy is approximately 83.2 per 100,000 individuals, with a reported prevalence of 3.5 per 1,000 population. The clinical manifestations typically include unilateral or bilateral neck and arm pain accompanied by sensory or motor disturbances. Although surgical intervention remains an available option, a substantial body of evidence supports the superiority of conservative management approaches, including cervical traction, manual therapy, and targeted strengthening exercises, in the treatment of this condition.[4]

Despite ongoing debate regarding the most effective nonsurgical intervention for cervical radiculopathy, a range of conservative techniques is regularly employed to alleviate symptoms and restore function. One such technique, neural mobilization, has demonstrated effectiveness in various musculoskeletal and neuropathic conditions, such as lower back pain, carpal tunnel syndrome, lateral epicondylitis, and cervicobrachial pain. Neural mobilization is believed to enhance nerve health by improving axoplasmic flow, promoting intraneural circulation, reducing edema, and restoring nerve mobility through the modulation of mechanical pressure and connective tissue dynamics.[5] Nerve gliding or sliding exercises, which strategically position limbs to stretch the nerve tissue, are commonly incorporated into therapeutic regimens for such disorders. However, further clinical investigation is warranted to establish its efficacy specifically in cases of cervical radiculopathy.

Research conducted by Dimitriadis has shown that individuals suffering from chronic neck pain often experience impaired respiratory function, characterized by reduced arterial carbon dioxide levels, decreased maximal voluntary ventilation, and compromised strength of respiratory musculature.[6] Factors contributing to this dysfunction include weakness and reduced endurance of deep neck flexors, impaired proprioception, and disturbed neuromuscular control within the cervical region. These findings indicate a significant link between chronic neck pain and abnormal respiratory patterns.[7]

Consequently, breathing retraining has emerged as an adjunctive relaxation technique in neck pain rehabilitation programs. Re-education of breathing patterns has been found to yield immediate improvements in cervical muscle function, primarily by limiting the overuse of accessory respiratory muscles and thereby reducing compensatory overactivation of deep cervical musculature.[8] Post-treatment analyses have demonstrated that individuals who undergo combined interventions involving both neural mobilization and breathing exercises report better outcomes on the neck disability index (NDI) compared to those receiving isolated interventions.[9]

This study was designed to assess and compare the impact of neural mobilization alone versus its combination with breathing reeducation on the strength and endurance of deep neck flexor muscles in patients diagnosed with cervical radiculopathy.[10] The objective was to enhance cervical mobility, reduce pain levels, and improve the functional range of motion (ROM) through a quasi-experimental clinical trial, taking into account specific variables and outcome measures that have not been thoroughly addressed in prior research.[11,12]

## METHODOLOGY

A quasi-experimental clinical trial was conducted in the department of physiotherapy, Allied Hospital, Faisalabad, for three months from

December 2024 to February 2025. About 40 participants were estimated through sample size calculation and divided into Group A and B, 20 in each group. Ethical clearance was obtained from the Government College University, Faisalabad. The participants were questioned on the cervical pain intensity, restricted ROM and previous history. The participants who met the inclusion criteria, such as a positive spurling test and Grade 2 strength of cervical flexors, were asked to sign the informed consent form to participate in this clinical trial. The participants who had hypertension, malignancy, cervical ribs and those who underwent cervical surgery were excluded. Pain intensity, ROM, strength of cervical flexors and endurance were assessed through NDI, goniometer, manual muscle testing (MMT), and deep neck flexors endurance test, respectively, at baseline, and the same measuring tools were used post-intervention to monitor the participant's progress.

The participants were assessed through the Spurling test, a physical examination technique used to assess cervical radiculopathy, which involves the combination of neck extension, lateral flexion and axial compression and is considered positive if it reproduces the patient's radicular pain. The examiner gently extended and side-bent the neck towards the affected side, and downward pressure was applied to the patient's neck. If it produces the patient's characteristic radicular pain, then it indicates cervical radiculopathy, which was further confirmed through the imaging techniques.[13] Goniometer assessed ROM, endurance and strength were evaluated using the deep neck flexor endurance test and MMT respectively.[14,15]

The participants in intervention group A underwent a 12-week neural mobilization (which consists of mobilization of the median, ulnar and radial nerve) along with breathing re-education, which commenced on the next day after the first examination and continued for three sessions per week. At each session, both interventions were applied to the involved limbs 15 times for 30-second periods with a minute pause between each application.[1] In the rehabilitation sessions, interventions were carried out without producing pain symptoms. Group A received neural mobilization in addition to breathing re-education, while Group B received only neural mobilization. The post-intervention measurements were completed at the end of the 12-week treatment sessions (Table 1). All statistical analysis was done using SPSS version 21. Mean and standard deviation of all variables were calculated and the level of significance was set at $p<0.00$. The obtained data were analyzed using a paired-sample t-test.

## RESULTS

A paired sample t-test was applied to Group 1, in which VAS shows a mean difference of 2.45 at baseline with standard deviation of 0.75, and after applying the intervention, shows a mean difference of 1.45±0.51. Cervical flexion ROM shows a mean difference of 1.35±0.48, and after intervention shows a mean difference of 2.55±0.51. Manual muscle testing shows a mean difference of 1.45±0.6, and after intervention shows a mean difference of 3.95±0.88. Deep neck flexor endurance shows a mean difference of 1.4±0.50, and after intervention shows a mean difference of 2.4±0.5 (Table 2).

Statistical evaluation of results shows that the group which received neural mobilization along with breathing reeducation showed more significant results with a significant p-value of <0.00 as compared to the group which received only neural mobilization. Similarly, a paired sample t-test was applied to Group 2, in which visual analogue scale (VAS) shows a mean difference of 2.5±0.76 at baseline and after intervention shows a mean difference of 2.3±0.8. Cervical flexion ROM shows a mean difference of 1.4±0.5 at baseline, and after intervention shows a mean difference of 1.7±0.57. The MMT shows a mean difference of 1.9±0.78 at baseline, and after intervention shows a mean difference of 2±0.79. Deep neck flexors endurance shows a mean difference of 2.1±0.71 at baseline, and after intervention shows a mean difference of 2.3±0.17 (Table 2).

Statistical results show that VAS and deep flexors endurance show significant results with a p-value of 0.04 on receiving neural mobilization while manual muscle testing and deep neck flexors endurance show non-significant results with a p-value of 0.08 and 0.16, respectively. Though this study has a limited number of participants, the findings show potential outcomes with more significant results. A limited time frame may not show long-term effectiveness or sustainability of improvements. The outcome measures were self-reported, which might be influenced by participant

**Table 1: Intervention plan**

| | |
|---|---|
| Week 1-3 | After performing cervical traction, I incorporated the passive neural glides/ flossing techniques, focused on the nerve involved by cervical radiculopathy, along with pursed lip breathing. Started with session 1-2 sessions per week, and each session was performed for 10-15 minutes. |
| Week 4-6 | Restored the normal cervical function by encouraging the patient to move the affected nerve root in a way that allowed it to slide through the tissue, combined with isometric breathing in the supine position. |
| Week 5-9 | Actively performed the neural gliding/ flossing techniques combined with abdominal breathing in semi-Fowler's position, two sessions per week for 10-15 minutes. |
| Week 10-12 | Strengthening exercises of neck flexors were continued with increased frequency of 2-3 sessions per week for 15-20 minutes combined with abdominal breathing in semi-Fowler's position. |

**Table 2: Paired sample t- test**

| | | | Paired Differences | | | | | t | df. | Sig (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Mean | Std. Deviation | Std. error Mean | 95% Confidence Interval of differences | | | | |
| | | | | | | Lower | Upper | | | |
| Group 1 | Pair 1 | VAS | 1.000 | 0.649 | 0.145 | 0.696 | 1.304 | 6.892 | 19 | <0.001 |
| | Pair 2 | Cervical Flexion ROM | -1.200 | 0.523 | 0.117 | -1.445 | -0.955 | -10.258 | 19 | <0.001 |
| | Pair 3 | MMT | -2.500 | 1.051 | 0.235 | -2.992 | -2.008 | -10.635 | 19 | <0.001 |
| | Pair 4 | Deep Neck Flexors Endurance | -1.000 | 0.459 | 0.103 | -1.215 | -0.785 | -9.747 | 19 | <0.001 |
| Group 2 | Pair 1 | VAS | 0.200 | 0.410 | 0.092 | 0.008 | 0.392 | 2.179 | 19 | 0.042 |
| | Pair 2 | Cervical Flexion ROM | -0.300 | 0.733 | 0.164 | -0.643 | 0.043 | -1.831 | 19 | 0.083 |
| | Pair 3 | MMT | -0.100 | 0.308 | 0.069 | -0.244 | 0.044 | -1.453 | 19 | 0.163 |
| | Pair 4 | Deep Neck Flexors Endurance | -0.200 | 0.410 | 0.092 | -0.392 | -0.008 | -2.179 | 19 | 0.042 |

perception. Lack of follow-up assessments may fail to capture.

## DISCUSSION

The current study compared the effectiveness of neural mobilization with or without breathing re-education for the relief of pain in cervical radiculopathy. The goals were to increase the neck range of motion, decrease the neck disability index, and lessen the amount of pain experienced in the neck. A comparison of pre- and post-intervention scores on NDI and range of motion in Group 1, which received both interventions, revealed statistically significant differences from Group 2, which only received neural mobilization. Pain reduction, cervical ROM, and functional ability all improved more in Group 1 after 8 weeks of intervention. This study demonstrates that the neural mobilization with breathing re-education is

Figure 1: Showing pre- and post-values of cervical flexion range of motion

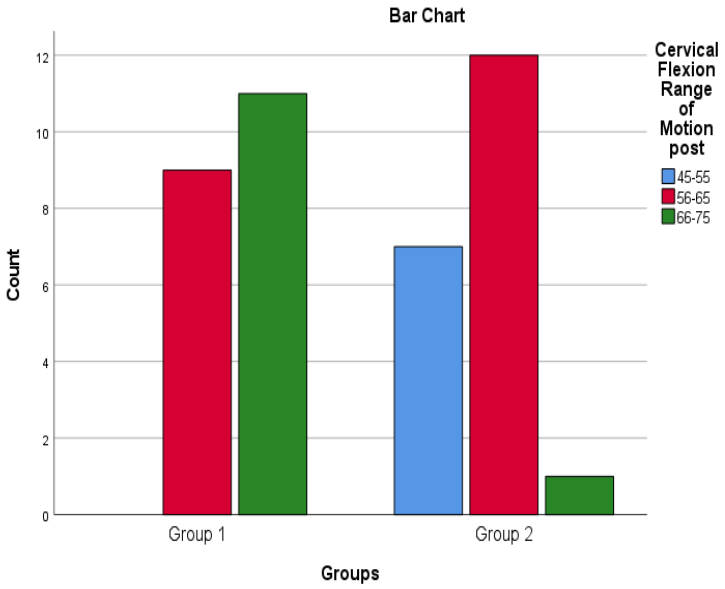



Figure 2: Showing pre- and post-values of visual analogue scale

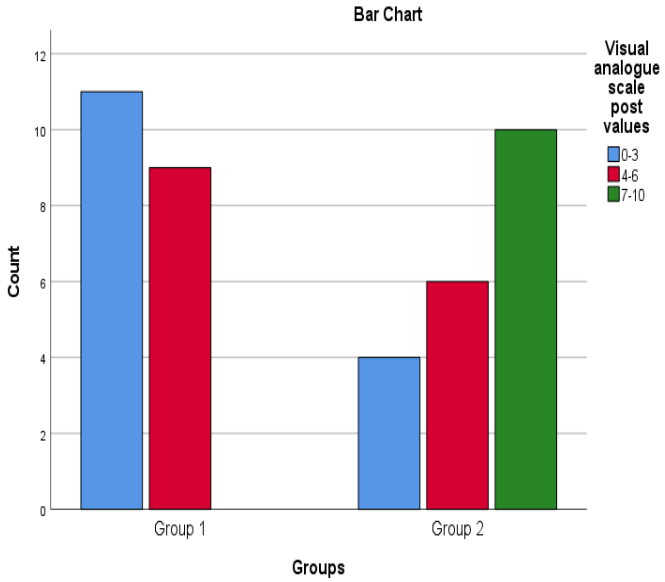
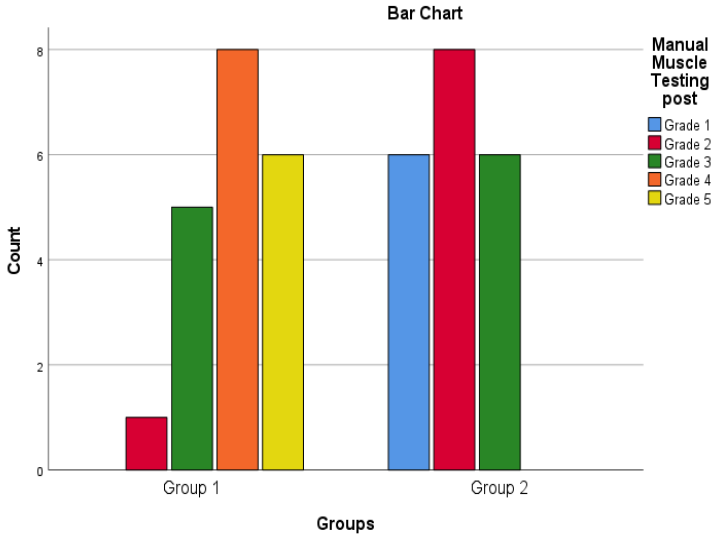



Figure 3: Showing pre- and post-values of manual muscle testing



more effective than neural mobilization alone in improving the strength and endurance of deep neck flexors in individuals with cervical radiculopathy. The results show significant differences between the two groups, with the group receiving breathing re-education exhibiting greater improvements in deep neck flexor strength and endurance.

Though this study has limited number of participants, the findings show potential outcome by having more significant results. Limited time frame may not show long-term effectiveness or sustainability of improvements. The outcome measures were self-reported, that might be influenced by participant perception. Lack of follow-up assessments may fail to capture recurrence or long-term maintenance of benefits.

## CONCLUSION

The present study concluded that both neural mobilization and breathing re-education were effective as an exercise program for patients with cervical radiculopathy; however, neural mobilization proved more effective in reducing pain, improving range of motion and increasing strength and endurance in participants with cervical radiculopathy.

## DECLARATIONS

**Consent to participate:** Written consent had been obtained from patients. All methods were performed following the relevant guidelines and regulations.

**Availability of Data and Materials:** Data will be made available upon request. The corresponding author will submit all dataset files.

**Competing interests:** None

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**Authors' contributions:** All authors had read and approved the final manuscript.

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