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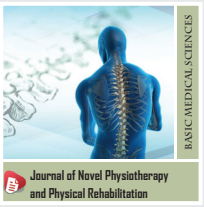

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Research Article

Efficacy of Proprioceptive Neuromuscular Facilitation (PNF) Technique in Patients with Cervical-Originated Arm Pain on Pain and Functional Disability: A Single-Arm Pilot Trial

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Abstract

Background: Cervical-originated arm pain (COAP) occurs when a cervical nerve root is affected, causing pain and muscle weakness that can lead to disability. The PNF technique concentrates on activating both the agonist and antagonist muscle groups to enhance neuromuscular control and improve functional movement patterns. The current study aimed to determine the effectiveness of PNF for cervical-originated arm pain.

Method: 10 patients with COAP received treatment using PNF and conventional physiotherapy for 2 weeks (6 sessions per week). Pre- and post-test data were collected for arm pain using the NPRS 101, neck pain and disability using the NPAD, and upper extremity disability using the Quick DASH Questionnaire, and were analysed.

Results: Results showed statistically significant improvement ($p<0.05$) in all outcomes.

Conclusions: This study concluded that the use of PNF to treat COAP is effective in clinical practice.

Abbreviations

COAP: Cervical-originated arm pain; NPAD: Neck Pain and Disability Index; NPRS: Numeric Pain Rating Scale; PNF: Proprioceptive Neuromuscular Facilitation; Quick DASH: Quick Disabilities of the Arm Shoulder and Hand Questionnaire

Introduction

Cervical-originated arm pain (COAP) refers to discomfort that radiates from the neck down the arm, primarily caused by compression or irritation of a cervical nerve root. This pain may appear as sharp, shooting, or aching and is often accompanied by additional symptoms such as numbness, tingling, muscle weakness, or sensory deficits in the affected arm or hand [1].

Each year, the condition affects approximately 107.3 per 100,000 men and 63.5 per 100,000 women [2]. Globally, the prevalence of neck pain between 2005 and 2011 was reported to be 33.5% [3].

The main underlying cause is the narrowing of the intervertebral foramen, which leads to nerve root impingement and inflammation. Any pathology that irritates the spinal nerve root can cause radicular symptoms [4]. Depending on the specific nerve root involved, pain and related symptoms

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may appear in areas such as the upper neck, shoulder, lateral upper arm, elbow, forearm, thumb, or fingers [5].

Diagnosis usually involves physical examination techniques such as Spurling's Test and Upper Limb Tension Tests [6-8]. The severity of pain is commonly measured using the Numeric Pain Rating Scale (NPRS) [9,10], while the combined assessment of neck pain and functional disability is performed with the Neck Pain and Disability Index (NPAD) [11,12]. The effect on upper limb function can be evaluated using the Quick Disabilities of the Arm, Shoulder, and Hand Questionnaire (Quick DASH) [13].

Research-based studies have demonstrated that cervical radiculopathy is associated with alterations in neuromuscular control involving agonist-antagonist muscle imbalances in the neck: in patients with COAP, tends to be increased co-activation of antagonist muscles, such as splenius capitis during cervical flexion or sternocleidomastoid during extension, which reflects a reorganised motor control strategy that decreases agonist recruitment, reduces maximal force production and increases perceived pain and disability [14]. Moreover, MRI studies have shown that patients with chronic unilateral cervical radiculopathy exhibit atrophy and asymmetry of deep cervical extensors, further perpetuating the imbalance between weakened agonists and compensatory antagonists [15].

Proprioceptive Neuromuscular Facilitation (PNF) has recently been introduced as a therapeutic approach for both mechanical and radicular pain [16]. The technique focuses on engaging both the agonist and antagonist muscle groups to promote neuromuscular control and enhance functional movement patterns [5]. Studies indicate that PNF is an impactful manual therapy intervention in treating neuromuscular conditions. The regulation of posture and movement is connected to proprioceptive or sensorimotor functions [16].

Limited studies have observed the efficacy of PNF to alleviate the symptoms of COAP. Our study aimed to provide information about the effectiveness of PNF on COAP that is essential for clinical decision making and to potentially reduce patients' suffering and enhance their quality of life.

Materials and methods

Study design

A single-arm pilot trial

Ethical statement

The study received approval from the Institutional Ethics Committee. It was conducted following the ethical guidelines of the Declaration of Helsinki (updated 2013) for medical research involving human subjects, as well as the 2017 National Ethical Guidelines for Biomedical and Health Research involving Human Participants from the Indian Council of Medical Research.

Eligibility criteria

Patients of both genders between the ages of 35 and 50 years [2] with neck pain radiating to one side of the upper limb, along with paraesthesia and numbness [2], were included in the study. The patients were tested with Spurling's test to confirm COAP [17]. However, patients were excluded if they had any recent history of trauma to the neck or upper limb region [2], recent surgery of the neck or upper limb on the affected side [18], current use of NSAIDS [18], or vertigo.

Sample size

The pilot single-arm study involved a total of 12 participants (n = 12) [19].

Study participants

The patients who visited the Nopany Physiotherapy clinic were informed by the researchers about the study. Signed written informed consents were obtained from all willing participants. Participants were free to withdraw from the study if they experienced any discomfort during the training period or if, for any reason, they wished to discontinue.

Procedure

Ten patients were included in the study based on subject selection criteria. Baseline (pre-test) data were recorded for neck and arm pain, neck disability, and upper extremity disability using NPRS 101, NPAD, and the Quick DASH Questionnaire, respectively. All patients received a combined treatment of PNF technique and conventional physiotherapy for 2 weeks (6 sessions per week). Conventional treatment involved applying a hot pack for 10 minutes; cervical isometric exercises were performed in 3 sets of 10 repetitions in each direction with 5-second holds. This approach was based on standard clinical practice for managing cervical-originated arm pain, where conservative modalities are commonly used as a baseline treatment to reduce acute symptoms and prepare patients for more active therapeutic interventions. We intended to maintain patient safety and ethical standards, especially considering the study design as a pilot trial. Subsequently, PNF was applied to the neck, scapula, and upper extremity in one set of 10 repetitions. Data were collected again after 2 weeks of intervention and then analyzed.

Intervention description

Proprioceptive Neuromuscular Facilitation: Dynamic Reversal and Repeated Contraction techniques were applied [20].

Dynamic reversal

- The technique began with isotonic contractions of the agonist muscles, followed by contractions of the antagonist muscles against the opposing force applied by the therapist.
- Muscle contraction typically begins with a stronger pattern and ends with a weaker pattern.

Repeated contraction

- This technique started with a quick muscle stretch in isotonic contraction and advanced with resistance,

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achieved through full or limited range based on weakness.

- Stretches were repeated either during a pattern or until the contraction weakened.

PNF patterns: [5,21,22]

	Neck	Scapula	Upper Extremity
Patient's Position	Short sitting position.	Side-lying position.	Supine lying with head and neck out of bed.
Physiotherapist's Position	Behind the right side of the participant.	Behind and facing towards the participant's head.	The patient's treatment side, facing the diagonal, with their hands and arms in motion.
Patterns	1. Flexion- Left-sided lateral flexion – rotation to the left side. 2. Extension - right-sided lateral flexion – rotation to the right side. 3. Flexion-right lateral flexion-right rotation. 4. Extension–left lateral flexion-left rotation. Gentle Traction and resistance were applied with the appropriate command.	1.Anterior Elevation 2. Posterior Depression 3.Anterior Depression 4. Posterior Elevation Gentle resistance was applied with appropriate command.	1. Flexion-adduction-external rotation with the elbow straight. (Conduct head and neck extension while rotating to the left concurrently.) 2. Extension-abduction- internal rotation with the elbow straight. (At the same time, extend your head and neck while rotating your head to the right.) Gentle resistance and stretching were applied with appropriate commands.

Statistical analysis

The statistical analysis was conducted using SPSS version 26.0. Demographic data and patient scores were analysed with descriptive statistics. Data were collected at two stages: baseline (pre-intervention) and after two weeks of intervention (post-intervention). Normality of the data was checked using the Shapiro-Wilk test and was found to be normally distributed (Table 1). The treatment effect was evaluated with the paired t-test, and a p-value of <0.05 was considered statistically significant (Tables 2-4).

Results

The patients were treated according to the PNF protocol. The results were analysed using a paired sample t-test and were reported in tables (Tables 1- 3). The baseline pre-intervention mean NPAD score was recorded, and after two weeks post-intervention, the mean score was taken. Findings from the paired t-test revealed a statistically significant ($p<0.05$) improvement in neck pain and disability. It indicates that the treatment was effective in reducing pain and improving disability in COAP.s

The results, when comparing pre- and post-intervention scores on the NPRS 101 scale, showed a statistically significant improvement ($p<0.05$) in reducing the COAP.

Table 1: Analysis of normality.

Variables	df	p-value
NPAD score difference	11	0.72
NPRS 101 score difference	11	0.40
Quick DASH score difference	11	0.83

Abbreviations: NPAD: Neck Pain and Disability Index, NPRS: Numeric Pain Rating Scale, Quick DASH: Quick Disabilities of the Arm, Shoulder, and Hand Questionnaire.

Table 2: Analysis of Pre and Post NPAD score by paired t-test.

Variable	(Mean ± SD)	t-value	p-value
Pre-intervention NPAD score	52.83± 15.18	4.92	.001*
Post-intervention NPAD score	39.66± 16.08		

Abbreviations: NPAD: Neck Pain and Disability Index

Table 3: Analysis of pre- and post-NPRS 101 scores by paired t-test.

Variable	Mean ± SD	t-value	p-value
Pre-intervention NPRS 101 score	56.33 ± 9.81	7.45	.0001*
Post-intervention NPRS 101 score	38.83± 10.32		

Abbreviations: NPRS: Numeric Pain Rating Scale

Table 4: Analysis of pre- and post-intervention Quick DASH score by paired t-test.

Variable	Mean ± SD	t-value	p-value
Pre-intervention Quick DASH score	50.41 ± 12.68	5.07	.001*
Post-intervention Quick DASH score	36.25 ± 13.90		

Abbreviations: Quick DASH: Quick Disabilities of the Arm, Shoulder, and Hand Questionnaire

The pre- and post-intervention data on upper extremity disability, analysed with the paired t-test, showed a statistically significant improvement ($p<0.05$) in the quick DASH scores, indicating that PNF is an effective treatment for reducing upper extremity disability in patients with neck pain of cervical origin.

Discussion

This single-armed pilot trial aimed to determine the efficacy of proprioceptive neuromuscular facilitation in patients with COAP.

Cervical-origin, which involves peripheral nerve disorders, commonly impairs daily functional activities, leading to painful inactivity and upper limb muscle deconditioning. Radiological studies frequently identify osteophyte formation and cervical disc herniation as the primary lesions, both of which contribute to nerve root compression and inflammation [23].

Neurological symptoms can include sharp, burning pain and electric shock-like sensations, along with sensory and motor disturbances such as numbness, paraesthesia, weakness, or gradual loss of active movement. Conservative and physiotherapeutic treatments are often used to manage these symptoms.

Our study showed that PNF patterns effectively reduced neck and arm pain while improving upper limb function. Patients first underwent hot pack therapy and cervical isometric exercises, followed by the introduction of PNF. Applying a hot pack raises tissue temperature and boosts circulation in the cervical muscles. Isometric exercises help

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strengthen weak muscles without changing muscle length by resisting movement at the involved joints [24,25].

Research indicates that PNF is one of the more effective manual therapies for improving neuromuscular control. It boosts upper limb coordination by activating the proprioceptor, providing increased sensory input during three-dimensional movement patterns. PNF patterns are specifically created to restore sensorimotor integration, thus reducing discomfort and enhancing function [5].

The PNF technique involves specific movement patterns that stimulate neuromuscular activity through proprioceptive activation. This activation increases the excitability of the pyramidal tract, the primary motor pathway, thereby boosting cortical stimulation and improving muscle recruitment through the Golgi tendon organ and muscle spindle. Additionally, the neck PNF pattern has been shown to support proper head and neck posture and mobility, while the scapula and upper limb PNF patterns enhance upper limb function, which likely helps optimize the performance of the proprioceptive system [24].

The contract-relax and hold-relax methods incorporated within the PNF techniques help reduce pain and enhance muscle flexibility through engaging agonist and antagonist muscles at the same time. Stretching, a component of repetitive contraction, improves both active and passive range of motion (ROM), contributing to better functional outcomes for the arm, shoulder, and hand [26].

In this study, the PNF pattern was introduced using PNF techniques such as dynamic reversal and repetitive contraction. These functional PNF movement patterns are task-specific and mimic real-life actions involving three-dimensional motions. The pattern's synergy is vital for minimizing muscle activation [16]. The contract-relax and hold-relax components of the dynamic reversal technique for the upper limb are known to enhance functional movement by reducing pain. Muscle elasticity was achieved through stretching, which is part of repetitive contraction [26]. After completing D1 and D2 patterns in the upper limb, stretching provides feedback to increase active and passive ROM and improve mobility of the arm, shoulder, and hand [24]. Bansal R, et al., in 2020, showed significant improvement with PNF techniques and patterns in cases of radiculopathy and dysfunctions affecting daily activities in cervical spondylosis [5].

The results of this study support a previous one where the combined effects of PNF and the conventional method (cervical isometric exercise) for 12 sessions were evaluated on patients with mechanical neck pain and were found effective in relieving pain and increasing range of motion [26].

The study indicates that PNF may serve as an effective intervention for managing radicular pain sassociated with cervical pathology. But the study is limited to a short intervention duration (2 weeks) with no long-term follow-up to assess sustained benefits.

Future research should use larger and more diverse sample sizes to confirm findings. It can include long-term follow-up assessments to check if therapeutic effects last. Comparing the combined effect of PNF and conservative treatment with only conservative treatment can help determine the isolated effect of PNF. It is also advisable to explore the neurophysiological mechanisms behind PNF benefits using imaging or EMG studies.

Conclusion

The findings of this single-arm pilot trial show that proprioceptive neuromuscular facilitation (PNF) effectively reduces neck and arm pain, enhances functional ability, and lowers disability in patients with COAP. The use of dynamic reversal and repeated contraction PNF techniques promoted neuromuscular activation, improved proprioceptive feedback, and increased upper limb function. These results support the clinical relevance of PNF as a helpful addition to conservative management of cervical radiculopathy-related symptoms.

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