Original Research Article

Effectiveness of Kinetic Control-Based Exercises Combined with Conventional Physiotherapy versus Conventional Physiotherapy Alone in Patients with Mechanical Neck Pain: A Randomized Controlled Trial

**Dr. Binkam Naga Mounika[1], Dr. G. Yatheendra Kumar[2],
Dr. Mohammed Ilyas Hussian[3], Dr. Ilyas Khan[4],
Dr. Mohammed Daleeluddin Talha[5], Dr. Maheen Fatima[6], Dr. Siva Jyothi. N[7],
Dr. Joveria Mubeen[8]**

[1] Assistant Professor - PDS Institute of Physiotherapy, KNR University
[2] Lecture in NIEPID - Secunderabad Telangana.
[3] Tutor- PDS institute of physiotherapy, KNR University
[4] Assistant Professor - PDS Institute of physiotherapy, KNR University
[5] Tutor- PDS Institute of physiotherapy, KNR University
[6] Tutor- PDS Institute of physiotherapy, KNR University
[7] Associate Professor - Durgabai Deshmukh of Physiotherapy, Hyderabad.
[8] Assistant Professor - PDS Institute of physiotherapy, KNR University
[1]Department of Physiotherapy, PDS college of Physiotherapy, Kaloji Narayana Rao (KNR) University, Hyderabad, India.

Corresponding Author: Dr. G. Yatheendra Kumar

ABSTRACT

Background: Mechanical neck pain is a prevalent musculoskeletal condition affecting global populations. While conventional physiotherapy exercises are widely used, kinetic control-based exercises targeting motor control deficits may provide superior outcomes.

Objective: To compare the effectiveness of kinetic control-based exercises combined with conventional physiotherapy versus conventional physiotherapy alone in patients with mechanical neck pain.

Methods: A randomized controlled trial was conducted with 84 participants (aged 25-55 years) diagnosed with mechanical neck pain. Participants were randomly allocated to Group A (kinetic control + conventional exercises, n=42) or Group B (conventional exercises alone, n=42). Both groups received treatment 3 times per week for 6 weeks. Outcome measures included Visual Analog Scale (VAS) for pain, Neck Disability Index (NDI), cervical range of motion (CROM), and pressure pain threshold (PPT). Assessments were conducted at baseline, 3 weeks, 6 weeks, and 3-month follow-up.

Results: Both groups showed significant improvements in all outcome measures ($p<0.001$). Group A demonstrated superior improvements in VAS scores (4.2 ± 1.1 vs 5.8 ± 1.3, $p<0.001$), NDI scores (18.6 ± 4.2 vs 26.4 ± 5.1, $p<0.001$), CROM (flexion: $48.2\pm3.4°$ vs $42.1\pm4.2°$, $p<0.001$), and PPT (2.8 ± 0.4 vs 2.3 ± 0.5 kg/cm², $p<0.001$) compared to Group B at 6 weeks. Improvements were maintained at 3-month follow-up.

Conclusion: Kinetic control-based exercises combined with conventional physiotherapy demonstrated superior effectiveness compared to conventional physiotherapy alone in reducing pain, disability, and improving function in patients with mechanical neck pain.

Keywords: Mechanical neck pain, kinetic control, motor control, cervical spine, physiotherapy, randomized controlled trial

1. INTRODUCTION

Mechanical neck pain represents one of the most prevalent musculoskeletal disorders globally, with an estimated lifetime prevalence ranging from 14.2% to 71% (1). The condition significantly impacts quality of life, work productivity, and healthcare utilization, contributing to substantial socioeconomic burden (2). Traditional management approaches often focus on symptom relief through passive interventions and general exercise programs, with varying degrees of success (3).

The etiology of mechanical neck pain is multifactorial, involving biomechanical dysfunction, muscle imbalances, altered motor control patterns, and psychosocial factors (4). Recent evidence suggests that individuals with chronic neck pain exhibit altered cervical proprioception, reduced muscular endurance, and impaired motor control strategies (5,6). These findings have led to the development of targeted interventions addressing specific motor control deficits.

Kinetic control-based exercises, originally developed by Comerford and Mottram, focus on identifying and correcting movement impairments through specific motor control training (7). This approach emphasizes the restoration of optimal movement patterns, addressing uncontrolled movement segments, and improving neuromuscular control (8). Unlike conventional exercises that primarily target strength and flexibility, kinetic control exercises specifically address movement dysfunction at the segmental level.

While conventional physiotherapy exercises including stretching, strengthening, and mobilization techniques have demonstrated efficacy in managing neck pain (9,10), the addition of specific motor control training may provide enhanced outcomes. Several studies have investigated motor control interventions for neck pain, with promising results regarding pain reduction and functional improvement (11,12).

However, limited research has directly compared the effectiveness of kinetic control-based exercises combined with conventional physiotherapy versus conventional physiotherapy alone in patients with mechanical neck pain. This study aims to address this gap by evaluating the comparative effectiveness of these two treatment approaches.

The primary objective of this study was to compare the effectiveness of kinetic control-based exercises combined with conventional physiotherapy versus conventional physiotherapy alone in reducing pain and disability in patients with mechanical neck pain. Secondary objectives included comparing improvements in cervical range of motion, pressure pain threshold, and functional outcomes between the two treatment groups.

2. MATERIALS & METHODS

2.1 Study Design

This study employed a single-blind, parallel-group, randomized controlled trial design. The study was conducted at PDS college of Physiotherapy, Kaloji Narayana Rao (KNR) University, Hyderabad, India.

2.2 Participants

Participants were recruited from the outpatient physiotherapy department of PDS college of Physiotherapy, Hyderabad between July 2024 and December 2024. Inclusion criteria were: (1) age 25-55 years,

(2) mechanical neck pain for ≥3 months, (3) pain intensity ≥4/10 on Visual Analog Scale, (4) ability to understand and follow instructions, and (5) signed informed consent. Exclusion criteria included: (1) cervical radiculopathy, (2) previous cervical spine surgery, (3) systemic inflammatory conditions, (4) neurological disorders, (5) pregnancy, and (6) contraindications to exercise therapy.

2.3 Sample Size Calculation
Sample size was calculated based on the primary outcome measure (VAS pain score) with an expected mean difference of 1.5 points between groups, standard deviation of 2.0, power of 80%, and alpha level of 0.05. The calculated sample size was 36 per group, increased to 42 per group to account for 15% dropout rate.

2.4 Randomization and Blinding
Participants were randomly allocated to either Group A (kinetic control + conventional exercises) or Group B (conventional exercises alone) using computer-generated random numbers in sealed opaque envelopes. The assessor was blinded to group allocation, while the treating physiotherapist could not be blinded due to the nature of interventions.

2.5 Interventions
Group A: Kinetic Control + Conventional Exercises
Participants received kinetic control-based exercises focusing on:
- Cervical proprioceptive training
- Segmental motor control exercises
- Postural correction techniques
- Deep neck flexor strengthening with motor control emphasis
- Scapular stabilization with kinetic chain integration

Plus conventional exercises including:
- Cervical stretching exercises
- Isometric strengthening
- Range of motion exercises
- Postural education

Group B: Conventional Exercises Alone
Participants received standard physiotherapy including:
- Cervical stretching exercises (upper trapezius, levator scapulae, SCM)
- Isometric strengthening exercises
- Active range of motion exercises
- Postural education and ergonomic advice
- Heat therapy and manual therapy as indicated

Both groups received treatment 3 times per week for 6 weeks, with each session lasting 45 minutes.

2.6 Outcome Measures
Primary Outcomes:
1. Visual Analog Scale (VAS): Pain intensity measured on 0-10 scale
2. Neck Disability Index (NDI): Functional disability assessment

Secondary Outcomes:
1. Cervical Range of Motion (CROM): Measured using digital inclinometer
2. Pressure Pain Threshold (PPT): Assessed using digital algometer
3. Patient Global Impression of Change (PGIC): 7-point Likert scale

2.7 Data Collection
Assessments were conducted at baseline, 3 weeks, 6 weeks (post-treatment), and 3-month follow-up by a blinded assessor. All measurements were taken at the same time of day to minimize circadian variation effects.

3. STATISTICAL ANALYSIS
Data analysis was performed using SPSS version 26.0. Descriptive statistics were calculated for all variables. Normality of data distribution was assessed using the Shapiro-Wilk test. Between-group comparisons were performed using independent t-tests for continuous variables and chi-square tests for categorical variables.

Within-group changes over time were analyzed using repeated measures ANOVA with Bonferroni post-hoc correction. Between-group differences at each time point were assessed using independent t-tests with Bonferroni correction for multiple comparisons. Effect sizes were calculated using Cohen's d, with values of 0.2, 0.5, and 0.8 representing small, medium, and large effects, respectively.

The significance level was set at p<0.05 for all statistical tests. Intention-to-treat analysis was performed for all participants, with the last observation carried forward method for missing data.

4. RESULT

4.1 Participant Characteristics

A total of 94 participants were screened, with 84 meeting inclusion criteria and being randomized (42 per group). Four participants (2 from each group) were lost to follow-up, resulting in 80 participants completing the study (95.2% completion rate).

Table 1: Baseline Characteristics of Participants

Characteristic	Group A (n=42)	Group B (n=42)	p-value
Age (years)	38.4 ± 8.2	39.1 ± 7.9	0.684
Gender (M/F)	18/24	16/26	0.664
BMI (kg/m²)	24.6 ± 3.1	25.1 ± 3.4	0.482
Duration of pain (months)	8.3 ± 4.2	7.9 ± 3.8	0.632
VAS Score	6.8 ± 1.2	6.9 ± 1.1	0.719
NDI Score	42.3 ± 6.4	43.1 ± 6.8	0.576

4.2 Primary Outcomes

Table 2: Primary Outcome Measures Across Time Points

Outcome	Group	Baseline	3 Weeks	6 Weeks	3 Months	Within-group p-value
VAS Score	A	6.8±1.2	5.1±1.0*	4.2±1.1*	4.0±1.0*	<0.001
	B	6.9±1.1	6.2±1.2*	5.8±1.3*	5.9±1.2*	<0.001
NDI Score	A	42.3±6.4	28.4±5.2*	18.6±4.2*	17.2±3.8*	<0.001
	B	43.1±6.8	35.7±6.1*	26.4±5.1*	28.1±5.4*	<0.001

*Significant within-group improvement from baseline (p<0.001)

Between-group comparisons:
- VAS at 6 weeks: Group A vs B (4.2±1.1 vs 5.8±1.3, p<0.001, Cohen's d=1.32)
- NDI at 6 weeks: Group A vs B (18.6±4.2 vs 26.4±5.1, p<0.001, Cohen's d=1.68)

4.3 Secondary Outcomes

Table 3: Cervical Range of Motion (degrees)

Movement	Group	Baseline	6 Weeks	Change	p-value
Flexion	A	38.2±4.1	48.2±3.4*	10.0±2.8	<0.001
	B	37.8±4.3	42.1±4.2*	4.3±2.1	<0.001
Extension	A	52.3±5.2	61.4±4.8*	9.1±3.2	<0.001
	B	51.9±5.1	56.2±5.4*	4.3±2.9	<0.001
R. Rotation	A	58.4±6.2	68.7±5.1*	10.3±3.4	<0.001
	B	57.9±6.1	62.1±6.3*	4.2±2.8	<0.001
L. Rotation	A	57.8±5.9	67.9±5.3*	10.1±3.1	<0.001
	B	58.1±6.2	61.8±6.1*	3.7±2.6	<0.001

*Significant within-group improvement (p<0.001) Between-group differences significant for all movements (p<0.001)

Table 4: Pressure Pain Threshold (kg/cm²)

Location	Group	Baseline	6 Weeks	Change	Between-group p-value
Upper Trapezius	A	1.8±0.3	2.8±0.4*	1.0±0.3	<0.001
	B	1.7±0.4	2.3±0.5*	0.6±0.3	
Levator Scapulae	A	1.9±0.4	2.9±0.5*	1.0±0.4	<0.001
	B	1.8±0.3	2.4±0.4*	0.6±0.3	

*Significant within-group improvement (p<0.001)

4.4 Patient Global Impression of Change
At 6 weeks, 85.7% of Group A participants reported "much improved" or "very much improved" compared to 61.9% in Group B (p=0.012).

4.5 Adverse Events
No serious adverse events were reported. Minor muscle soreness was reported by 3 participants in Group A and 2 in Group B, resolving within 48 hours.

DISCUSSION
This randomized controlled trial demonstrated that kinetic control-based exercises combined with conventional physiotherapy resulted in superior outcomes compared to conventional physiotherapy alone in patients with mechanical neck pain. The findings support the hypothesis that addressing specific motor control deficits enhances treatment effectiveness beyond traditional approaches.

The primary outcome measures showed clinically significant improvements in both groups, with Group A achieving superior results. The mean VAS reduction of 2.6 points in Group A versus 1.1 points in Group B exceeds the minimal clinically important difference of 1.3 points for neck pain (13). Similarly, the NDI improvements of 23.7 points in Group A versus 16.7 points in Group B both exceed the 5-point threshold for clinical significance, though Group A achieved nearly twice the improvement (14).

These findings align with previous research investigating motor control approaches for neck pain. Jull et al. (15) demonstrated that specific exercise targeting deep cervical flexors resulted in superior outcomes compared to general exercise in patients with cervical headache. Similarly, Falla et al. (16) showed that motor control training addressing altered muscle activation patterns improved outcomes in chronic neck pain patients.

The superior improvements in cervical range of motion observed in Group A may be attributed to the specific focus on movement quality and segmental control inherent in kinetic control exercises. Unlike conventional stretching exercises that primarily address tissue length, kinetic control exercises target movement coordination and motor control, potentially addressing underlying movement dysfunction (17). This is consistent with the work of Sarig Bahat et al. (18), who demonstrated that neck pain patients exhibit altered movement patterns that improve with specific motor control training.

The significant improvements in pressure pain threshold observed in Group A suggest that kinetic control exercises may influence central pain processing mechanisms. Previous research has shown that motor control training can reduce central sensitization in chronic pain conditions (19). The integration of proprioceptive training and movement awareness inherent in kinetic control exercises may contribute to improved pain modulation pathways (20).

The maintenance of improvements at 3-month follow-up in Group A suggests that kinetic control training may provide more sustainable benefits compared to conventional exercises alone. This finding is particularly relevant given the recurrent nature of neck pain. The emphasis on movement quality and motor learning in kinetic control exercises may lead to lasting changes in movement patterns and reduced risk of recurrence (21).

Several mechanisms may explain the superior effectiveness of kinetic control exercises. First, the approach addresses specific movement impairments rather than general weakness or stiffness. Second, the emphasis on motor learning and movement quality may lead to improved neuromuscular control and movement efficiency. Third, the integration of proprioceptive training may enhance cervical proprioception, which is often impaired in neck pain patients (22).

The study has several limitations that should be acknowledged. The inability to blind participants and treating physiotherapists may introduce performance bias. However, the use of a blinded assessor minimizes detection bias. The relatively short follow-up period of 3 months limits conclusions about long-term effectiveness. Future studies should include longer follow-up periods to assess sustained benefits. Additionally, the study was conducted in a single center, which may limit generalizability.

The findings have important clinical implications for physiotherapy practice. The integration of kinetic control-based exercises into conventional treatment protocols may enhance outcomes for patients with mechanical neck pain. However, the implementation of kinetic control exercises requires specific training and expertise, which may present challenges for widespread adoption.

Future research should investigate the optimal dosage and progression of kinetic control exercises, identify patient subgroups most likely to benefit from this approach, and evaluate cost-effectiveness compared to conventional treatment. Additionally, biomechanical and neurophysiological studies could provide insight into the mechanisms underlying the superior effectiveness of kinetic control exercises.

CONCLUSION

This randomized controlled trial provides evidence that kinetic control-based exercises combined with conventional physiotherapy are more effective than conventional physiotherapy alone for managing mechanical neck pain. The combination approach resulted in superior improvements in pain, disability, range of motion, and pressure pain threshold, with benefits maintained at 3-month follow-up. These findings support the integration of kinetic control principles into physiotherapy practice for patients with mechanical neck pain.

The study contributes to the growing body of evidence supporting targeted motor control interventions for musculoskeletal conditions. Healthcare practitioners should consider incorporating kinetic control-based exercises into treatment protocols for mechanical neck pain patients, while ensuring appropriate training in these techniques.

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