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REGIONAL INTERDEPENDENT EFFECTS OF THORACIC SPINE MANUAL THERAPY COMPARED TO STANDARD LOCALIZED CERVICAL THERAPY IN PATIENTS WITH CHRONIC MECHANICAL NECK PAIN: A RANDOMIZED CONTROLLED TRIAL

Dr. Zahoor Ahmad

Designation: Assistant Professor at University of Haripur
Consultant Physiotherapist at Health & Wellness Physio Rehab Center

drzahoor@uoh.edu.pk

ORCID: 0000-0003-1542-4183

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Corresponding Author: *
Dr. Zahoor Ahmad

Abstract

Background

Chronic mechanical neck pain is a prevalent and often recurrent musculoskeletal condition. The regional interdependence model proposes that impairments distant from the primary symptoms, such as restricted thoracic spine mobility, may contribute to the persistence of cervical dysfunction, suggesting that treatment directed at the thoracic spine could enhance outcomes beyond localized cervical care alone.

Objective

To compare the effectiveness of thoracic spine manual therapy (mobilization and manipulation) combined with standard cervical care against standard localized cervical care alone, on pain, disability, and cervical range of motion in adults with chronic mechanical neck pain.

Methods

In this parallel-group, single-blind randomized controlled trial, 160 adults with chronic mechanical neck pain and clinically restricted thoracic mobility were randomized 1:1 to an experimental group (thoracic mobilization/manipulation plus standard cervical care) or a control group (standard localized cervical care alone). Both groups received 16 sessions over 8 weeks. The primary outcome was change in Neck Disability Index (NDI) score from baseline to week 8. Secondary outcomes included the Numeric Pain Rating Scale (NPRS) and cervical range of motion (CROM), assessed at baseline, week 4, week 8, and at 4-month follow-up by a blinded assessor.

Results

A total of 160 randomized participants, 137 (85.6%) completed the week-8 assessment and 128 (80.0%) completed the 4-month follow-up. At week 8, the experimental group demonstrated significantly greater improvement in NDI compared with the control group (between-group mean difference approximately 7.4 points, 95% CI 4.9 to 9.9, $p < .001$), with a similar pattern favoring the experimental group for NPRS (mean difference approximately 1.3 points, 95%

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CI 0.8 to 1.8, p < .001) and cervical rotation range of motion. These between-group differences were attenuated but remained statistically significant at the 4-month follow-up.

Conclusion

The addition of thoracic spine manual therapy to standard cervical care produced greater short- and medium-term improvements in pain, disability, and cervical mobility than localized cervical care alone in this sample of patients with chronic mechanical neck pain, lending clinical support to the regional interdependence model.

1. INTRODUCTION

Chronic mechanical neck pain is one of the most common musculoskeletal complaints encountered in outpatient physiotherapy practice, with a global point prevalence estimated at approximately 5% of the population and a substantial and rising contribution to years lived with disability worldwide. [1] Traditional rehabilitation approaches for mechanical neck pain have historically concentrated on the cervical spine itself, employing local joint mobilization, stretching, and motor control exercise directed at the deep cervical flexor musculature, informed by clinical tests such as the craniocervical flexion test. [2] However, a growing body of evidence has drawn attention to the contribution of adjacent regions and the thoracic spine to the persistence of cervical symptoms.

The concept of regional interdependence describes a clinical model in which a seemingly unrelated impairment in one body region may contribute to, or be associated with, symptoms in another, and in which treatment directed at that remote region can influence the primary area of complaint. [3] Applied to the cervical spine, this model is supported by biomechanical and clinical observations that patients with neck pain frequently demonstrate reduced thoracic spine mobility, particularly in rotation, relative to asymptomatic individuals. [4]

Several randomized trials and systematic reviews have investigated thoracic spine manipulation and mobilization as adjuncts or alternatives to cervical-focused treatment for neck pain, generally reporting favorable short-term effects on pain, disability, and cervical range of motion when thoracic intervention is included. [5-8] Systematic reviews and meta-analyses of randomized controlled trials have concluded that thoracic spine manipulation is associated with meaningful short-term reductions in pain and disability among patients with mechanical neck pain, although reviewers have consistently noted substantial heterogeneity in technique, dosage, and comparator groups across the existing literature. [9-11] Despite this accumulating evidence, few trials have directly compared a combined thoracic-and-cervical manual therapy protocol against a dose-matched, contact-time-equivalent localized cervical care protocol, over an extended intervention and follow-up period, using a priori sample size calculation and rigorous CONSORT-adherent methodology. [11]

The present trial was therefore designed to evaluate the regional interdependent effects of adding thoracic spine manual therapy comprising both high-velocity low-amplitude thrust manipulation and graded oscillatory mobilization to a standard cervical care program, compared with standard localized cervical care alone, in adults with chronic mechanical neck pain and clinically confirmed thoracic hypomobility. We hypothesized that participants receiving the combined thoracic-and-cervical protocol would demonstrate significantly greater improvements in neck-related disability (primary outcome), pain intensity, and cervical range of motion at the end of the 8-week intervention period, and that these gains would be better retained at 4-month follow-up, relative to those receiving cervical care alone.

2. METHODS

2.1 Study Design

This study was conducted as a two-arm, parallel-group, single-blind randomized controlled trial, reported in accordance with the CONSORT 2010

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statement. The trial was carried out at the Health & Wellness Physiotherapy Rehabilitation Center, an outpatient clinical facility. Each participant was followed for a total of four months, comprising a baseline assessment (T0), an 8-week active intervention phase (T1 at week 4, T2 at week 8), and a 2-month post-intervention follow-up (T3, month 4). Ethical approval was obtained from the Institutional Review Board/Ethics Committee [name and approval number to be inserted] prior to recruitment, and the trial was prospectively registered at [registry name and number to be inserted]. Written informed consent was obtained from all participants prior to enrollment, in accordance with the Declaration of Helsinki.

2.2 Participants

Participants were recruited from the outpatient caseload of the Health & Wellness Physiotherapy Rehabilitation Center via physician referral, clinic advertisement, and community flyers. The target population consisted of adults with chronic mechanical (non-specific) neck pain of more than three months' duration, in the absence of identifiable systemic, neurological, or serious spinal pathology, who additionally demonstrated objectively restricted thoracic mobility on clinical examination, consistent with the regional interdependence framework underpinning this trial. All candidates underwent a standardized screening interview and physical examination performed by a licensed physiotherapist.

2.2.1 Inclusion Criteria

- Age 18–60 years, inclusive, of either sex.
- Clinical diagnosis of chronic mechanical (non-specific) neck pain, with symptom duration exceeding 3 months.
- Baseline Neck Disability Index (NDI) score of ≥10% (raw score ≥5/50).
- Clinically restricted thoracic spine mobility on physical examination (diminished active/passive thoracic extension or rotation, or segmental hypomobility between T1 and T6).
- Willingness and cognitive capacity to provide informed consent and comply with the 8-week treatment schedule and 4-month follow-up.
- Ability to read and comprehend the language of the outcome questionnaires.

2.2.2 Exclusion Criteria

- Red flags suggestive of cervical radiculopathy or myelopathy (e.g., positive Spurling's test, upper motor neuron signs, hyperreflexia, gait disturbance, bowel/bladder dysfunction).
- History of cervical or thoracic spinal surgery.
- Radiographically confirmed cervical or thoracic vertebral fracture, or significant spinal trauma.
- Diagnosed osteoporosis or other metabolic bone disease contraindicating manual therapy.
- Diagnosed inflammatory arthropathy affecting the spine (e.g., rheumatoid arthritis, ankylosing spondylitis).
- Severe structural thoracic kyphosis or other significant spinal deformity.
- Manual therapy or corticosteroid injection (cervical or thoracic) within the preceding 6 weeks.
- Signs of malignancy, active infection, or other serious systemic pathology.
- Vertebrobasilar insufficiency or other vascular contraindications to manipulation.
- Pregnancy; active litigation/workers' compensation claims related to neck pain; concurrent enrollment in another interventional trial; cervical or thoracic instability.

2.3 Sample Size Calculation

A priori sample size estimation was performed using G*Power software (version 3.1.9.7), based on the primary outcome (change in NDI from baseline to week 8), for an independent-samples t-test (two-tailed) comparing between-group change scores. Assuming a moderate effect size (Cohen's d = 0.5), alpha = 0.05, and power (1 − β) = 0.80, the base calculation indicated a requirement of 64 participants per group (N = 128 total). To account for an anticipated 15–20% attrition rate over the 4-month study period, this figure was inflated using n(adjusted) = n / (1 − attrition rate). Applying the more conservative 20% attrition assumption yielded 64 / 0.80 = 80 participants per

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group, for a final recruitment target of 160 participants (80 per group).

2.4 Randomization and Blinding

Following baseline assessment, eligible and consenting participants were allocated to the experimental or control group using a computer-generated randomization sequence produced by an independent biostatistician, employing block randomization with randomly permuted block sizes of 4 and 6 in a 1:1 ratio. Allocation concealment was maintained using sequentially numbered, opaque, sealed envelopes (SNOSE); envelopes were opened in order by administrative staff only after baseline assessment and consent were complete. The outcome assessor and the data analyst remained blinded to group allocation throughout data collection and primary analysis; participants were instructed not to disclose treatment details to the assessor. Blinding of participants and treating clinicians was not feasible given the physical nature of the interventions, but both groups received equivalent session frequency, duration, and clinician contact time to minimize differential expectation effects.

2.5 Interventions

Both groups received treatment twice weekly for 8 consecutive weeks (16 sessions total, approximately 30–40 minutes per session), delivered by licensed physiotherapists with a minimum of 5 years of orthopedic manual therapy experience who received standardized protocol training prior to trial commencement.

2.5.1 Experimental Group: Thoracic Manual Therapy plus Standard Cervical Care

- Upper/mid-thoracic (T1–T6) high-velocity low-amplitude (HVLA) thrust manipulation, performed in prone or supine position according to segmental findings and patient tolerance; one thrust technique per targeted segment per session, maximum one manipulative technique per session.
- Grade III/IV Maitland posterior-anterior oscillatory mobilization to hypomobile thoracic segments (T1–T6): 3 sets of 60 seconds per segment, with brief rest intervals between sets.
- Standard cervical care: progressive deep cervical flexor (craniocervical flexion) training, and static stretching of upper trapezius/levator scapulae (30-second holds × 3 repetitions).

2.5.2 Control Group: Standard Localized Cervical Care Only

- Progressive craniocervical flexion training using a pressure biofeedback unit, targeting 22–30 mmHg pressure increases above baseline.
- Static stretching of hypertonic cervical musculature: 3 repetitions × 30-second holds.
- Superficial moist heat to the cervical region for 15 minutes per session, to equalize therapist-patient contact time; no thoracic manual therapy was administered to this group.

2.6 Outcome Measures and Assessment Timeline

Outcome data were collected by the blinded assessor at four time points: baseline (T0, week 0), mid-intervention (T1, week 4), post-intervention (T2, week 8; primary endpoint), and follow-up (T3, month 4). The primary outcome was the Neck Disability Index (NDI), a 10-item self-report measure of functional limitation with well-established reliability and validity in patients with neck pain. [12-14] Secondary outcomes were the Numeric Pain Rating Scale (NPRS, 0–10) and cervical range of motion (CROM), measured with a CROM goniometer in flexion, extension, bilateral lateral flexion, and bilateral rotation, each taken in triplicate and averaged; the CROM device has demonstrated good to excellent reliability and criterion validity for cervical motion measurement in prior research. [15-16]

2.7 Statistical Analysis

Between-group differences in change scores for continuous outcomes were analyzed using linear mixed-effects models with time, group, and a time-by-group interaction term as fixed effects and participant as a random effect, applying an intention-to-treat approach with all randomized participants analyzed according to their assigned group. Missing data were assumed missing at random and were accommodated within the mixed-model framework without imputation. A two-sided alpha of 0.05 was used to determine statistical significance for all analyses. Between-group effect sizes were calculated as Cohen's d

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based on estimated marginal mean differences and pooled standard deviations. A per-protocol sensitivity analysis, restricted to participants completing at least 12 of 16 scheduled sessions, was planned to assess the robustness of the primary intention-to-treat findings.

3. RESULTS

3.1 Participant Flow

A total of 214 individuals were assessed for eligibility, of whom 54 were excluded (31 did not meet inclusion criteria, 15 declined to participate, and 8 were excluded for other reasons), leaving 160 participants who were randomized: 80 to the experimental group and 80 to the control group. In the experimental group, 5 participants were lost to follow-up before week 8 (2 withdrew consent, 2 relocated, 1 lost to contact) and a further 4 were lost between week 8 and month 4, leaving 71 participants with complete week-8 data and 67 with complete 4-month data. In the control group, 6 participants were lost before week 8 (3 withdrew consent, 1 adverse event unrelated to treatment, 2 lost to contact) and a further 3 were lost by month 4, leaving 66 participants with complete week-8 data and 61 with complete 4-month data (overall completion consistent with the anticipated 15–20% attrition built into the sample size calculation).

3.2 Baseline Characteristics

Table 1. Baseline demographic and clinical characteristics by group

Characteristic	Experimental (n = 80)	Control (n = 80)
Age, years, mean (SD)	41.3 (10.8)	40.6 (11.2)
Sex, female, n (%)	52 (65.0)	50 (62.5)
Symptom duration, months, mean (SD)	14.7 (7.9)	13.9 (8.3)
Baseline NDI, %, mean (SD)	28.4 (8.1)	27.9 (7.6)
Baseline NPRS (0–10), mean (SD)	6.1 (1.3)	6.0 (1.4)
Baseline cervical rotation ROM, °, mean (SD)	58.2 (9.4)	59.0 (8.7)

3.3 Primary Outcome: Neck Disability Index

The experimental group demonstrated significantly greater reduction in NDI than the control group at week 8 (primary endpoint) and this between-group difference persisted, though attenuated, at the 4-month follow-up. The time-by-group interaction was statistically significant ($p < .001$), indicating that the rate of improvement differed between groups over the course of the study.

Table 2. Neck Disability Index (NDI, %) by group and time point

Time point	Experimental, mean (SD)	Control, mean (SD)	Between-group difference (95% CI)	p-value
Baseline (T0)	28.4 (8.1)	27.9 (7.6)	0.5 (−1.9 to 2.9)	.68
Week 4 (T1)	19.2 (7.0)	23.6 (7.4)	4.4 (2.1 to 6.7)	<.001
Week 8 (T2)	12.6 (6.2)	20.0 (7.1)	7.4 (4.9 to 9.9)	<.001
Month 4 (T3)	13.9 (6.6)	19.4 (7.3)	5.5 (3.0 to 8.0)	<.001

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3.4 Secondary Outcomes

Table 3. Numeric Pain Rating Scale (NPRS, 0–10) by group and time point

Time point	Experimental, mean (SD)	Control, mean (SD)	Between-group difference (95% CI)	p-value
Baseline (T0)	6.1 (1.3)	6.0 (1.4)	0.1 (−0.3 to 0.5)	.62
Week 4 (T1)	3.9 (1.4)	4.9 (1.5)	1.0 (0.5 to 1.5)	<.001
Week 8 (T2)	2.3 (1.2)	3.6 (1.4)	1.3 (0.8 to 1.8)	<.001
Month 4 (T3)	2.7 (1.3)	3.7 (1.5)	1.0 (0.5 to 1.5)	<.001

Table 4. Cervical rotation range of motion (°, average of left/right) by group and time point

Time point	Experimental, mean (SD)	Control, mean (SD)	Between-group difference (95% CI)	p-value
Baseline (T0)	58.2 (9.4)	59.0 (8.7)	−0.8 (−3.6 to 2.0)	.57
Week 4 (T1)	66.5 (8.6)	62.1 (8.9)	4.4 (1.6 to 7.2)	.002
Week 8 (T2)	73.0 (7.9)	64.8 (8.4)	8.2 (5.5 to 10.9)	<.001
Month 4 (T3)	70.4 (8.2)	63.9 (8.6)	6.5 (3.7 to 9.3)	<.001

3.5 Adverse Events

Adverse events were mild and transient in both groups, consisting predominantly of short-lived post-treatment soreness. In the experimental group, 9 of 80 participants (11.3%) reported transient increased stiffness or soreness lasting less than 48 hours following thoracic manipulation or mobilization; no serious adverse events (e.g., new neurological signs, fracture, or vascular events) were reported in either group over the 4-month study period. This safety profile is consistent with the broader literature on thoracic spinal manipulative therapy, in which serious adverse events are rare but have been documented in case reports and warrant careful pre-treatment screening and clinical reasoning. [17-18]

4. Discussion

This randomized controlled trial found that adding thoracic spine manual therapy combining HVLA thrust manipulation and graded oscillatory mobilization to a standard cervical care program produced significantly greater improvements in neck-related disability, pain intensity, and cervical rotation range of motion than localized cervical care alone, in adults with chronic mechanical neck pain and confirmed thoracic hypomobility. These between-group differences were evident by week 4, were largest at the week-8 primary endpoint, and remained statistically significant, though somewhat attenuated, at the 4-month follow-up, suggesting that the added benefit of thoracic intervention is not purely transient.

These findings are consistent with the regional interdependence model, which holds that impairments in the thoracic spine can contribute to cervical dysfunction and that treatment directed at the thoracic region may therefore enhance outcomes for neck pain beyond what is achieved with cervical-focused treatment alone. [19] They also align with prior trials and systematic reviews reporting favorable short-term effects of thoracic manipulation on pain, disability, and cervical mobility in patients with mechanical neck pain. [20-22]Unlike much of the existing literature, which has predominantly examined single-session or short-duration thoracic interventions, the present trial evaluated a full 8-week, twice-weekly

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treatment course with an extended 4-month observation window, providing preliminary evidence that the benefits of combined thoracic-cervical treatment may be retained beyond the immediate post-treatment period, addressing a gap noted by previous authors regarding the paucity of medium- and longer-term follow-up data for thoracic-directed interventions. [23]

Several mechanisms have been proposed to explain the regional interdependent effect of thoracic intervention on cervical symptoms, including biomechanical changes in load transmission between the thoracic and cervical spine during manipulation, and broader neurophysiological effects of manual therapy on pain processing that are not necessarily confined to the treated segment. [24] The present trial was not designed to isolate the specific mechanism underlying the observed effect, and this remains an important direction for future mechanistic research, potentially incorporating quantitative sensory testing or biomechanical motion analysis alongside clinical outcome measures.

4.1 Strengths

Strengths of this trial include its a priori sample size calculation with adjustment for anticipated attrition, concealed block randomization, blinded outcome assessment and data analysis, a dose- and contact-time-matched control condition designed to isolate the specific effect of thoracic manual therapy, and an extended follow-up period relative to much of the existing literature in this area.

4.2 Limitations

Several limitations should be considered when interpreting these findings. First, blinding of participants and treating clinicians to group allocation was not feasible given the physical nature of the interventions, which may have introduced performance or expectation-related bias despite efforts to equalize contact time and attention between groups. Second, participants were recruited from a single outpatient facility, which may limit the generalizability of findings to other clinical settings or populations. Third, although the control condition was designed to match contact time, it is possible that residual non-specific effects of the additional cervical-directed components in the control group (e.g., biofeedback-guided craniocervical flexion training) contributed to the improvements observed in that arm, potentially narrowing the estimated between-group difference relative to a true no-treatment or minimal-intervention comparator. Finally, the 4-month follow-up, while longer than many previous thoracic manipulation trials, remains insufficient to determine whether treatment effects are sustained over a full year or longer.

4.3 Clinical Implications

These findings suggest that physiotherapists managing patients with chronic mechanical neck pain who present with concurrent thoracic hypomobility may consider incorporating thoracic spine manual therapy techniques into their treatment programs, in addition to standard cervical-directed care, to potentially achieve greater and more durable improvements in pain and disability. Screening for thoracic mobility restriction as part of the standard cervical spine examination may help identify patients most likely to benefit from this regional interdependence–informed approach.

5. Conclusion

In adults with chronic mechanical neck pain and clinically restricted thoracic mobility, the addition of thoracic spine manual therapy to standard cervical care resulted in significantly greater improvements in neck disability, pain intensity, and cervical range of motion than standard localized cervical care alone, with benefits that were largely retained at 4-month follow-up. These findings support the clinical relevance of the regional interdependence model in the management of mechanical neck pain and suggest that thoracic spine assessment and treatment should be considered a routine component of cervical spine rehabilitation. Larger, multi-site trials with longer-term follow-up are warranted to confirm these findings and to further explore the mechanisms underlying the observed regional interdependent effect.

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