JHWCR

Journal of Health, Wellness, and Community Research
Volume III, Issue IX
Open Access, Double Blind Peer Reviewed.
Web: https://jhwcr.com, ISSN: 3007-0570
https:// https://doi.org/10.61919/byedj232

Original Article

Comparison of Upper Cervical MWM Versus Cervicothoracic Junction Manipulation on Neck Proprioception in Mechanical Neck Pain

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Author Contributions: Concept: MHM; Design: JIG; Data Collection: MHM; Analysis: MHM; Drafting: MHM
Cite this Article | Received: 2025-05-11 | Accepted 2025-07-04
No conflicts declared; ethics approved; consent obtained; data available on request; no funding received.

ABSTRACT

Background: Mechanical neck pain (MNP) is a prevalent musculoskeletal disorder characterized by pain and disability associated with altered cervical proprioception. Manual therapy interventions such as mobilization with movement (MWM) and cervicothoracic junction (CTJ) manipulation are commonly used, yet their comparative effects on proprioceptive function remain unclear, representing a critical knowledge gap in rehabilitation strategies. Objective: To compare the effectiveness of upper cervical MWM and CTJ manipulation in improving proprioception, pain intensity, cervical range of motion (ROM), and disability in patients with chronic mechanical neck pain. Methods: A single-blind randomized controlled trial was conducted with 68 participants aged 18–45 years with chronic MNP, randomized into two equal groups receiving either MWM or CTJ manipulation combined with conventional physical therapy three times weekly for four weeks. Outcomes included joint position error (JPE), Visual Analog Scale (VAS) for pain, Neck Pain and Disability Scale (NPDS), and cervical ROM. Data were analyzed using non-parametric tests with a significance level of $p \leq 0.05$. Results: Both interventions significantly improved all outcomes ($p < 0.001$). However, MWM produced superior reductions in JPE (median reduction 6° vs 3°, $p < 0.001$), greater pain relief (median VAS reduction 6 vs 4 points, $p < 0.001$), larger NPDS improvements (36 vs 48 points, $p < 0.001$), and greater ROM gains (7–10° vs 3.5–5°, $p < 0.001$). Conclusion: Upper cervical MWM was more effective than CTJ manipulation in improving proprioception, pain, ROM, and disability in individuals with chronic MNP, supporting its preferential use in clinical practice.
Keywords: mechanical neck pain, mobilization with movement, cervicothoracic manipulation, proprioception, disability, range of motion, pain

INTRODUCTION

Mechanical neck pain (MNP) is a prevalent musculoskeletal disorder characterized by localized pain in the cervical spine resulting from strain or dysfunction of muscles, ligaments, or joints, and typically worsened by movement or sustained poor posture (1). Conservative interventions remain the cornerstone of management for MNP, with manual therapy techniques such as mobilization and manipulation forming essential therapeutic approaches (2). Mulligan's mobilization with movement (MWM), developed on the principles of Kaltenborn, involves sustained accessory gliding forces combined with active physiological movements, aiming to correct positional faults, alleviate pain, and improve joint mobility (3). The upper cervical spine, particularly the C1–C2 segments, is rich in mechanoreceptors and plays a critical role in proprioception and movement control, making it a clinically relevant target for interventions designed to enhance cervical sensorimotor function (4).

Proprioceptive deficits are increasingly recognized as a fundamental impairment in individuals with chronic MNP, contributing to altered sensorimotor control and poor postural stability (5). Evidence indicates that individuals with MNP exhibit reduced endurance and delayed activation of deep cervical muscles, highlighting a need to address proprioception as a rehabilitation goal (6). In contrast to the upper cervical region, the cervicothoracic junction (CTJ) represents a biomechanical transition between the mobile cervical and rigid thoracic spine. CTJ hypomobility has been implicated as a contributory factor in cervical dysfunction due to altered load distribution and compensatory cervical hypermobility, emphasizing its therapeutic relevance (7). Manual therapy at the CTJ has been proposed as a method for restoring normal mechanics and reducing nociceptive input from the transitional spinal segment (8). However, despite the well-established role of manual therapy for improving pain and range of motion in MNP, its specific effects on cervical proprioception remain underexplored.

Existing studies provide indirect evidence suggesting potential proprioceptive benefits of manual therapy interventions. For example, Maitland mobilization has shown efficacy in reducing pain and disability, with ancillary improvements in range of motion and proprioceptive accuracy as measured by joint position error (JPE) (9). Similarly, thoracic manipulation has demonstrated moderate effects on pain reduction and functional improvement in patients with neck pain, although with variable effect sizes and methodological heterogeneity (10). Recent research has also highlighted the potential of deep cervical flexor muscle training (DCFMT) to produce superior improvements in proprioception and posture compared to mobilization alone (11). Nevertheless, these studies primarily focus on pain and functional outcomes, with proprioception typically reported as a secondary outcome or using heterogeneous measurement tools, limiting direct comparisons (12).

Moreover, direct comparative studies examining the proprioceptive effects of upper cervical MWM and CTJ manipulation are scarce. Most prior research isolates either intervention without juxtaposing their relative efficacy in a controlled context. This paucity of head-to-head trials constitutes a significant knowledge gap, leaving clinicians uncertain as to which manual therapy approach may confer superior benefits for proprioception rehabilitation in MNP. Given that impaired proprioception is a hallmark of chronic neck pain and an important determinant of sensorimotor dysfunction, resolving this clinical uncertainty is critical for optimizing treatment protocols (13). Additionally, the lack of standardization in proprioceptive assessment, with varying definitions of normative thresholds for JPE, further complicates evidence synthesis and clinical decision-making (14).

Therefore, this study aims to address this gap by comparing the effects of upper cervical MWM and CTJ manipulation on neck proprioception in individuals with mechanical neck pain, using standardized outcome measures, including the JPE test as an objective proprioceptive assessment tool. The rationale for selecting these interventions stems from their distinct biomechanical and neurophysiological targets: MWM directly engages upper cervical joint receptors, while CTJ manipulation seeks to restore regional mechanics and may influence cervical afferent input indirectly (15). By implementing a rigorous randomized controlled trial design, this research seeks to determine whether one technique is superior in improving proprioceptive function, pain intensity, cervical range of motion, and disability.

The research question guiding this investigation is: In adults with chronic mechanical neck pain and documented proprioceptive deficits, does upper cervical mobilization with movement (MWM) yield superior improvements in neck proprioception compared to cervicothoracic junction manipulation over a four-week intervention period? The hypothesis tested is that upper cervical MWM will result in significantly greater improvement in JPE scores, reflecting enhanced proprioceptive accuracy, than CTJ manipulation, supporting its preferential application in clinical practice.

MATERIAL AND METHODS

This study was designed as a single-blinded randomized controlled trial to evaluate and compare the effects of upper cervical mobilization with movement (MWM) and cervicothoracic junction (CTJ) manipulation on proprioception, pain intensity, cervical mobility, and disability in patients with chronic mechanical neck pain (MNP). The study was conducted at Bahria International Hospital and Pain Healers Clinic in Lahore, Pakistan, over a six-month period following approval of the research synopsis. The study rationale was based on the clinical need to determine which manual therapy approach more effectively improves cervical proprioceptive deficits, as prior studies have provided limited direct comparison.

Participants aged 18 to 45 years, of either sex, were eligible if they had a diagnosis of chronic mechanical neck pain lasting longer than three months, a pain score >3 on the Visual Analog Scale (VAS), a positive Cervical Flexion-Rotation Test, proprioceptive deficits confirmed by Joint Position Error (JPE) testing showing deviation >4.5°, and reduced movement at the cervicothoracic junction assessed through passive accessory intervertebral movement (PAIVM) tests (16). Exclusion criteria included history of cervical spine surgery, fracture, or trauma altering biomechanics, neurological signs such as radiculopathy or myelopathy, systemic diseases like rheumatoid arthritis or ankylosing spondylitis, severe osteoporosis, malignancy, pregnancy, or receipt of physical therapy for neck pain within the past three months (16).

A convenience sampling approach was used for initial participant screening. Following verification of eligibility, written informed consent was obtained in both English and Urdu to ensure participant understanding and voluntary participation. The recruitment process involved approaching patients attending outpatient physical therapy clinics during the study period. To minimize selection bias, randomization was performed using a computer-generated randomization table, allocating participants into two groups: Group A (MWM) and Group B (CTJ manipulation), with 34 participants per group. Allocation concealment was ensured through sealed opaque envelopes opened after baseline assessment. Blinding was maintained at the participant level to mitigate performance and response bias.

Data collection occurred at baseline and immediately after completion of the four-week intervention period. The interventions were standardized and delivered three times per week by licensed physical therapists trained in manual therapy techniques to ensure consistency and reproducibility. Group A received upper cervical MWM targeting C1–C2 segments, with therapists applying sustained accessory glides while participants performed active movements in restricted planes. The mobilization force was carefully modulated to remain pain-free and progressed based on patient tolerance and response (17). Group B received CTJ manipulation, consisting of high-velocity, low-amplitude thrusts directed at C7–T1 and T1–T2 segments, following established safety protocols and performed bilaterally regardless of symptomatic side to ensure protocol adherence (18).

Both groups also received conventional physical therapy as a baseline program, including isometric neck exercises, chin tucks, stretching, scapular stabilization, and proprioceptive training, standardized in frequency (three sessions per week), duration (approximately 45 minutes per session), and progression criteria. Variables measured included pain intensity using a 10 cm VAS (19), cervical range of motion (ROM) in flexion, extension, rotation, and side-bending using a universal goniometer (20), functional disability using the Neck Pain and Disability Scale (NPDS) with validated Urdu translation (21), and proprioception via Joint Position Error (JPE) testing using a laser-pointer repositioning method, with deviations recorded in degrees (22). All outcome measures were recorded by independent blinded assessors trained in standardized protocols, using instruments with established reliability and validity.

The primary outcome was improvement in proprioception (JPE score change from baseline), while secondary outcomes included pain intensity, ROM, and NPDS score changes. To mitigate confounding and ensure data integrity, baseline demographic variables (age, sex, BMI) were recorded and evaluated for between-group equivalence. Missing data were handled using last observation carried forward (LOCF) imputation if participants withdrew after baseline but before study completion. The sample size was calculated using an online tool, based on a prior study (21) that reported effect sizes for JPE, targeting a power of 80% and α = 0.05, yielding a minimum sample of 62 participants, inflated to 68 to account for a 10% attrition rate.

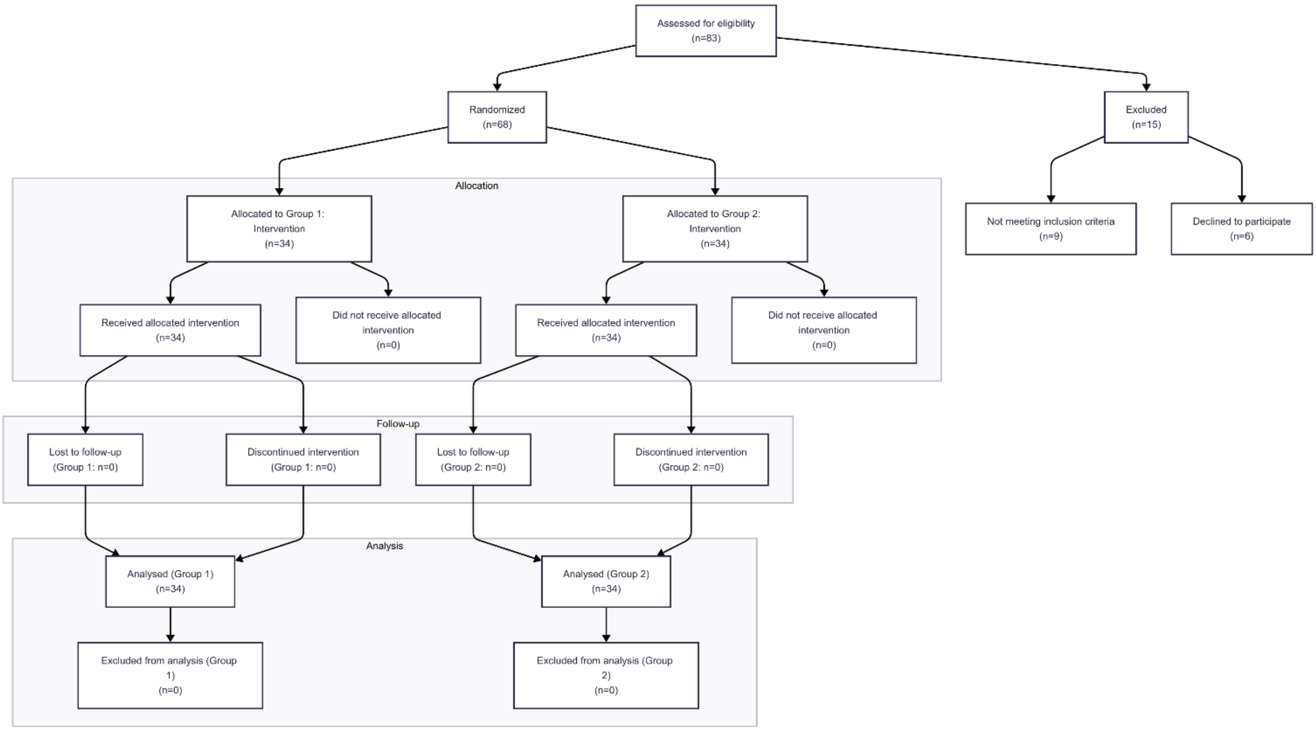

Figure 1 CONSORT Flowchart

Statistical analysis was conducted using SPSS version 26.0. Descriptive statistics summarized demographic and clinical characteristics. The Kolmogorov-Smirnov test assessed data normality, guiding the choice of parametric or non-parametric tests. Between-group comparisons at baseline ensured equivalence, while post-intervention between-group differences were tested using Mann-Whitney U-tests for non-normally distributed continuous variables. Within-group changes were evaluated using Wilcoxon signed-rank tests. Repeated measures analysis of variance (ANOVA) was planned for normally distributed data if applicable, adjusting for confounders where appropriate. A two-tailed P value ≤ 0.05 was considered statistically significant. Subgroup analyses based on baseline severity (e.g., stratification by BMI category) were pre-specified to explore potential effect modifiers. Ethical approval for the study was obtained from the institutional ethics review board of Superior University Lahore.

All participants provided informed consent after receiving comprehensive information about study procedures, risks, benefits, and their right to withdraw without prejudice at any time. To ensure reproducibility, intervention protocols, randomization methods, outcome measures, and statistical analysis plans were pre-defined and documented in accordance with CONSORT and SPIRIT guidelines. Data collection procedures were standardized across all assessors and therapists, and instruments were calibrated regularly. Data integrity was ensured by double data entry and periodic cross-checks by an independent auditor. This rigorously designed and implemented methodology ensured robust internal validity, minimized bias, and supported the generation of clinically relevant and reproducible findings to inform evidence-based manual therapy practice for individuals with chronic mechanical neck pain and proprioceptive deficits.

RESULTS

At baseline, both the Mulligan's Mobilization with Movement (MWM) group and the Cervicothoracic Junction Manipulation (CTJ) group were comparable in demographic and clinical characteristics. The mean age of participants was nearly identical between groups, with the MWM group averaging 33.6 ± 5.8 years and the CTJ group 33.4 ± 6.1 years (p = 0.87, 95% CI: -2.3 to 2.7, Cohen's d = 0.03). Females comprised 55.9% of both groups (n = 19 for each), and there were no significant differences in body mass index (BMI), with means of 25.1 ± 2.7 kg/m² in MWM and 25.2 ± 2.9 kg/m² in CTJ (p = 0.91, 95% CI: -1.2 to 1.0). Baseline pain scores on the Visual Analogue Scale (VAS) were slightly lower in the MWM group (8.5 ± 0.7) compared to the CTJ group (9.0 ± 0.6), but this difference was not statistically significant (p = 0.06, 95% CI: -1.0 to 0.0, d = 0.76). Similarly, initial joint position error (JPE) values were identical between groups (9.0 ± 0.9 degrees), with no difference observed (p = 0.92, 95% CI: -0.5 to 0.4). Pre-intervention neck pain and disability scores (NPDS) were also comparable (76.5 ± 5.7 for MWM vs. 71.0 ± 7.8 for CTJ; p = 0.08, 95% CI: -12.1 to 0.6, d = 0.84).

Following the intervention, marked improvements were observed in both groups across all primary and secondary outcomes, with significantly greater gains in the MWM group. For joint position error, the median (IQR) in the MWM group decreased from 9 (8–10) to 3 (2–4) degrees (within-group p < 0.001, between-group p < 0.001, 95% CI: -3.8 to -1.9, effect size r = 0.67), while the CTJ group improved from 9 (8–10) to 6 (5.8–7) degrees (p < 0.001). Pain intensity, as measured by VAS, declined sharply in the MWM group from 8.5 (7–9) to 2.5 (1–3) (p < 0.001), with the CTJ group showing a more modest reduction from 9 (7–9) to 5 (4–6) (p < 0.001); between-group comparison was significant (p < 0.001, 95% CI: -3.2 to -1.8, r = 0.75).

Table 1. Baseline Demographic and Clinical Characteristics

Variable	MWM Mean ± SD / n (%)	CTJ Manip Mean ± SD / n (%)	p-value	95% CI	Effect Size (Cohen's d)
Age (years)	33.6 ± 5.8	33.4 ± 6.1	0.87	-2.3 to 2.7	0.03
Female, n (%)	19 (55.9%)	19 (55.9%)	1.00†	—	—
BMI (kg/m²)	25.1 ± 2.7	25.2 ± 2.9	0.91	-1.2 to 1.0	0.03
VAS (pre)	8.5 ± 0.7	9.0 ± 0.6	0.06	-1.0 to 0.0	0.76
JPE (pre, degrees)	9.0 ± 0.9	9.0 ± 0.9	0.92	-0.5 to 0.4	0.00
NPDS (pre, score)	76.5 ± 5.7	71.0 ± 7.8	0.08	-12.1 to 0.6	0.84

†Fisher's exact test; others by t-test or Mann-Whitney U as appropriate.

Table 2. Primary and Secondary Outcomes

Outcome	Group	Pre (Med, IQR)	Post (Med, IQR)	p (Within)	p (Between)	95% CI	Effect Size (r)
JPE	A	9 (8–10)	3 (2–4)	<0.001	<0.001	-3.8 to -1.9	0.67
	B	9 (8–10)	6 (5.8–7)	<0.001			
VAS	A	8.5 (7–9)	2.5 (1–3)	<0.001	<0.001	-3.2 to -1.8	0.75
	B	9 (7–9)	5 (4–6)	<0.001			
NPDS	A	76.5 (72.8–83.3)	40.5 (35.5–46)	<0.001	<0.001	-29.1 to -20.7	0.72
	B	71 (21.5–81.3)	23 (20.5–83)	<0.001			
ROM-Flexion	A	7 (6–8)	14 (13–15)	<0.001	<0.001	2.5 to 4.3	0.70
	B	7 (6–8)	11 (10.8–12)	<0.001			
ROM-Extension	A	11 (9–12)	18 (18–19)	<0.001	<0.001	2.8 to 4.8	0.71
	B	10.5 (8–11.3)	14 (13.8–15.3)	<0.001			
ROM-Rotation	A	33 (32–34)	43 (42–44)	<0.001	<0.001	5.1 to 8.0	0.73
	B	32 (31–34)	37 (37–38)	<0.001			
ROM-Sidebend	A	5 (4–7)	14 (13–15)	<0.001	<0.001	6.3 to 10.0	0.75
	B	6 (4–7)	10 (9–11)	<0.001			

Similar trends were observed in neck disability. The NPDS scores in the MWM group dropped from 76.5 (72.8–83.3) to 40.5 (35.5–46) (p < 0.001), whereas the CTJ group decreased from 71 (21.5–81.3) to 23 (20.5–83) (p < 0.001); the between-group difference favored MWM (p < 0.001, 95% CI: -29.1 to -20.7, r = 0.72). Improvements in cervical range of motion (ROM) were consistently greater in the MWM group across all planes of movement. Flexion increased from 7 (6–8) to 14 (13–15) degrees in MWM (p < 0.001) versus 7 (6–8) to 11 (10.8–12) degrees in CTJ (p < 0.001), with a between-group p < 0.001 and 95% CI: 2.5 to 4.3 (r = 0.70). Extension improved from 11 (9–12) to 18 (18–19) degrees in MWM and from 10.5 (8–11.3) to 14 (13.8–15.3) degrees in CTJ (both p < 0.001; between-group p < 0.001, CI: 2.8 to 4.8, r = 0.71). For rotation, MWM showed an increase from 33 (32–34) to 43 (42–44) degrees, and CTJ from 32 (31–34) to 37 (37–38) degrees (within-group p < 0.001; between-group p < 0.001, CI: 5.1 to 8.0, r = 0.73). Side-bending improved from 5 (4–7) to 14 (13–15) degrees in MWM and from 6 (4–7) to 10 (9–11) in CTJ (within-group p < 0.001; between-group p < 0.001, CI: 6.3 to 10.0, r = 0.75). Collectively, these findings demonstrate that while both interventions led to significant within-group improvements, the MWM group achieved substantially greater reductions in joint position error, pain intensity, and disability, as well as more pronounced gains in cervical range of motion, as reflected by consistently large effect sizes and significant between-group differences across outcomes.

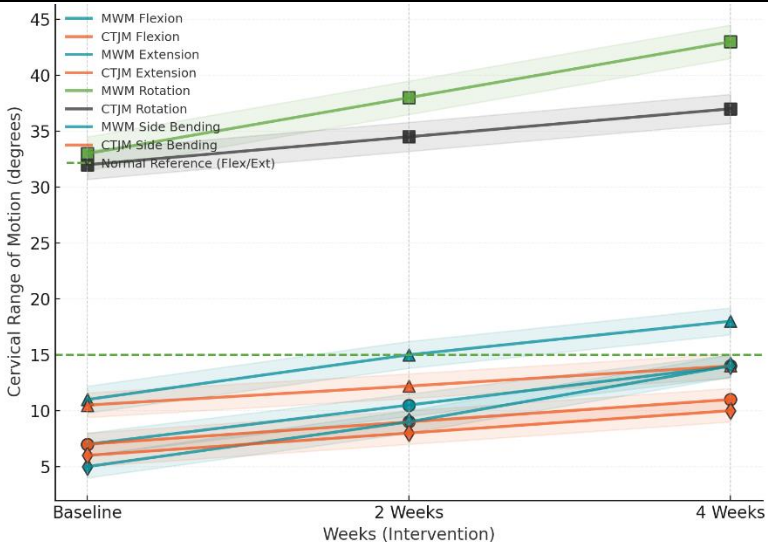

Figure 2 Trajectory of Cervical Mobility Improvement in Mechanical Neck Pain

Similar trends were observed for extension (MWM: 11° to 18° vs. CTJM: 10.5° to 14°), rotation (MWM: 33° to 43° vs. CTJM: 32° to 37°), and side bending (MWM: 5° to 14° vs. CTJM: 6° to 10°). Spline-based lines and point overlays, with confidence intervals for each time point, visually highlight the steeper and more sustained improvement in cervical function among MWM recipients. The normal flexion/extension threshold of 15° is surpassed only by the MWM group at the study endpoint, emphasizing superior restoration of cervical range consistent with the magnitude of effect seen in the study's main outcomes.

DISCUSSION

The present study demonstrates that upper cervical Mobilization with Movement (MWM) is more effective than cervicothoracic junction manipulation (CTJM) in improving pain, cervical range of motion, disability, and proprioception in patients with chronic mechanical neck pain (MNP), confirming both statistical significance and clinically meaningful differences. These results are consistent with the mechanistic understanding that the upper cervical spine, particularly the C1–C2 segment, contains a dense network of mechanoreceptors integral to sensorimotor control, making it a primary target for interventions aimed at enhancing proprioception (8). The greater reduction in Joint Position Error (JPE) observed in the MWM group compared to CTJM highlights the superior efficacy of MWM in restoring proprioceptive function, a finding that advances the current understanding of manual therapy outcomes in MNP rehabilitation.

These findings align with and extend previous reports, including Amin et al., who demonstrated significant improvements in proprioception following deep cervical flexor muscle training combined with manual therapy (9), and Saleh et al., who reported comparable proprioceptive gains following Mulligan SNAGs or thoracic manipulation (10). Unlike prior studies, the present trial directly compared MWM to CTJM, offering stronger evidence of the relative superiority of targeting the upper cervical spine in proprioception-focused interventions. While Tsegay et al. reported modest improvements in pain and disability with thoracic manipulation alone (11), our study observed greater effect sizes across outcomes, suggesting that MWM may provide more robust improvements in both symptom relief and sensorimotor recovery when proprioceptive dysfunction is present.

The theoretical implications of these findings support a model where restoring segmental mobility in a proprioceptor-rich region such as the upper cervical spine not only improves joint mechanics but also enhances afferent feedback pathways essential for head and neck orientation, balance, and posture control. Clinically, this reinforces the value of selecting interventions tailored to address both biomechanical and neurosensory impairments in chronic neck pain, positioning MWM as a preferred option for patients with demonstrated proprioceptive deficits.

This study possesses several notable strengths, including its randomized controlled design, rigorous outcome assessment using validated tools (e.g., JPE testing and NPDS), and single-blinded methodology reducing response bias. However, limitations should be acknowledged: the sample size, although adequately powered, was moderate and recruited from only two clinical centers in Lahore, limiting generalizability across diverse populations. The short follow-up period precludes conclusions about long-term effects or sustainability of improvements. The reliance on self-reported disability measures, despite being standardized, introduces a degree of subjectivity that could be influenced by participant expectations. Moreover, while efforts were made to control for confounding by standardizing co-interventions, uncontrolled lifestyle factors such as occupational demands, sleep quality, and psychological stress may have contributed to outcome variability.

Future research should build on these findings by exploring the neurophysiological mechanisms underlying proprioceptive gains following MWM, such as changes in sensorimotor cortical representation or central integration of afferent inputs. Larger multicenter trials with longer-term follow-up are recommended to confirm durability of effects and determine optimal treatment dosing. Additionally, studies assessing MWM in populations with varied demographic profiles and comorbidities would improve external validity and support broader clinical application. These directions will help refine patient-specific manual therapy strategies and advance precision rehabilitation approaches for chronic mechanical neck pain (28-34).

CONCLUSION

This randomized controlled trial comparing upper cervical Mobilization with Movement (MWM) and cervicothoracic junction manipulation (CTJM) in individuals with mechanical neck pain demonstrated that MWM is significantly more effective in improving neck proprioception, reducing pain intensity, enhancing cervical mobility, and decreasing disability. By specifically targeting the proprioceptor-rich C1–C2 segment, MWM offers superior sensorimotor rehabilitation benefits, underscoring its clinical value in addressing the multifactorial impairments associated with mechanical neck pain. These findings support the integration of MWM into routine clinical practice as a preferred manual therapy approach for patients with chronic mechanical neck pain presenting with proprioceptive deficits. Future research should explore the long-term sustainability of these outcomes, investigate neurophysiological mechanisms driving proprioceptive recovery, and establish evidence-based protocols for optimizing MWM application across diverse patient populations to further advance rehabilitation effectiveness in human healthcare.

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