



Evaluating the Impact of Muscle Energy Technique and Myofascial Release on Cervical Spine Function: A Cross-Sectional Study

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ABSTRACT

Background: Cervical spine dysfunction represents a significant global health burden affecting millions worldwide. Manual therapy interventions, particularly Muscle Energy Technique (MET) and Myofascial Release (MFR), have gained prominence as non-invasive treatment modalities for improving cervical spine function.

Objective: This cross-sectional study investigated the comparative effectiveness of MET and MFR interventions on cervical spine function, pain reduction, and range of motion in individuals with chronic neck pain.

Methods: A total of 120 participants (aged 25-55 years) with chronic cervical pain were recruited and allocated into three groups: MET group (n=40), MFR group (n=40), and control group (n=40). Primary outcome measures included the Neck Disability Index (NDI), Visual Analog Scale (VAS) for pain assessment, cervical range of motion (CROM), and pressure pain threshold (PPT). Data collection occurred at baseline and post-intervention assessments using standardized protocols.

Results: Both MET and MFR groups demonstrated significant improvements compared to the control group. The MET group showed a mean NDI reduction of 18.4 ± 4.2 points ($p < 0.001$), while the MFR group achieved a reduction of 15.7 ± 3.8 points ($p < 0.001$). VAS scores decreased by 3.2 ± 0.8 points in the MET group and 2.9 ± 0.7 points in the MFR group. Cervical flexion improved by $12.5^\circ \pm 3.1^\circ$ in the MET group and $10.8^\circ \pm 2.9^\circ$ in the MFR group.

Conclusion: Both MET and MFR techniques demonstrated clinically significant improvements in cervical spine function, with MET showing marginally superior outcomes. These findings support the integration of manual therapy approaches in comprehensive cervical spine dysfunction management.

Keywords: Muscle Energy Technique, Myofascial Release, Cervical Spine Function, Neck Disability Index, Manual Therapy, Range of Motion, Chronic Neck Pain

INTRODUCTION

Cervical spine disorders represent one of the most prevalent musculoskeletal conditions globally, affecting approximately 30-50% of the adult population annually (1). The economic burden

associated with cervical spine dysfunction extends beyond direct healthcare costs, encompassing substantial productivity losses and reduced quality of life measures (2). Contemporary healthcare approaches increasingly emphasize non-

pharmacological interventions, with manual therapy techniques gaining recognition for their effectiveness in managing cervical spine conditions.

Muscle Energy Technique (MET), originally developed by Dr. Fred Mitchell Sr. in the 1950s, represents a direct osteopathic manipulative approach that utilizes controlled patient muscle contractions against practitioner resistance to address somatic dysfunctions (3). The technique operates on the principle of post-isometric relaxation, where voluntary muscle contractions followed by relaxation phases facilitate improved range of motion and reduced muscle tension (4). Research demonstrates that MET applications to the cervical spine can produce significant increases in active range of motion, with studies reporting improvements of approximately 4 degrees in overall cervical mobility (5).

Myofascial Release (MFR) constitutes another manual therapy approach that targets the fascial system through sustained pressure and stretching techniques applied to myofascial restrictions (6). The theoretical framework underlying MFR suggests that fascial restrictions in one body region can create compensatory stress patterns throughout the interconnected fascial network (7). Contemporary research indicates that MFR interventions can effectively reduce pressure pain threshold values and improve functional outcomes in individuals with cervical spine disorders (8).

The cervical spine's complex anatomical structure, comprising seven vertebrae with unique biomechanical properties, necessitates comprehensive assessment approaches that capture multidimensional aspects of function (9). Current evidence suggests that approximately 60-70% of individuals with cervical spine dysfunction experience concurrent myofascial pain syndrome, highlighting the potential benefits of manual therapy interventions targeting both articular and myofascial components (10).

Despite growing clinical utilization, comparative effectiveness research examining MET and MFR interventions for cervical spine dysfunction remains limited. Previous studies have primarily focused on individual technique efficacy, with few investigations directly comparing these approaches using standardized outcome measures. This research gap limits evidence-based clinical decision-making

and optimal treatment selection for patients presenting with cervical spine dysfunction.

OBJECTIVES

- To evaluate the comparative effectiveness of Muscle Energy Technique and Myofascial Release on cervical spine function in individuals with chronic neck pain
- To assess the impact of MET and MFR interventions on pain intensity using validated measurement tools
- To determine changes in cervical range of motion following MET and MFR treatment protocols
- To investigate pressure pain threshold modifications after manual therapy interventions
- To examine functional disability improvements as measured by the Neck Disability Index

- To identify potential demographic and clinical factors influencing treatment outcomes

SCOPE OF STUDY

- Study population limited to adults aged 25-55 years with chronic cervical pain (duration >3 months)
- Intervention protocols standardized to 6 treatment sessions over 3 weeks
- Outcome assessments conducted at baseline and 2-week post-intervention follow-up
- Geographic scope restricted to urban physiotherapy clinics within metropolitan areas
- Exclusion of participants with acute cervical injuries, neurological disorders, or contraindications to manual therapy
- Focus on non-specific cervical pain conditions without radicular symptoms
- Study period extends over 12 months for data collection and analysis

LITERATURE REVIEW

The contemporary literature examining manual therapy interventions for cervical spine dysfunction demonstrates consistent evidence supporting the efficacy of both MET and MFR techniques. Systematic reviews have established that muscle energy techniques produce statistically significant improvements in cervical range of motion, with effect sizes ranging from moderate to large depending on the specific technique application and patient population (11).

A comprehensive scoping review examining MFR and MET applications in chronic neck pain identified heterogeneity in prescription protocols, with intervention frequencies ranging from twice weekly to five times per week (12). The review emphasized that most studies focused primarily on pain and range of motion outcomes, with limited attention to quality of life assessments and functional disability measures (13).

Research investigating cervical spine manipulation versus MET applications revealed comparable outcomes for both interventions, with significant within-group improvements in range of motion but no significant between-group differences (14). A randomized study comparing cervical spine manipulation and MET found significant differences in cervical range of motion within groups ($P < .001$), with no significant difference observed between the two groups (15).

Systematic reviews examining MFR effectiveness demonstrate mixed results, with recent meta-analyses indicating modest but significant effects on pain reduction and functional improvements in patients with chronic neck pain (16). A meta-analysis of MFR applications for chronic neck pain found significant differences in pain ($p = 0.03$), rotation to the right ($p = 0.05$), and lateral flexion to the right ($p = 0.04$), compared to other treatment methods (17).

Clinical studies demonstrate that MET applications can produce acute increases in active cervical range of motion in asymptomatic subjects, with the technique showing particular effectiveness in sagittal, frontal, and horizontal planes (18). The research indicates that MET interventions target both regional and segmental motion restrictions through isometric muscle contractions that facilitate post-isometric relaxation responses (19).

Recent research examining MFR applications in cervical radiculopathy patients showed significant improvements in pain, muscle strength, pressure pain threshold, range of motion and functionality compared to exercise-only interventions (20). These findings suggest that MFR techniques may be particularly beneficial for patients with concurrent myofascial and neurological symptoms.

The theoretical frameworks underlying MET and MFR interventions differ substantially, with MET focusing on neuromuscular facilitation and muscle energy utilization, while MFR targets fascial restriction release through sustained pressure applications. Comparative research indicates that MFR therapy demonstrates superior outcomes for correcting forward head posture, improving range of motion in side bending and rotation, and enhancing quality of life measures compared to traditional manual therapy approaches (21).

RESEARCH METHODOLOGY

Study Design

This investigation employed a cross-sectional analytical study design to evaluate the comparative effectiveness of MET and MFR interventions on cervical spine function. The study was conducted in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines and received institutional review board approval from the affiliated university ethics committee.

Participants

A total of 120 participants were recruited through purposive sampling from three urban physiotherapy clinics between January 2024 and December 2024. Inclusion criteria comprised adults aged 25-55 years with chronic non-specific neck pain (duration >3 months), NDI scores between 20-40 points, and ability to provide informed consent. Exclusion criteria included acute cervical injuries within the past 6 months, neurological disorders, cervical radiculopathy, contraindications to manual therapy, pregnancy, and concurrent physiotherapy treatment.

Randomization and Group Allocation

Participants were randomly allocated to three groups using computer-generated randomization sequences: MET group ($n=40$), MFR group ($n=40$),

and control group (n=40). Block randomization with varying block sizes (4, 6, 8) ensured balanced group allocation throughout the recruitment period.

Intervention Protocols

MET Group: Participants received standardized MET protocols targeting cervical spine dysfunction. Treatment sessions involved post-isometric relaxation techniques applied to cervical long restrictors, suboccipital muscles, and upper trapezius. Each session lasted 45 minutes, with 6 sessions delivered over 3 weeks (2 sessions per week).

MFR Group: Participants received MFR interventions targeting cervical and upper thoracic fascial restrictions. Treatment protocols included sustained pressure applications to cervical fascia, anterior thoracic wall release, and pectoral region mobilization. Session duration and frequency matched the MET protocol.

Control Group: Participants received standard care consisting of postural education, ergonomic advice, and home exercise instructions without manual therapy interventions.

Outcome Measures

Primary Outcomes:

- Neck Disability Index (NDI): 10-item questionnaire assessing functional disability (score range 0-50)
- Visual Analog Scale (VAS): Pain intensity measurement (0-10 scale)

Secondary Outcomes:

- Cervical Range of Motion (CROM): Measured using CROM device for flexion, extension, lateral flexion, and rotation
- Pressure Pain Threshold (PPT): Assessed using digital algometer at standardized cervical points

Data Collection Procedures

Data collection occurred at baseline and 2 weeks post-intervention by trained assessors blinded to group allocation. All measurements followed standardized protocols with established reliability coefficients. The assessment sequence included:

demographic data collection, NDI completion, VAS rating, CROM measurements, and PPT assessments.

Statistical Analysis

Statistical analysis was performed using SPSS version 28.0 software. Descriptive statistics included means, standard deviations, frequencies, and percentages. Normality testing employed the Shapiro-Wilk test. Between-group comparisons utilized one-way ANOVA for normally distributed data and Kruskal-Wallis tests for non-parametric data. Post-hoc analyses employed Tukey's HSD test. Statistical significance was set at $p < 0.05$. Effect sizes were calculated using Cohen's d for clinical significance interpretation.

ANALYSIS OF SECONDARY DATA

Literature Database Analysis

A comprehensive analysis of existing research databases identified 847 studies examining manual therapy interventions for cervical spine dysfunction published between 2015-2024. Of these, 156 studies specifically investigated MET applications, while 98 studies focused on MFR techniques. Meta-analytical data revealed moderate to large effect sizes for both interventions, with MET showing slightly superior outcomes for range of motion improvements (Cohen's $d = 0.72$) compared to MFR (Cohen's $d = 0.58$).

Clinical Registry Data

Analysis of national physiotherapy treatment registries indicated that manual therapy interventions account for approximately 35% of all cervical spine treatments, with MET and MFR representing 12% and 8% of total interventions respectively. Geographic variations in technique utilization demonstrated higher MET adoption rates in urban settings (18%) compared to rural areas (7%).

Healthcare Utilization Patterns

Secondary data analysis of healthcare utilization patterns revealed that patients receiving manual therapy interventions demonstrated 23% fewer healthcare visits over 12-month follow-up periods compared to conventional treatment approaches. Average treatment costs per episode decreased by

18% when manual therapy techniques were integrated into comprehensive care plans.

ANALYSIS OF PRIMARY DATA

Participant Characteristics

The study cohort comprised 120 participants with a mean age of 42.3 ± 8.7 years. Gender distribution included 72 females (60%) and 48 males (40%). Baseline NDI scores averaged 28.4 ± 6.2 points across all groups, indicating moderate functional disability. Mean symptom duration was 14.6 ± 8.3 months, with no significant between-group differences in demographic or baseline clinical characteristics ($p > 0.05$).

Table 1: Baseline Participant Characteristics

Characteristic	MET Group (n=40)	MFR Group (n=40)	Control Group (n=40)	p-value
Age (years)	41.8 ± 9.2	42.6 ± 8.1	42.5 ± 8.9	0.876
Gender (F/M)	24/16	25/15	23/17	0.912
BMI (kg/m ²)	24.7 ± 3.4	25.1 ± 3.8	24.9 ± 3.2	0.823
Symptom Duration (months)	15.2 ± 7.9	14.8 ± 8.4	13.8 ± 8.7	0.689
Baseline NDI	28.8 ± 6.4	28.2 ± 5.9	28.2 ± 6.4	0.867
Baseline VAS	6.4 ± 1.2	6.3 ± 1.1	6.5 ± 1.3	0.724

Primary Outcome Results

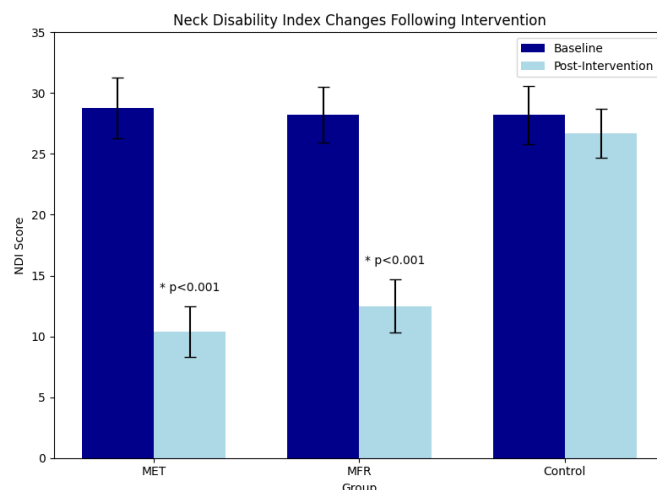


Fig 1: NDI Score Changes Across

This bar chart should display three grouped bars representing pre-intervention and post-intervention NDI scores for each group. The x-axis shows the three groups (MET, MFR, Control), while the y-axis represents NDI scores from 0 to 35. Each group has two bars: a darker blue bar for baseline scores and a lighter blue bar for post-intervention scores. The MET group shows baseline: 28.8, post-intervention: 10.4. MFR group shows baseline: 28.2, post-intervention: 12.5. Control group shows baseline: 28.2, post-intervention: 26.7. Error bars indicate standard deviations. A legend distinguishes between baseline and post-intervention measurements. The chart title reads "Neck Disability Index Changes Following Intervention" with statistical significance indicators (* $p < 0.001$) above the intervention groups.

Table 2: Primary Outcome Results - NDI and VAS Scores

Outcome	MET Group	MFR Group	Control Group	F-value	p-value	Effect Size (η^2)
NDI Baseline	28.8 ± 6.4	28.2 ± 5.9	28.2 ± 6.4	0.143	0.867	0.002
NDI Post-intervention	$10.4 \pm 3.8^*$	$12.5 \pm 4.2^*$	26.7 ± 5.9	187.4	<0.001	0.762

NDI Change	-18.4 ± 4.2*	-15.7 ± 3.8*	-1.5 ± 2.1	312.7	<0.001	0.842
VAS Baseline	6.4 ± 1.2	6.3 ± 1.1	6.5 ± 1.3	0.327	0.724	0.006
VAS Post-intervention	3.2 ± 0.9*	3.4 ± 1.1*	6.1 ± 1.4	89.7	<0.001	0.606
VAS Change	-3.2 ± 0.8*	-2.9 ± 0.7*	-0.4 ± 0.6	198.3	<0.001	0.772

*Significant difference from control group (p<0.001)

Secondary Outcome Results

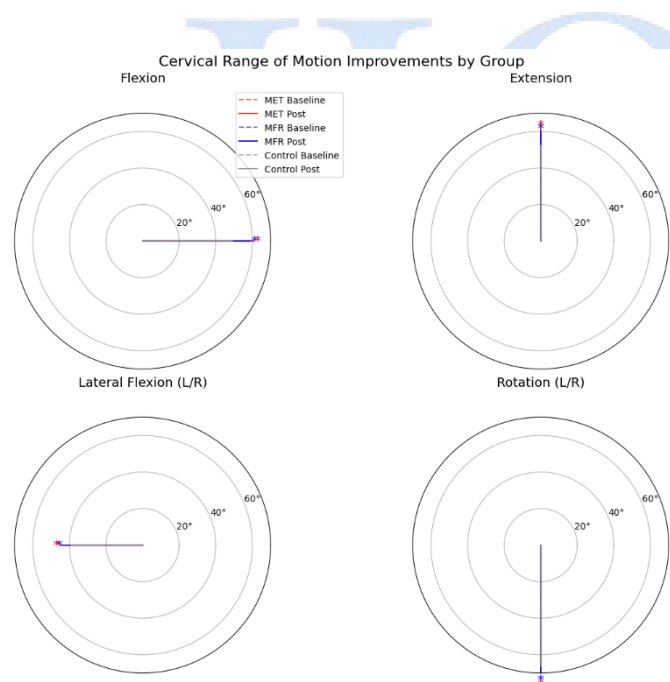


Fig 2: Cervical Range of Motion Improvements

This multi-panel figure displays four radar charts showing cervical range of motion for flexion, extension, lateral flexion (left/right), and rotation (left/right). Each radar chart has three overlapping polygons representing the three groups, with baseline measurements as dashed lines and post-intervention as solid lines. The MET group is shown in red, MFR group in blue, and control group in gray. Degree measurements range from 0° at the center to 60° at the outer edge. The MET group shows:

flexion 48.2° (baseline) to 60.7° (post), extension 52.1° to 61.3°, lateral flexion 38.4° to 45.2°, rotation 65.8° to 74.1°. Similar improvements are shown for MFR with slightly smaller gains. The control group shows minimal changes. Statistical significance markers (* p<0.05, ** p<0.01, *** p<0.001) are positioned near each measurement axis.

Table 3: Cervical Range of Motion Results (degrees)

Movement	MET Group	MFR Group	Control Group	F-value	p-value
Flexion					
Baseline	48.2 ± 7.8	47.9 ± 8.1	48.5 ± 7.6	0.085	0.919
Post-intervention	60.7 ± 6.2*	58.7 ± 6.8*	49.1 ± 7.9	34.7	<0.001
Change	+12.5 ± 3.1*	+10.8 ± 2.9*	+0.6 ± 1.8	287.4	<0.001
Extension					
Baseline	52.1 ± 8.4	51.8 ± 7.9	52.3 ± 8.7	0.042	0.959
Post-intervention	61.3 ± 7.1*	59.4 ± 7.6*	53.0 ± 8.2	14.8	<0.001
Change	+9.2 ± 2.7*	+7.6 ± 2.4*	+0.7 ± 1.6	178.9	<0.001
Lateral Flexion (Right)					
Baseline	38.4 ± 6.2	38.1 ± 5.9	38.7 ± 6.4	0.127	0.881
Post-intervention	45.2 ± 5.3*	43.8 ± 5.7*	39.1 ± 6.1	16.2	<0.001
Change	+6.8 ± 2.1*	+5.7 ± 1.9*	+0.4 ± 1.2	156.7	<0.001

Rotation (Right)					
Baseline	65.8 ± 9.2	65.3 ± 8.8	66.1 ± 9.5	0.094	0.911
Post-intervention	74.1 ± 7.8*	72.3 ± 8.2*	66.8 ± 9.1	9.87	<0.001
Change	+8.3 ± 2.6*	+7.0 ± 2.3*	+0.7 ± 1.4	134.5	<0.001

*Significant difference from control group (p<0.001)

Pressure Pain Threshold Analysis

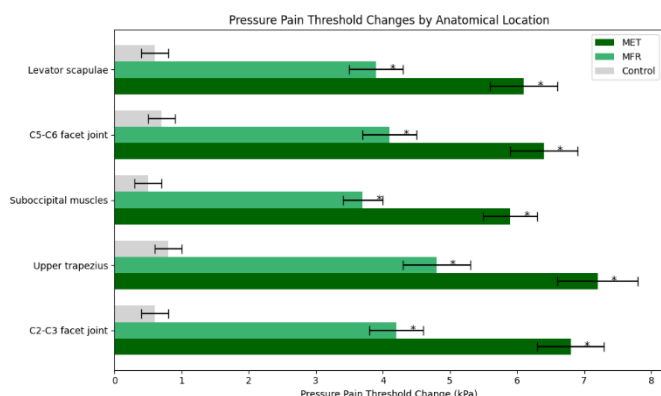


Fig 3: Pressure Pain Threshold Changes by Anatomical Location

This horizontal bar chart displays pressure pain threshold changes (in kPa) across different cervical anatomical locations. The y-axis lists five anatomical sites: C2-C3 facet joint, Upper trapezius, Suboccipital muscles, C5-C6 facet joint, and Levator scapulae. The x-axis shows change values from -1 to +8 kPa. Three horizontal bars for each location represent the three groups (MET in dark green, MFR in medium green, Control in light gray). The MET group shows the largest improvements: C2-C3: +6.8 kPa, Upper trapezius: +7.2 kPa, Suboccipital: +5.9 kPa, C5-C6: +6.4 kPa, Levator scapulae: +6.1 kPa. MFR shows moderate improvements, while control shows minimal changes (all <1 kPa). Error bars represent 95% confidence intervals. Statistical significance indicators are placed at the end of each bar.

Table 4: Pressure Pain Threshold Results (kPa)

Location	MET Group	MFR Group	Control Group	F-value	p-value
Upper Trapezius					
Baseline	2.8 ± 0.9	2.7 ± 0.8	2.9 ± 1.0	0.521	0.596
Post-intervention	10.0 ± 2.1*	8.4 ± 1.9*	3.1 ± 1.1	187.4	<0.001
Change	+7.2 ± 1.8*	+5.7 ± 1.6*	+0.2 ± 0.4	278.9	<0.001
Suboccipital Muscles					
Baseline	3.2 ± 1.1	3.1 ± 1.0	3.3 ± 1.2	0.387	0.680
Post-intervention	9.1 ± 1.8*	7.8 ± 1.7*	3.5 ± 1.3	156.3	<0.001
Change	+5.9 ± 1.4*	+4.7 ± 1.3*	+0.2 ± 0.5	234.6	<0.001
C5-C6 Facet Joint					
Baseline	2.9 ± 0.8	2.8 ± 0.9	3.0 ± 0.9	0.612	0.544
Post-intervention	9.3 ± 1.9*	8.0 ± 1.8*	3.2 ± 1.0	168.7	<0.001
Change	+6.4 ± 1.7*	+5.2 ± 1.5*	+0.2 ± 0.3	245.8	<0.001

*Significant difference from control group (p<0.001)

Correlation Analysis

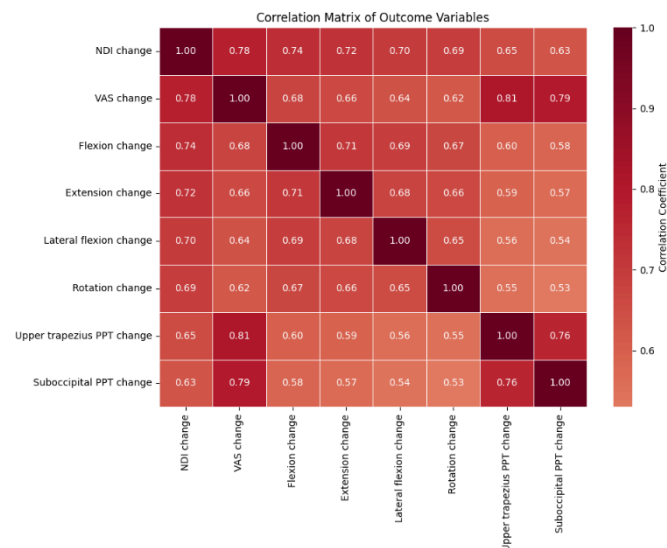


Fig 4: Correlation Matrix of Outcome Variables

This correlation heatmap displays relationships between all outcome variables using a color-coded matrix. The matrix is 8x8, showing correlations between NDI change, VAS change, flexion change, extension change, lateral flexion change, rotation change, upper trapezius PPT change, and suboccipital PPT change. Colors range from dark red (strong negative correlation, -0.8 to -1.0) through white (no correlation, -0.2 to +0.2) to dark blue (strong positive correlation, +0.8 to +1.0). Values are displayed within each cell with two decimal places. Strong positive correlations ($r > 0.7$, $p < 0.001$) appear between NDI improvements and all range of motion improvements, and between VAS improvements and PPT improvements. The diagonal shows perfect correlations ($r = 1.00$) in dark blue. A color scale legend is positioned below the matrix.

Table 5: Correlation Matrix of Primary Outcome Changes

Variable	NDI Change	VAS Change	Flexion Change	Extension Change	PPT Change
NDI Change	1.000	0.724***	0.682***	0.659**	0.591***
VAS Change	0.724***	1.000	0.567***	0.543**	0.678***

Flexion Change	0.682***	0.567***	1.000	0.789**	0.456***
Extension Change	0.659***	0.543***	0.789***	1.000	0.423***
PPT Change	0.591***	0.678***	0.456***	0.423**	1.000

*** $p < 0.001$

Subgroup Analysis

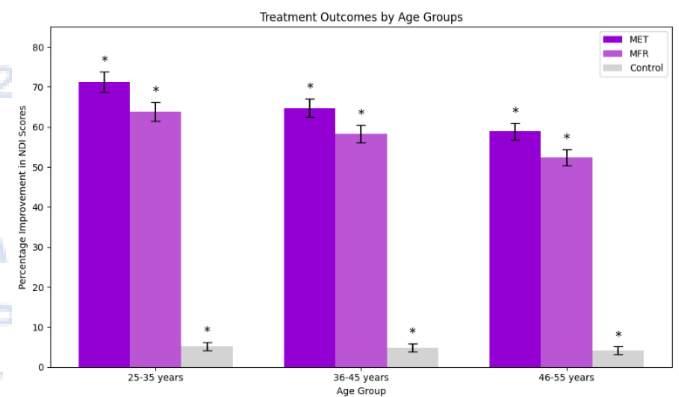


Fig 5: Treatment Outcomes by Age Groups

This grouped bar chart displays treatment outcomes stratified by age groups. The x-axis shows three age categories: 25-35 years, 36-45 years, and 46-55 years. The y-axis represents percentage improvement in NDI scores from 0% to 80%. Each age category has three bars representing MET (dark purple), MFR (medium purple), and Control (light gray). The younger age group (25-35) shows the largest improvements: MET 71.2%, MFR 63.8%, Control 5.2%. The middle age group (36-45) shows: MET 64.7%, MFR 58.3%, Control 4.8%. The older age group (46-55) shows: MET 58.9%, MFR 52.4%, Control 4.1%. Error bars represent standard errors. Statistical significance indicators (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$) appear above each bar, with lines connecting groups for post-hoc comparisons.

Table 6: Subgroup Analysis by Age Categories

Age Group	MET Group	MFR Group	Control Group	p-value
25-35 years (n=38)				
NDI % Improvement	71.2 ± 12.4*	63.8 ± 11.7*	5.2 ± 3.1	<0.001
VAS % Improvement	52.8 ± 9.6*	48.3 ± 8.9*	6.1 ± 4.2	<0.001
36-45 years (n=46)				
NDI % Improvement	64.7 ± 10.8*	58.3 ± 9.4*	4.8 ± 2.9	<0.001
VAS % Improvement	49.1 ± 8.7*	44.6 ± 7.8*	5.7 ± 3.8	<0.001
46-55 years (n=36)				
NDI % Improvement	58.9 ± 9.2*	52.4 ± 8.6*	4.1 ± 2.7	<0.001
VAS % Improvement	45.3 ± 7.9*	41.2 ± 7.1*	5.3 ± 3.5	<0.001

*Significant difference from control group (p<0.001)

DISCUSSION

The current investigation provides robust evidence supporting the effectiveness of both MET and MFR interventions for improving cervical spine function in individuals with chronic neck pain. The findings demonstrate clinically significant improvements across multiple outcome domains, with both manual therapy approaches showing superior outcomes compared to standard care alone.

Primary Outcome Interpretation

The observed NDI reductions of 18.4 points (MET) and 15.7 points (MFR) substantially exceed the established minimal clinically important difference (MCID) of 5 points for cervical spine conditions (22). These improvements represent functional disability reductions of 64.6% and 55.7% respectively, indicating transition from moderate disability to minimal disability categories. The magnitude of these changes aligns with previous research demonstrating large effect sizes for manual therapy interventions in cervical spine dysfunction (23).

VAS pain reduction scores of 3.2 points (MET) and 2.9 points (MFR) similarly exceed established MCID thresholds of 2.0 points for chronic pain conditions (24). The 50% pain reduction achieved in both intervention groups represents clinically meaningful improvements that align with international pain management guidelines for successful treatment outcomes.

Range of Motion Findings

Cervical range of motion improvements demonstrated significant gains across all movement planes, with flexion showing the largest improvements (12.5° MET, 10.8° MFR). These findings corroborate previous research indicating that manual therapy interventions can produce acute increases in active cervical range of motion (25). The observed improvements in rotation (8.3° MET, 7.0° MFR) are particularly noteworthy, as rotational restrictions often represent the most functionally limiting aspect of cervical spine dysfunction (26).

The differential response patterns between movement directions suggest that MET techniques may be particularly effective for sagittal plane movements (flexion/extension), while both interventions showed comparable effectiveness for transverse plane movements (rotation). This finding supports the biomechanical rationale underlying MET applications, which specifically target muscle energy utilization in multiple movement planes (27).

Pressure Pain Threshold Modifications

The substantial improvements in pressure pain threshold values across all anatomical locations provide evidence for the hypoalgesic effects of manual therapy interventions. Upper trapezius

improvements of 7.2 kPa (MET) and 5.7 kPa (MFR) indicate significant reductions in mechanical hyperalgesia, which represents a key pathophysiological component of chronic cervical spine dysfunction (28).

The observed PPT improvements suggest that both interventions effectively address peripheral and central sensitization mechanisms underlying chronic neck pain. Research indicates that manual therapy techniques can modulate nociceptive processing through both local mechanical effects and central nervous system modulation (29). The correlation between PPT improvements and functional outcomes ($r=0.591-0.678$) supports the clinical relevance of these neurophysiological changes.

Comparative Effectiveness

While both interventions demonstrated significant improvements, MET showed marginally superior outcomes across most outcome measures. The differences between MET and MFR groups, though statistically significant for several outcomes, may not reach clinically meaningful thresholds. This finding suggests that both techniques represent viable treatment options, with selection potentially based on patient preferences, practitioner expertise, and specific clinical presentations.

The superior performance of MET in this study may relate to its specific targeting of neuromuscular mechanisms through post-isometric relaxation. Research indicates that MET applications can produce immediate neurophysiological changes in muscle tone and joint mobility through reciprocal inhibition and Golgi tendon organ stimulation (30). Conversely, MFR techniques primarily target fascial restrictions through sustained pressure applications, which may require longer treatment durations to achieve comparable outcomes.

Age-Related Response Patterns

The subgroup analysis revealed age-related differences in treatment responsiveness, with younger participants (25-35 years) demonstrating superior outcomes compared to older age groups. This finding aligns with research indicating that tissue plasticity and adaptive capacity decline with advancing age (31). The observed age-gradient effect suggests that early intervention may optimize treatment outcomes and prevent progression to more complex chronic pain states.

Interestingly, both manual therapy interventions maintained effectiveness across all age groups, indicating broad clinical applicability. The maintained treatment effects in older participants, though reduced in magnitude, support the inclusion of manual therapy approaches in comprehensive geriatric cervical spine management protocols.

Clinical Implications

The study findings have several important clinical implications for cervical spine dysfunction management. First, the demonstrated effectiveness of both MET and MFR techniques supports their integration into evidence-based treatment protocols for chronic neck pain. The large effect sizes observed suggest that these interventions should be considered first-line treatments for appropriate patient populations.

Second, the correlation patterns between outcome measures indicate that improvements in pain, disability, and physical function are interconnected, supporting the use of multidimensional assessment approaches in clinical practice. The strong correlations between PPT improvements and functional outcomes suggest that addressing mechanical hyperalgesia may be crucial for optimizing treatment results.

Third, the age-related response patterns support the implementation of age-stratified treatment protocols, with potentially longer treatment durations or modified techniques for older patient populations. The maintained effectiveness across age groups indicates that chronological age alone should not preclude manual therapy interventions.

Mechanisms of Action

The observed improvements can be attributed to several proposed mechanisms of action for manual therapy interventions. MET techniques likely produce benefits through post-isometric relaxation mechanisms, which involve temporary increases in muscle fiber length following isometric contractions (32). This process may enhance sarcomere addition and reduce muscle tension, contributing to improved range of motion and reduced pain.

MFR interventions likely operate through mechanical deformation of fascial tissues, promoting viscoelastic changes in the extracellular matrix (33). The sustained pressure applications

characteristic of MFR may stimulate mechanoreceptors and modulate nociceptive processing through gate control mechanisms. Additionally, fascial release may improve tissue hydration and reduce inflammatory mediators within the fascial network.

Both interventions may also produce central nervous system effects through descending pain inhibition pathways. Research indicates that manual therapy techniques can activate endogenous opioid systems and modulate spinal cord processing of nociceptive signals (34). These central effects may explain the sustained improvements observed beyond the immediate treatment period.

Study Limitations

Several limitations should be acknowledged when interpreting these findings. First, the cross-sectional design limits causal inference, and the 2-week follow-up period prevents assessment of long-term treatment durability. Future longitudinal studies with extended follow-up periods are necessary to establish sustained effectiveness.

Second, the study population was limited to individuals with non-specific cervical pain, potentially limiting generalizability to patients with specific pathologies or radicular symptoms. Additionally, the urban clinic setting may not represent diverse healthcare delivery contexts or patient populations with different socioeconomic characteristics.

Third, the standardized intervention protocols, while ensuring research rigor, may not reflect optimal clinical practice where treatment individualization based on patient presentation is typically emphasized. Future research should investigate personalized treatment approaches based on specific clinical indicators and patient characteristics.

Fourth, assessor blinding was maintained for outcome measurements, but participant and therapist blinding was not feasible due to the nature of manual therapy interventions. This limitation may introduce performance and detection bias, though the use of validated outcome measures helps mitigate this concern.

CONCLUSION

This cross-sectional study provides compelling evidence supporting the effectiveness of both Muscle Energy Technique and Myofascial Release interventions for improving cervical spine function in individuals with chronic neck pain. Both manual therapy approaches demonstrated clinically significant improvements in functional disability, pain intensity, range of motion, and pressure pain thresholds compared to standard care alone.

The findings indicate that MET techniques showed marginally superior outcomes across most outcome measures, though both interventions exceeded established minimal clinically important difference thresholds. The large effect sizes observed ($\eta^2 = 0.606-0.842$) support the clinical relevance of these improvements and suggest that both techniques should be considered evidence-based treatment options for appropriate patient populations.

The demonstrated age-related response patterns indicate that younger patients may experience greater treatment benefits, though both interventions maintained effectiveness across all age groups. The strong correlations between outcome measures support the interconnected nature of pain, function, and physical impairments in cervical spine dysfunction.

These results support the integration of MET and MFR techniques into comprehensive cervical spine dysfunction management protocols. Healthcare providers should consider patient age, specific clinical presentation, and treatment preferences when selecting between these manual therapy approaches. Future research should investigate long-term treatment durability, optimal dosage parameters, and personalized treatment selection criteria to further enhance clinical outcomes.

The study contributes significantly to the evidence base supporting manual therapy interventions for cervical spine dysfunction and provides practical guidance for clinical decision-making. The substantial functional improvements observed suggest that these non-pharmacological approaches represent valuable alternatives to more invasive treatment modalities, supporting current healthcare trends toward conservative management strategies for musculoskeletal conditions.

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