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Efficacy Comparison of Osteopathic Muscle Energy Techniques and Cervical Mobilization on Pain, Disability, and Proprioception in Cervical Spondylosis Patients

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Data Interpretation D
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Background: Cervical spondylosis (CS) is a degenerative disease of the cervical spine characterized by persistent neck pain. Cervical facet joint mobilization (CM) and the osteopathic muscle energy technique (MET) are effective manual procedures for the treatment of neck pain. In this study, we compared the efficacy of the MET and CM techniques on pain, disability, and proprioception in 76 patients with CS.

Material/Methods: A total of 96 participants with a diagnosis of CS were randomized into an electro-thermal therapy (ET) group (control group, n=32), ET+MET group (experiment I, n=32), and ET+CM group (experiment II, n=32). All patients received 3 treatment sessions per week for 4 consecutive weeks. Pain intensity, functional disability and cervical position sense were measured using the visual analog scale (VAS), Copenhagen Neck Functional Disability Scale (CNFDS), and cervical range of motion (CROM) device.

Results: The study was completed by 76 participants. VAS and CNFDS scores decreased significantly after treatment in all 3 groups ($P<0.001$); however, there was no significant difference between the groups ($P>0.05$). Between-group analysis showed a significant difference in extension joint position error in favor of MET ($P<0.001$), while there was no significant difference between the groups in other movement directions ($P>0.05$).

Conclusions: MET and CM have similar effects on improving pain and disability in individuals with CS and chronic neck pain. However, the results of this study show that MET combined with ET is a more effective method for improving cervical position sense.

Keywords: **Musculoskeletal Manipulations • Neck Pain • Proprioception • Spondylosis**

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Introduction

Cervical spondylosis (CS) is a chronic degenerative condition of the cervical spine that affects the osteocartilaginous components of the cervical spine [1]. CS is considered a natural process of aging, with a 95% prevalence by age 65 years [1]. Factors such as severe spinal trauma, congenital narrow spinal canal, increased work, and life stress contribute to an accelerated disease process and early onset CS [1,2]. The diagnosis of CS is based on magnetic resonance imaging of the cervical spine, X-ray findings, and corresponding clinical symptoms [2,3].

Neck pain, the most common symptom of symptomatic CS, causes disability in most patients, as it is associated with activity restrictions, decreased work productivity, and decreased quality of life [1]. In addition, cervical proprioceptive disorder is another important symptom that should not be ignored in patients with CS and neck pain [4-6]. Loss of regional proprioception can affect segmental stability, leading to a delayed reflex response that increases the risk of injury [5]. Furthermore, improper proprioceptive input can trigger increased and prolonged reflex activation of neck muscles, which can lead to persistent neck pain over time [5]. Therefore, it is important to evaluate and manage sensorimotor control in patients with CS.

The treatment of CS typically involves surgical and conservative options, with conservative treatment being the primary approach [1,7]. Various conservative interventions, such as the use of pharmacological agents, manual therapy, electrotherapy, different types of injections, and acupuncture, are used to relieve neck pain in patients with CS [1,7]. Manual therapy includes many different concepts, such as the Cyriax, Maitland, McKenzie, Kalternborn, and Mulligan techniques [8]. Generally, manual therapy techniques are classified as manipulation, joint mobilization (passive or active), and soft tissue mobilization [9]. Cervical facet joint mobilization (CM) focuses on restoring joint arthrokinematics and involves applying a non-thrusting manual force to the spinal joints within the passive joint range of motion [10]. On the other hand, the osteopathic muscle energy technique (MET) is a manual approach that aims to relax and lengthen the muscles and connective tissue by autogenic or reciprocal inhibition by utilizing isotonic and/or isometric contractions produced by the patient in a controlled direction and force [11].

The literature supports the use of both CM and MET in the treatment of neck pain and disability [12,13], but it is not yet known which is more effective. There are few studies comparing the effects of MET and CM on neck pain and disability in patients with cervical disorders [14,15].

CM techniques [16,17] and MET [11] have been suggested to increase the activation of mechanoreceptors and proprioceptors, which can improve position and movement sense in the neck. However, few studies have investigated the effects of both techniques on proprioception [18-21]. Therefore, in this study, we aimed to compare the efficacy of osteopathic MET and CM techniques on pain, disability, and proprioception in 76 patients with CS.

Material and Methods

Ethics Approval and Study Design

The study protocol was approved by the Eastern Mediterranean University Health Ethics Subcommittee, dated 07.01.2020, numbered 2020/01, and recorded prospectively at ClinicalTrials.gov (registration no: NCT04777318). Written informed consent was obtained from participants prior to the study. This study was a randomized controlled trial with a pretest-posttest design and 3 parallel groups. The study was conducted at the Famagusta State Hospital Physiotherapy and Rehabilitation Polyclinic in the Turkish Republic of Northern Cyprus between December 2020 and September 2023. All assessment and interventions were provided by a same physiotherapist, to standardize the study. The physiotherapist had over 7 years of clinical experience in the field of manual therapy and postgraduate competence in the field of orthopedic rehabilitation.

Participants

The differential diagnosis of CS was made by the orthopedic surgeon of Famagusta State Hospital. Diagnosis was supported by physical examination and radiographic examination of the cervical spine, including anteroposterior and lateral radiographs or magnetic resonance imaging/computed tomography scans. Then, patients with a diagnosis of CS were referred to the Physiotherapy and Rehabilitation Department for treatment. A total of 118 patients with a diagnosis of CS who applied to the Physiotherapy and Rehabilitation Department were screened for eligibility. The inclusion criteria were age between 40 and 65 years, neck pain for more than 3 months, and no conservative treatment in the last 6 months. Exclusion criteria were pain or numbness spreading to the arms; cervical spine surgery; neurological disease; musculoskeletal problem, such as shoulder impingement or thoracic outlet syndrome; contraindication to cervical spine mobilization; taking analgesics; and inability to comply with the study.

Sample Size

The sample size was determined using the G*Power 3.1.6 program (Universitaet Dusseldorf, Dusseldorf, Germany). The initial sample size in the study was calculated as 66 participants, under the assumption that the effect size was f=0.40, α=0.05,

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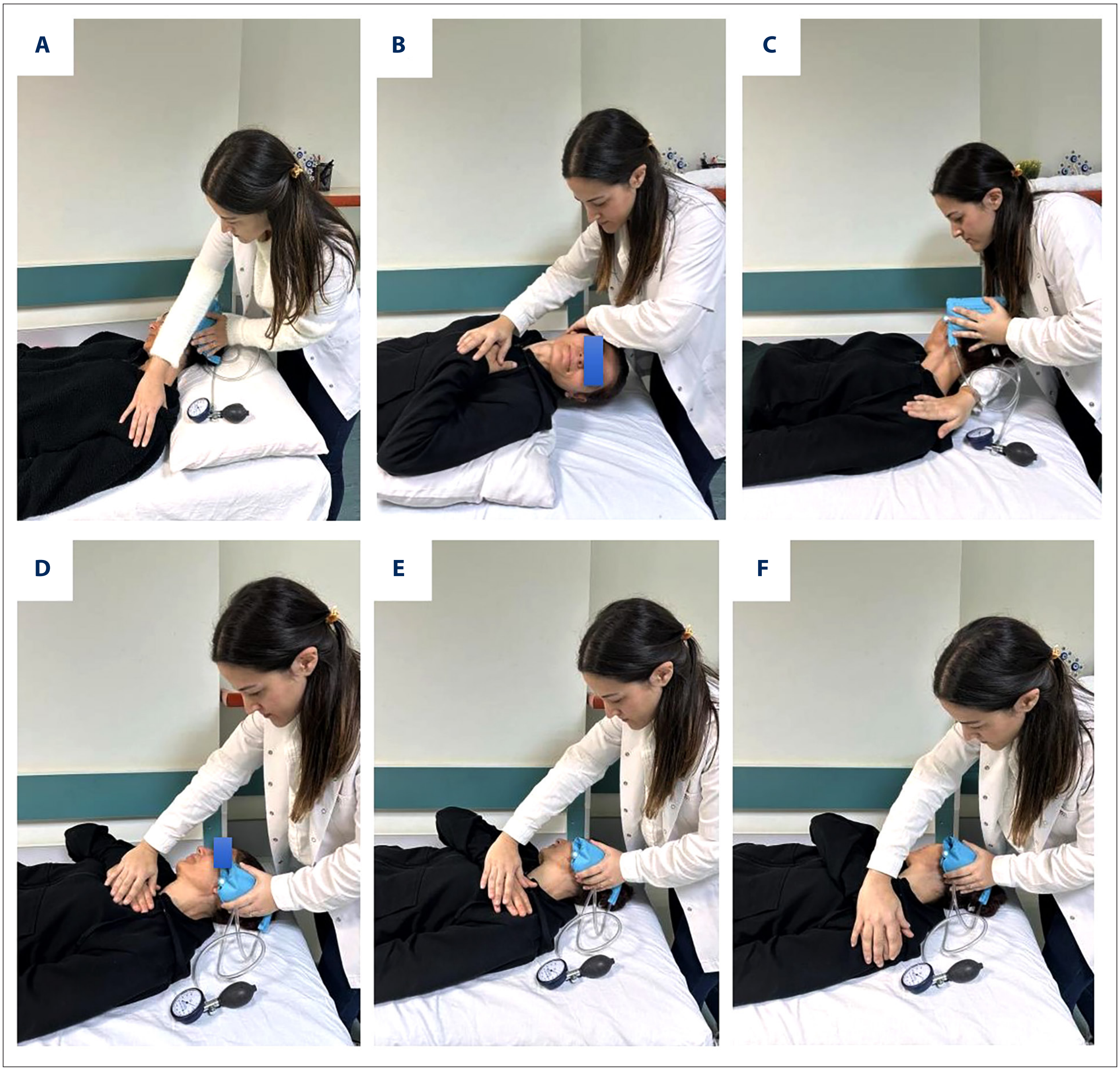

Figure 1. Muscle energy technique treatment for (**A**) upper trapezius (left side); (**B**) sternocloidomastoideus (right side); (**C**) levator scapula (left side); (**D**) anterior scalene (left side); (**E**) middle scalene (left side); and (**F**) posterior scalene (left side) muscles.

and β=0.20 [22]. Considering the possibility that the non-parametric equivalent can be used instead of the parametric ANOVA test in the analyses, this initial sample size was increased by 15% and corrected to 76 participants. Considering that there could be those who would leave the study, this sample size was increased by 25%, and the final sample size was determined to be 96 participants.

Randomization

A total of 96 patients with CS who met the inclusion criteria were divided equally into 3 groups, ET, MET, and CM, using a simple randomization method of random numbers generated based on the date of arrival at the clinic. An independent statistician created the randomization sequence using a computer program (Random Allocation Software, version 1.0). The randomization sequence was written on a piece of paper and was hidden in an envelope. Allocation was performed by a non-intervention researcher. This ensured that patients and the practitioner were blinded before allocation. Due to the nature of the intervention, neither participants nor practitioner could be blinded to allocation.

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Figure 2. Cervical joint mobilization techniques: (**A**) cervical manual traction; (**B1, B2**) bridging; (**C**) lateral glide; (**D1, D2**) rotation with manual traction; and (**E1, E2**) anteroposterior glide with manual traction.

Interventions

All groups were included in the treatment program for a total of 12 treatment sessions over a period of 4 weeks, with sessions taking place every other day 3 times a week. One group received the ET program alone, whereas the other 2 groups received ET+MET or ET+CM applications.

Electro/Thermal Therapy (ET)

The ET group received application of superficial thermal and electrotherapy, which included heat pack application, modulated transcutaneous electrical nerve stimulation (TENS), and therapeutic ultrasound administration. For 20 min, a heat pack was placed on the trapezius and suboccipital muscles. Modulated TENS (80 Hz, 70 μs-180 μs) was applied with a Chattanooga's Cefar device (Chattanooga Group, USA) for 20 min. Therapeutic ultrasound was performed with the Intelect Mobile Combo device (Chattanooga Group, USA) in continuous mode (probe: 5 cm^2, 1 MHz, 1.5 wt/cm^2) for 10 min [23,24].

Muscle Energy Technique (MET)

In addition to the aforementioned ET, the MET was applied to the patients in the MET group based on Lewit's post-isometric relaxation method [25]. MET was applied as a set of 3 repetitions bilaterally to the upper trapezius, sternocloidomastoideus, scalene (anterior-medius-posterior), and levator scapula muscles, considering the patient positions recommended by Lewit (**Figure 1**) [25]. Before application, maximal muscle strength was measured with a biofeedback device (Stabilizer, Chattanooga Group Inc, Hixson, TN, USA) by checking the pressure change for each muscle, and then 20% of maximal muscle strength was calculated. The biofeedback device was inflated to 20 mmHg and placed on the patient's head in the appropriate direction. The patients breathed a sigh before the application. While holding their breath, the patients were asked to perform an isometric contraction of a 7-s duration, corresponding to 20% of the maximum isometric contraction force, against the resistance of the therapist at the point where the restriction was felt. During the application, the accuracy of the isometric pressure force was checked by observing the change in pressure on the biofeedback device. During isometric contraction, the patients were asked to open their eyes and look in the direction of resistance. After the application, the patients were asked to relax and close their eyes while exhaling. Meanwhile, the patients were passively taken to the new limitation point by a physiotherapist, and the technique was repeated [11].

Cervical Mobilization (CM)

In addition to the aforementioned ET treatment, the CM group received Dr. James Cyriax's CM techniques [26]. The patients underwent a vertebral artery test and a deep friction massage on painful spasmic nuchal muscles for 3 to 4 min prior to mobilization. CM consisted of 5 different types of osteopathic passive mobilization techniques that were applied when the patients were in the supine position (**Figure 2**). These techniques included bridging, cervical manual traction, rotation with manual traction, anteroposterior glide with manual traction, and lateral glide [27]. Bridging and manual traction techniques were applied in the first few sessions. In the following sessions, the remaining mobilization techniques were introduced, and a full set of techniques was performed. Traction techniques were applied with 3 to 5 repetitions for 2 to 3 s. Duration, frequency, and progression were personalized according to individual patients [26].

Outcome Measures

Outcomes were measured twice: before treatment and 4 weeks after treatment. Sociodemographic information of the patients was recorded before treatment. Pain intensity and disability were evaluated as primary outcome measures, whereas cervical joint position sense (JPS) was evaluated as a secondary outcome measure.

Visual Analog Scale (VAS)

Neck pain intensity in the neck area during rest and activity was assessed using a VAS. The VAS is a psychometric response scale consisting of a horizontal or vertical line without a number, from 0 mm (no pain) to 100 mm (worst imaginable pain) [28]. The VAS has been reported to have good-to-excellent reliability in the assessment of neck pain (intraclass correlation coefficient [ICC=0.93]), [28]. This study used a 10-cm horizontal line to represent pain intensity at both ends: "no pain" and "worst pain imaginable". The explanatory terms were not used in the intermediate sections. Individuals marked the point they felt best represented the intensity of pain they felt during rest and activity. The distance between the starting point and marked point was measured using a tape measure for analysis [28].

Copenhagen Neck Functional Disability Scale (CNFDS)

Neck pain-related disability was assessed using the CNFDS, which consists of 15 questions. The CNFDS has excellent internal consistency, test-retest reliability (ICC=0.86), and very good validity [29]. The total score of the questionnaire can ranged from 0 (no neck complaints) to 30 (the worst possible disability due to neck complaints) [29]. The questions were answered and scored as yes (0 points), occasionally (1 point), and no (2 points). To avoid repetitive responses, after the fifth question, scores were reversed to yes (2 points), occasionally (1 point), and no (0 points). In this study, the CFDS scale was explained

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to individuals and filled in by themselves. Total score was calculated to be used in statistical analysis [29].

Cervical Joint Position Sense (JPS)

A cervical range of motion (CROM) device (CROM Deluxe, Performance Attainment Associates, MN, USA) was used to evaluate cervical JPS. CROM is a type of goniometer specially designed for the cervical spine and is attached to the head. CROM has excellent time validity with 3D Fastrack (r=0.93-0.98) and excellent inter-rater reliability (ICC=0.89-0.98) [30]. During the measurement, the patients were seated on a chair with their knees and hips at 90º flexion, feet on the floor, and thoracic spine touching the backrest. A sleep mask was used to blindfold the patients. A Velcro strap was used to fix and limit the body and shoulder movements during the test [5]. The CROM unit was fixed on top of the head, and the magnetic yoke of the CROM device was placed on the patients' shoulder. The test was conducted in 2 ways: with a neutral head position test and a target head position test.

For the neutral head position test, the patients were instructed to bring their head to a neutral position by stretching or extending the neck while sitting with their eyes closed and upright. This self-selected neutral head position was considered the reference position. After the head was held in this position for 3 s, the patients were asked to fully rotate their head, and then slowly return it to the starting position in a controlled manner. The test was repeated in the right and left rotational directions [5].

For the target head position test, the researcher passively placed the patients' head at 50% of the maximum range of motion, which was the predetermined target position. The head was held in the target position for 3 s, and then the patients were first asked to bring their head to the neutral position and then to move it back to the target position. The target head position test measurements were performed in 6 movement directions (flexion, extension, right lateral flexion, left lateral flexion, right rotation, and left rotation). When the head reached the target position during the test procedure, the repositioning error was recorded in degrees. Three trials were performed in each movement direction by the patients, and the average was recorded for analysis. The mean of these trials (mean error) was recorded for use in analysis [5].

Statistical Analysis

IBM SPSS Statistics for Windows, version 26.0 (IBM Corp, Armonk, NY, USA) was used for the statistical analysis. Normality was analyzed using the Kolmogorov-Smirnov test. The data were not suitable for normal distribution. Sociodemographic variables were compared between the groups at the pre-intervention stage using the chi-square test. Mean (x) and standard deviation (SD) values were reported for continuous variables, and frequency (n) and percentage (%) values were reported for categorical variables. The Wilcoxon signed-rank test was used for within-group comparisons, and the Kruskal-Wallis test was used for between-group comparisons of the outcome measures. The Quade non-parametric ANCOVA test for cases in which time was corrected according to groups was used to analyze pre- and post-differences between the groups. Post hoc Bonferroni correction was used to identify the different groups. Differences were considered statistically significant at $P<0.05$. Cohen's d coefficient was used to calculate within-group effect size. The effect size was classified as small (d=0.2), medium (d=0.5), or large (d=0.8) [31].

Results

General Characteristics

A total of 96 patients met the eligibility criteria and were included in this study. Fifteen patients left the study prior to treatment after the grouping stage. Loss of motivation and the COVID-19 pandemic were the 2 reasons provided by the patients for leaving. Five patients left the study during the treatment process due to health reasons (SARS-CoV-2 infection). A total of 76 patients completed the study (ET, n=25; MET+ET, n=25; CM+ET, n=26). None of the patients reported any adverse effects caused by treatment. Demographic data in the 3 groups were similar at baseline (**Table 1**).

Pain Intensity

VAS rest and VAS activity values were significantly similar between the groups before treatment ($P>0.05$; **Table 1**). In each group, pain intensity decreased significantly after treatment compared with before treatment ($P<0.001$). All 3 treatments were found to have a significant effect on the VAS rest and VAS activity scores (d≥0.8). The ANCOVA analysis did not show a statistically significant difference between the 3 groups in terms of improvement in the VAS rest ($P=0.912$) and VAS activity ($P=0.176$) scores (**Table 2**).

Neck-Related Disability

There was no significant difference in CNFDS scores between the groups before treatment ($P>0.05$). In each group, neck-related disability decreased significantly after treatment ($P<0.05$). All 3 treatments had a large effect (d≥0.8) on the CNFDS. Between-group analysis revealed that there was no statistically significant difference in disability level improvement among the 3 groups ($P=0.441$; **Table 2**).

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Table 1. General characteristics of patients.

Variables	ET (n=25)	MET (n=25)	CM (n=26)	*P* value
Age, years, (mean±SD)	55.48±8.24	51.60±7.64	50.54±8.43	0.068*
BMI, kg/m², (mean±SD)	28.47±5.45	27.11±4.80	28.63±5.93	0.741*
Pain duration, months, (mean±SD)	27.80±32.02	21.16±25.73	32.69±39.41	0.358*
Sex, Male/Female, n (%)	10 (40)/15 (60)	8 (32)/17 (68)	3 (11.5)/23 (88.5)	0.063**
Arm dominance, right/left, n (%)	25 (100)/0 (0)	23 (92)/2 (8)	24 (92.3)/2 (7.7)	0.192***
Leg dominance, right/left, n (%)	23 (92)/2 (8)	21 (84)/4 (16)	23 (88.5)/3 (11.5)	0.679***
Occupation type, n (%)				
White collar	10 (40)	7 (28)	9 (34.6)	0.206***
Blue collar	2 (8)	9 (36)	3 (11.5)	
Retired	6 (24)	3 (12)	4 (15.4)	
Homemaker	7 (28)	6 (24)	10 (38.5)	

SD – standard deviation; ET – electro/thermal therapy; MET – muscle energy technique; CM – cervical mobilization; BMI – body mass index. * Kruskal-Wallis H test; **Chi-square test; *** Likelihood ratio chi-square test.

Table 2. Comparison of pain and disability within groups and between groups.

Variables		ET (n=25)	MET (n=25)	CM (n=26)	*P* value*	*P* value***
VAS: rest, cm	Baseline	5.12±2.80	5.69±3.06	5.69±1.68	0.710	0.912
	Post-treatment	2.13±2.02	2.52±2.53	2.35±1.68	0.797	
	P value**	**<0.001**	**<0.001**	**<0.001**		
	d	1.23	1.13	1.99		
VAS: activity, cm	Baseline	6.26±2.93	6.84±3.14	6.74±.2.53	0.567	0.176
	Post-treatment	3.10±2.63	3.74±2.63	4.31±2.36	0.219	
	P value**	**<0.001**	**<0.001**	**<0.001**		
	d	1.14	1.07	0.99		
CNFDS score	Baseline	12.92±7.58	14.44±6.81	14.50±6.24	0.765	0.441
	Post-treatment	6.80±6.58	7.08±5.01	8.62±6.40	0.356	
	P value**	**<0.001**	**<0.001**	**<0.001**		
	d	0.86	1.23	0.93		

ET – electro/thermal therapy; MET – muscle energy technique; CM – cervical mobilization; VAS – visual analogue scale; CNFDS – Copenhagen neck functional disability scale. Values are mean±SD unless otherwise indicated. * Kruskal-Wallis H test; ** Wilcoxon signed-rank test; *** Quade test (non-parametric ANCOVA). d – effect size.

Cervical Joint Position Sense

There was no significant difference in any of the joint position error (JPE°) values between the groups before treatment (*P*>0.05). After treatment, the mean extension JPE° value was significantly higher in the ET group than in the MET group (*P*<0.001). In the MET group, a statistically significant decrease in all cervical JPE° values was observed after treatment, compared with baseline (*P*<0.05). MET was found to have a large effect on reducing flexion, extension, left rotation, and left lateral flexion JPE° values (d≥0.8), a moderate to large effect on right rotation, right lateral flexion, and left-neutral JPE° values (d=0.5-0.8), and a small effect on right-neutral JPE°. Only the left lateral flexion JPE° value decreased significantly in the mobilization group after treatment, compared with baseline (*P*=0.046; d=0.469). Between-group analysis showed that there was a statistically significant difference between the 3 groups for extension of JPE° improvement in favor of MET

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Table 3. Comparison of joint position error within groups and between groups.

Variables		ET (n=25)	MET (n=25)	CM (n=26)	P value*	P value***
Right-neutral JPE, °	Baseline	4.79±3.19	4.17±3.49	3.79±3.20	0.407	0.092
	Post-treatment	4.66±4.27	2.69±3.71	3.10±2.79	0.133	
	P value**	0.192	**0.005**	0.071		
	d	0.03	0.41	0.22		
Left-neutral JPE, °	Baseline	7.15±6.84	5.12±4.36	4.74±3.59	0.467	0.055
	Post-treatment	6.21±5.91	2.88±3.75	3.97±3.76	0.061	
	P value**	0.161	**0.001**	0.148		
	d	0.14	0.55	0.21		
Flexion, JPE, °	Baseline	3.12±2.93	3.57±2.49	3.41±2.59	0.568	0.116
	Post-treatment	2.36±1.66	1.86±1.61	2.73±2.22	0.213	
	P value**	0.139	**0.003**	0.172		
	d	0.31	0.81	0.28		
Extension, JPE, °	Baseline	2.99±2.04	2.64±1.56	2.88±2.18	0.843	**<0.001**
	Post-treatment	3.14±1.87[x]	1.42±1.17[y]	2.15±1.02	**<0.001**	
	P value**	0.572	**0.004**	0.143		
	d	0.08	0.89	0.43		
Right rotation JPE, °	Baseline	3.39±2.36	3.86±2.78	3.79±2.81	0.935	0.243
	Post-treatment	2.93±2.12	2.55±2.11	3.36±1.97	0.295	
	P value**	0.372	**0.011**	0.352		
	d	0.20	0.53	0.16		
Left rotation JPE, °	Baseline	3.06±1.74	4.48±2.85	2.88±1.84	0.096	0.482
	Post-treatment	2.66±2.29	2.21±1.33	2.75±2.15	0.783	
	P value**	0.365	**0.002**	0.909		
	d	0.20	1.02	0.06		
Right lateral flexion	Baseline	3.44±3.37	2.36±1.90	2.34±1.67	0.612	0.132
	Post-treatment	2.52±2.55	1.36±1.27	2.11±1.67	0.135	
	P value**	0.115	**0.010**	0.442		
	d	0.30	0.62	0.14		
Left lateral flexion, JPE, °	Baseline	2.21±1.66	2.06±1.37	2.75±1.72	0.218	0.450
	Post-treatment	1.81±1.50	1.17±0.95	1.96±2.17	0.367	
	P value**	0.135	**0.011**	**0.046**		
	d	0.25	0.75	0.40		

ET – electro/thermal therapy; MET – muscle energy technique; CM – cervical mobilization; JPE – joint position error. Values are mean±SD unless otherwise indicated. * Kruskal-Wallis H test; ** Wilcoxon signed-rank test; *** Quade test (non-parametric ANCOVA); d – effect size; [x,y] – there is a significant difference between groups with different letters.

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(P<0.001). The decrease in the extension JPE° obtained in the MET group was significantly greater than that in the CM and ET groups (**Table 3**).

Discussion

The main finding of this study was that MET led to an improvement in cervical proprioception. The study results showed that MET and CM were equally effective on pain and disability, and that using MET or CM techniques in addition to ET therapy did not provide any additional benefit in reducing pain intensity and disability, compared with ET therapy alone.

In the present study, within-group analyses of the VAS showed a significant reduction in pain intensity after 12 treatment sessions in all groups. In addition, between-group analyses showed similar improvements for both VAS rest and VAS activity scores in the 3 groups. The effect sizes of the within-group differences for pain intensity at rest and activity were large in all 3 groups. The mean difference score for pain in all groups in this study exceeded the reported minimum clinically important difference on the VAS, which was 4.6 mm to 21.4 mm [32]. The results of the present study are consistent with those in the international literature, which reports that manipulative techniques have similar efficacy to other treatments for neck pain [17,33]. Similarly, randomized controlled clinical trials found that passive joint mobilization as an adjunct to a standard physiotherapy program was no more effective in reducing neck pain and disability than standard physiotherapy alone [34,35]. A recent study compared the effect of post-isometric relaxation-MET application and Maitland facet joint mobilization applied 3 times a week for 2 weeks in patients with chronic neck pain. Similar to our results, this study reported that the 2 techniques were similarly effective for pain intensity and functional disability [14]. Additionally, the findings of the this study showed that the post-isometric relaxation-MET and Maitland mobilization groups were not statistically superior to the active control group in measurements immediately after treatment [14]. In the present study, there was no difference in pain intensity when CM or MET was added to ET, which is consistent with the current literature [14,34,35].

This study has shown that patients with CS can achieve sufficient reduction in chronic neck pain and neck-related disability in the short term with the combination of a heat pack, TENS, and therapeutic ultrasound. Increased local metabolism, circulation, and connective tissue extensibility with ET treatment combination are thought to lead to a reduction in inflammation and muscle tone and to reduce axial neck pain [36,37]. The fact that the addition of MET and CM techniques to ET did not bring about any additional improvement in neck pain could be due to the fact that these techniques act primarily mechanically, and their hypoalgesic effects are mainly based on spinal and supraspinal mechanisms.

The study results showed that disability as measured by the CNFDS improved in all 3 groups, with no statistically significant differences between the groups. The positive correlation between disability level and neck pain severity has been proven in previous studies [38,39]. Reduced neck pain can lead to improved function, increased independence, and reduced disability [38,39]. In our study, it was thought that the improvement in the level of disability obtained in the 3 groups was due to a decrease in the severity of neck pain during rest and activity.

Another important finding of this study was that the 12-session MET program was effective in improving cervical position errors in all movement directions. The Cohen values for clinical effect size indicate that MET has a large effect on reducing JPS, especially in flexion, extension, left rotation, and left lateral flexion. However, although the MET group achieved better results, no statistical significance was found between the groups, with the exception of position error in extension. In this study, the results of the intra-group analysis showed no statistically significant difference in the CM group, except for the left lateral flexion JPE. The results of the present study highlight the findings of Shah et al, who reported that the post-isometric relaxation-MET technique, applied for 2-week period, improved the accuracy of head positioning in individuals with forward head posture [21]. MET involves various special levers on the spinal joints with controlled, targeted isometric muscle contraction performed by the patient, as well as their localization and oculomotor movements [11]. In this study, it was thought that the improvement in JPS with the application of MET is due to the fact that MET normalizes proprioceptive and motor coordination in the segment with proprioceptive disorders by stimulating muscle and joint proprioceptors, as suggested by Chaitow [11].

It is plausible that joint mobilization improves proprioception by stimulating the mechanoreceptors of the joints and ligaments [12] and by restoring normal biomechanical and proprioceptive function of the spine by restoring joint motion [40]. However, studies investigating the effect of mobilization techniques on the JPS reached different results [18,19]. Hussien et al reported that the Mulligan sustained natural apophyseal glides (SNAG) applied to patients with chronic non-specific low back pain for 4 weeks improved trunk flexion JPS more than the control group [18]. On the contrary, Reid et al (2014) showed that Mulligan SNAG or passive Maitland mobilization techniques applied for 6 weeks had no significant effect on neutral head position error [19]. In the present study, although it was observed that the deviation from the target angle decreased in all movement directions in the CM group, no significant clinical effect of CM on proprioception was detected.

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Active participation of the patient in the movement is extremely important in proprioceptive feedback, motor control, and motor learning [41]. The fact that MET is an active technique may explain why it improves proprioception more than CM techniques. In their study, Sachdeva et al (2019) reported that MET techniques applied to the first rib in patients with chronic neck pain were more effective in improving cervical position sense than Maitland mobilization [15]. The results of their study are consistent with our findings. In addition, some studies have shown that treatment programs that previously included isometric exercise can improve proprioception [42,43]. In this respect, repeated isometric contractions in MET may have stimulated proprioceptors by increasing the contractile tension of the relevant tendons. However, some studies have shown that proprioceptive sensory development occurs only after 6 to 12 weeks of treatment [44]. Since our study treatment program was 4 weeks long, the possible effect on proprioception may not have been revealed in the mobilization group. Whether the results could change with long-term applications should be examined in future studies.

In particular, increased activation and shortness of the suboccipital muscles observed in forward head posture, caused by degenerative disc disease, are associated with impaired proprioceptive input of the muscle [45,46]. The MET technique may reduce hyperactivation and tension in the suboccipital muscles by a neurophysiological mechanism that activates the Golgi tendon reflex and inhibits alpha motor neuron [47]. In the present study, the improvement in extensor proprioception observed in the MET group compared with the other 2 groups may have been due to the normalization of erroneous neuromuscular signals, especially in the extensor region.

MET is a promising technique for improving cervical proprioception. We believe that our results will shed light on future studies by increasing awareness of chronic cervical pain management. Larger and long-term studies are needed to investigate the effectiveness of MET and mobilization approaches in the management of CS.

This study had some limitations. First, it looked only at the short-term effect of the treatment modalities. Therefore, we cannot be sure that these results will be maintained in the long term. Second, the VAS used to evaluate pain is a subjective scale. However, there is no accepted objective method for pain assessment. Considering that increased inflammation may be the source of axial neck pain in patients with CS, it may be useful for future studies to evaluate the effects of CM and MET applications on inflammatory factors.

Conclusions

The present results showed that MET and CM have similar effects in improving pain and disability in individuals with CS with chronic neck pain. Another important result was that the addition of MET to ET improved cervical JPS. Considering the importance of the cervical region in the sensorimotor system, it is thought that this multimodal treatment approach can be beneficial in the treatment of proprioceptive disorder and related symptoms in patients with CS.

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Declaration of Figure's Authenticity

The authors declare that all figures presented were created by them, that the images are not copies, and that all of them have not been published before.

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