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COMPARISON OF THE EFFECTS OF MULLIGAN MOBILIZATION TECHNIQUE COMBINED WITH CERVICAL STABILIZATION EXERCISES WITH THE EFFECTS OF CERVICAL STABILIZATION EXERCISES ALONE IN CHRONIC NECK PAIN: RANDOMIZED CONTROLLED STUDY

KRONİK BOYUN AĞRISINDA SERVİKAL STABİLİZASYON EGZERSİZLERİ İLE KOMBİNE EDİLEN MULLİGAN MOBİLİZASYON TEKNİĞİNİN ETKİLERİNİN TEK BAŞINA SERVİKAL STABİLİZASYON EGZERSİZLERİNİN ETKİLERİ İLE KARŞILAŞTIRILMASI: RANDOMİZE KONTROLLÜ ÇALIŞMA

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ABSTRACT

Objective: The aim of the study was to compare the effects of Mulligan mobilization techniques applied in addition to cervical stabilization exercises on pain intensity, range of motion (ROM), cervical muscle endurance, pressure pain threshold (PPT), and quality of life compared to cervical stabilization exercises alone in individuals with chronic neck pain (CNP).

Method: Forty individuals with CNP were included in the study and randomly divided into two groups: the cervical stabilization group (SG, n=20) and the cervical stabilization-Mulligan mobilization group (SMG, n=20). The SG group only received cervical stabilization exercises for four weeks, while the SMG received Mulligan mobilization techniques for four weeks in addition to cervical stabilization exercises. Before and after the treatment programs, the subjects were evaluated in terms of pain intensity (visual analogue scale), ROM (goniometric measurement), cervical muscle endurance (endurance tests), PPT (algometric measurement), and quality of life (Short Form-36, SF-36).

Results: Significant improvements were found in all parameters in both groups after the treatment programs ($p<0.05$). In addition, there were more improvements in ROM, PPT, and SF-36 scores in SMG compared to SG ($p<0.05$).

Conclusion: The application of cervical stabilization exercises in CNP may improve pain intensity, ROM, cervical muscle endurance, PPT, and quality of life. However, it can be said that Mulligan mobilization techniques applied in addition to cervical stabilization exercises are more effective in improving ROM, PPT, and quality of life compared to cervical stabilization exercises alone in individuals with CNP.

Key Words: Neck Pain, Exercise, Manipulative Therapies, Quality of Life, Rehabilitation

ÖZ

Amaç: Çalışmanın amacı kronik boyun ağrısı (KBA) olan bireylerde servikal stabilizasyon egzersizlerine ek olarak uygulanan Mulligan mobilizasyon tekniklerinin, tek başına uygulanan servikal stabilizasyon egzersizlerine kıyasla ağrı şiddeti, eklem hareket açıklığı (EHA), servikal kas enduransı, basınç ağrı eşiği (BAE) ve yaşam kalitesi üzerindeki etkilerini karşılaştırmaktı.

Yöntem: Kırk KBA'lı bireyin dahil edildiği çalışmada bireyler rastgele servikal stabilizasyon grubu (SG, n=20) ve servikal stabilizasyon-Mulligan mobilizasyon grubu (SMG, n=20) olmak üzere iki gruba ayrıldı. SG'ye sadece dört haftalık servikal stabilizasyon egzersizleri uygulanırken, SMG'ye servikal stabilizasyon egzersizlerine ek olarak dört hafta boyunca Mulligan mobilizasyon teknikleri uygulandı. Tedavi programları öncesinde ve sonrasında bireyler ağrı şiddeti (görsel analog skala), EHA (gonyometrik ölçüm), servikal kas enduransı (endurans testleri), BAE (algometrik ölçüm) ve yaşam kalitesi (Kısa Form-36, KF-36) bakımından değerlendirildi.

Bulgular: Tedavi programları sonrasında her iki grupta da bütün parametrelerde anlamlı iyileşmeler bulundu ($p<0.05$). Ayrıca, SMG'de SG'ye kıyasla; EHA, BAE ve KF-36 skorlarında daha fazla iyileşme görüldü ($p<0.05$).

Sonuç: KBA'da servikal stabilizasyon egzersizlerinin uygulanmasıyla, ağrı şiddeti, EHA, servikal kas enduransı, BAE ve yaşam kalitesinde iyileşmeler elde edilebilir. Bununla birlikte, KBA'lı bireylerde servikal stabilizasyon egzersizlerine ek olarak uygulanan Mulligan mobilizasyon tekniğinin tek başına uygulanan servikal stabilizasyon egzersizlerine kıyasla EHA, BAE ve yaşam kalitesini iyileştirmede daha etkili olduğu söylenebilir.

Anahtar Kelimeler: Boyun Ağrısı, Egzersiz, Manipulatif Tedaviler, Yaşam Kalitesi, Rehabilitasyon

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INTRODUCTION

Neck pain is one of the most common musculoskeletal problems, after low back pain [1]. It has been reported that the lifetime prevalence of neck pain, which is more common in females, increases with age and ranges between 43% and 66.7% [2]. Neck pain tends to become chronic, and neck pain lasting longer than three months is called chronic neck pain (CNP). It has been reported that half to three-quarters of individuals with neck pain experience neck pain again within 1–5 years [3]. In individuals with neck pain, the function of neck muscles and sensory receptors may be impaired. Electromyography studies have reported a decrease in the activity of deep neck flexor and extensor muscles and an increase in the activation of superficial muscles [2,4]. However, it has been reported that prolonged overactivity of superficial cervical muscles causes more muscle fatigue and tenderness, decreased muscle strength and endurance capacity, and decreased range of motion (ROM) in patients with neck pain [2,4]. Neck pain can lead to reduced work capacity and significantly increased treatment costs. Clinicians and physiotherapists are still searching for the most effective and appropriate treatments to improve the quality of life and reduce treatment costs for individuals suffering from CNP [5].

Many methods have been utilized in the conservative treatment of CNP, including analgesics, physiotherapy, education, exercise, and manual therapy [6]. Among these, exercise is considered one of the methods with high evidence value [4,7]. Among the exercises, cervical stabilization exercises (CSE) are frequently used, especially to activate deep neck muscles and reduce the overactivity of superficial muscles. Studies have reported that CSE is effective in the treatment of individuals with CNP [4,8-10]. Another treatment method with a high evidence value for neck pain is manipulation and mobilization [6,11]. Mulligan mobilization technique (MMT) is one of the mobilization techniques that can be used in the treatment of CNP. This technique aims to decrease pain and increase functionality by focusing on reducing limitations in ROM and correcting positional errors in the joint [12]. In CNP patients who underwent MMT application to the cervical region, improvements in pain-free ROM of the cervical region were recorded after the application [13]. In a randomized controlled trial, MMT was reported to improve pain and disability symptoms in CNP patients after a nine-session protocol and at one-month follow-up [14]. In another study, MMT was found to be more effective in improving pain, kinesiophobia, functional level, ROM, depression, and quality of life in elderly individuals with neck pain compared to conventional treatment [13].

In the literature, no randomized controlled study was found in which CSE and MMT were used together. Therefore, the aim of this study was to compare the effects of MMT combined with CSE and CSE alone on pain intensity, ROM, cervical muscle endurance, pressure pain threshold, and quality of life in individuals with CNP.

METHOD

Study Design

The study was designed as randomized, controlled, and single-blinded research.

Participants

The study was conducted with individuals aged between 18 and 50 years with CNP who had neck pain for more than three months (pain intensity ≥3 according to the visual analogue scale), were diagnosed with CNP by specialist physicians, and applied to a private physiotherapy clinic in FizyoKaraman for treatment. Individuals who had neck pain for at least 3 months, whose neck pain was not caused by a neurologic, rheumatologic, or psychiatric disorder, and who had not received any treatment for neck pain for the last 3 months were included in the study. Those who had undergone spinal surgery, neck pain caused by various pathologies (rheumatoid arthritis, ankylosing spondylitis, fracture, tumor, etc.), nerve root compression, a positive vertebrobasilar artery test, severe radiculopathy, osteoporosis, or osteopenia, and long-term use of corticosteroids or anticoagulants were excluded from the study. Individuals who met the inclusion criteria were randomly divided into two groups: the cervical stabilization group (SG), in which only cervical stabilization exercises were performed, and the cervical stabilization-Mulligan mobilization group (SMG), in which cervical stabilization exercises and MMT were combined. Age, gender, duration of complaint, and body mass index (BMI) were noted for all participants.

Interventions

An experienced specialist physiotherapist (HK) performed both the CSE program and MMT. All treatment programs were applied four days a week for four weeks.

Cervical Stabilization Exercise Program

The CSE program, which was created by taking into account similar studies in the literature, consisted of static, dynamic, and functional phases, respectively, taking into account the motor learning and sensory-motor integration steps [4,15,16]. Each exercise session consisted of 5-10 minutes of warm-up exercises, 30 minutes of stabilization exercises, and 5-10 minutes of cool-down exercises. Neck stretching exercises were performed during the warm-up and cool-down periods to increase the flexibility of the neck muscles. In the first phase, the exercises were performed slowly and in a controlled manner to increase motor control and kinesthetic awareness. Participants were trained in craniocervical flexion exercises at the beginning of the static phase, enabling them to achieve deep neck flexor muscle activation and minimize superficial neck flexor muscle activation. The craniocervical flexion exercise was practiced in the supine hook position using a pressurized biofeedback device (Stabilizer™, Chattanooga, USA). Exercises were performed supine, prone, crawling, sitting, and standing after cervical bracing (craniocervical flexion and deep cervical muscle contraction) was achieved. In order to ensure conscious motor control in the dynamic phase, upper and lower extremity movements were added to the cervical bracing, and exercises were performed unilaterally, bilaterally, or reciprocally in different neurodevelopmental positions with gradually increasing difficulty, respectively. The difficulty of the exercises was gradually increased according to the individuals' ability to perform and tolerate the movements correctly. Resisted isometric exercises for the cervical region were then performed using elastic bands (Thera-Band® Hygenic Corporation, Akron, OH). The resistance of the elastic bands was chosen according to the tolerance of the participants. Isometric exercises were performed in 3 sets of 8-12 repetitions per set. In the functional phase, it was aimed at gaining subconscious control of movement. In this phase, elastic bands and an exercise ball were utilized when performing the exercises. The program progressed with combined functional exercises such as extremity movements while sitting on the ball with cervical bracing, squeezing the ball between the head and the wall while standing, controlling the ball, and extremity movements with elastic bands during ball control. The exercises were performed as 10 repetitions with 10 seconds of contraction and 5 seconds of relaxation [4]. All exercises were performed under only physiotherapist supervision for four weeks.

Mulligan Mobilization Applications

MMT, which was applied in addition to cervical stabilization exercises, was performed by a physiotherapist certified in MMT with 15 years of professional experience. MMT procedures were performed with the participants sitting in a chair with their backs supported. The first intervention of MMT was the natural apophyseal glides (NAGs) between C2 and C7 (Figure 1). The second intervention was the application of sustained natural apophyseal glides (SNAGs). SNAGs, an important MMT for the cervical spine, are a full-range painless movement that is a combination of the patient's physiological movement and the gliding motion applied to the facet joint by the therapist [12]. In SNAGs, the gliding movement was continued until

the last angle of the joint with the active movement of the patient, and high pressure (overpressure) was applied at the last point (Figure 2). MMT applications were performed in 3 sets with 10 repetitions and a 15-20-second rest between sets [13,17]. All NAGs and SNAGs techniques in Mulligan mobilization applications were applied manually by an experienced and certified specialist physiotherapist for four weeks.

Figure 1. Natural apophyseal glides (NAGs)

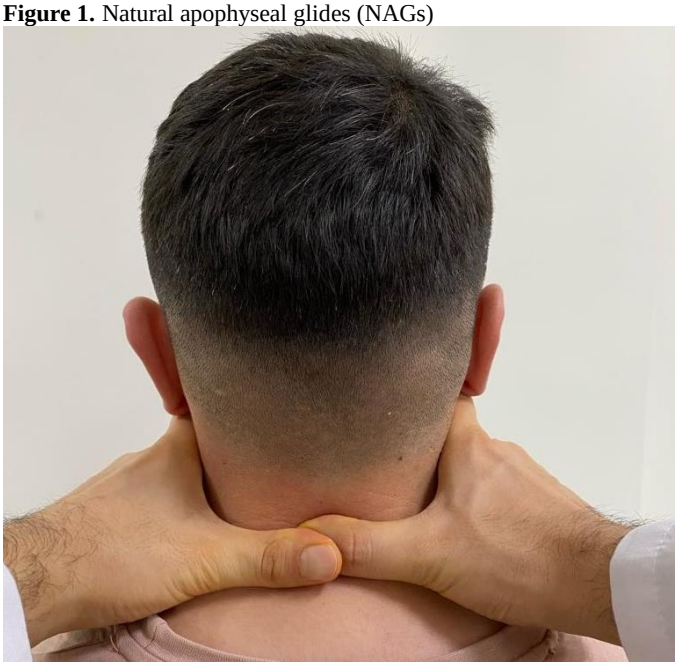

Figure 2. Sustained natural apophyseal glides (SNAGs)

Outcome Measures

Pain Intensity: The pain intensity of the participants during rest (static positions in which the head and neck are at rest) and activity (dynamic positions of the head and neck such as forward and backward bending and rotation) was assessed using a visual analogue scale (VAS). Participants were asked to mark the intensity of pain they felt on a 10-cm-long line (0 represents no pain and 10 represents severe pain). Results were recorded in cm [18]. The measurement of pain intensity with VAS has been stated to be valid and reliable [19].

Range of Motion: Cervical flexion, extension, right and left lateral flexion, and rotation movements were assessed with a universal goniometer while participants were seated with both feet on the floor, hips and knees positioned at a 90° angle, and hips resting on the back of the chair. Three measurements were made for each direction of movement, and the mean value of the measurements was taken and recorded in degrees of pain-free active ROM for each direction of movement. It has been reported that ROM measurements with a universal goniometer showed good reliability [20].

Cervical Muscle Endurance: To assess the endurance of the cervical flexor muscles, the participant was asked to perform a chin tuck and bring the chin slightly closer to the chest in the supine hook position with the hands on the belly. The examiner placed his hand under the participant's occiput to determine whether the position could be maintained. The amount of time this position could be maintained was recorded in seconds. To evaluate the endurance of the cervical extensor muscles, the participant was positioned in the prone position with his or her head hanging from the bed, and a 2 kg weight was placed on his or her head. The time this position could be maintained was recorded in seconds [17,21].

Pressure Pain Threshold: The pressure pain threshold (PPT) was measured using a digital algometer (JTech Medical Industries, ZEVEX Company) by placing the probe of the device at a 90° angle to the midpoint of the upper body of the trapezius muscle between the seventh cervical vertebra and the acromion. The probe of the device was applied by increasing the pressure until the patient felt pain, and the pressure value at which pain was felt was determined as the pain threshold. The measurement was performed three times, and the average of the values obtained was recorded as kg/cm². The evaluations were performed separately on both the right and left sides. Measurements with a digital algometer have been reported to have high reliability [22].

Quality of Life: Quality of life was assessed with the Turkish version of the Short Form-36 (SF-36) scale, the validity and reliability of which were demonstrated by Koçyiğit et al. In the SF-36, which consists of thirty-six questions and eight subscales, the physical section score (FSS) is obtained by averaging four subscales related to physical parameters, while the mental section score (MSS) is obtained by averaging the other four subscales. FSS and MSS main section scores range from 0-100, with higher scores indicating better quality of life [23].

Randomization and Blinding

The 40 individuals with CNP included in the study were randomly divided into SG (n=20) and SMG (n=20) groups using gender- and age-matched pairs randomization. Matched pairs randomization was conducted using the Research Randomizer program on the website www.randomizer.org [24]. All assessments in the groups at baseline and at the end of the four-week treatment programs were performed by the same investigator (NTY), who was blinded to the treatment groups. However, participants in the groups were not blinded to the treatment methods in the study.

Sample Size

The G*Power program (Version 3.1.9.4.3, Heinrich-Heine Universität, Düsseldorf, Germany) was utilized to determine the sample size. Based on a previous similar study [4], the effect of exercises on neck pain was calculated, yielding a total of 32 individuals according to repeated measures analysis of variance (ANOVA) within and between interactions to achieve 80% statistical power (1-β error probability) at an effect size of 0.26 with an α error level probability of 0.05. A total of 40 participants, 20 in each group, were included in the study, taking into account that approximately 20% of the participants may drop out of the follow-up.

Ethical Approval

Ethical approval for the study was obtained from the Muş Alparslan University Scientific Research and Publication Ethics Committee (Decision No. 7-2023/37). Verbal and written informed consent was obtained from all participants in the study, all stages of which were conducted in accordance with the Declaration of Helsinki. In addition, the necessary permissions were obtained from the private FizyoKaraman physiotherapy clinic where patients with CNP applied for treatment and where the study was carried out.

Statistical Analysis

Statistical analyses were performed using SPSS (IBM SPSS Statistics for Windows, Version 24.0, Armonk, NY: IBM Corp., USA) software. Descriptive analyses were given as mean and standard deviation for numerical variables whose normal distribution was checked by visual (histograms, probability plots) and analytical methods (Shapiro-Wilk and Kolmogorov-Smirnov tests). Nominal variables were expressed as numbers and percentages. An independent sample t-test was used to compare the numerical demographic data of the groups. The chi-square test was utilized to compare categorical variables. To evaluate the effects of treatments on pain intensity, cervical ROM, cervical muscle endurance, PPT, and quality of life, with group (SG, SMG) as the between-patient variable and time (pre-treatment, post-treatment) as the within-patient variable, a two-way mixed design repeated measures analysis of variance (ANOVA) was conducted. Also, pairwise comparisons, using the Bonferroni correction, were performed to analyze any significant between-group differences in change scores from baseline to the last treatment session. Partial eta squared was used as the effect size, with small (0.10), medium (0.25), and large (0.40) values considered [25]. The statistical significance level was determined as $p<0.05$.

RESULTS

Fifty-four individuals diagnosed with CNP by specialist physicians and referred to the clinic were examined for eligibility; nine did not meet the inclusion criteria, and five declined to participate in the study. Forty individuals with CNP who were eligible for the study and agreed to participate were randomly assigned to two treatment groups.

The study was completed with the full participation of all participants in the treatment and assessment programs in both groups (Figure 3).

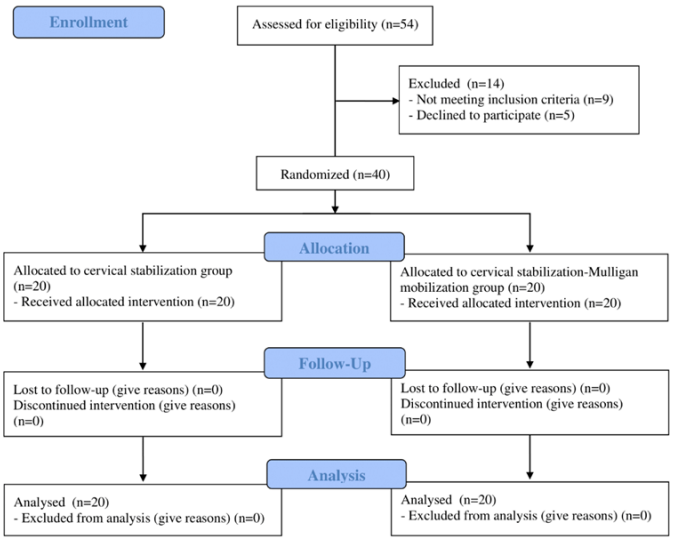

Figure 3. Study flow diagram

Demographic characteristics of the SG and SMG groups are presented in Table 1. The groups were similar in terms of demographic characteristics ($p>0.05$).

Table 1. Demographic characteristics of the groups

Variables	SG (n=20)	SMG (n=20)	p
Age (year), (Mean±SD)	49.65±9.47	47.61±12.84	0.481[a]
BMI (kg/m^2), (Mean±SD)	28.21±5.18	27.39±5.62	0.553[a]
Duration of complaint (month), (Mean±SD)	30.9±3.4	31.7±3.6	0.268[a]
Gender (n)			
Male	8	7	0.799[b]
Female	12	13	

SG: Cervical stabilization group; SMG: Cervical stabilization+Mulligan mobilization group; SD: Standard deviation; BMI: Body mass index; [a]p: Independent sample-t test; [b]p: Chi-square test.

The comparison of VAS scores of the SG and SMG groups before and after treatment is given in Table 2. When the changes within the groups over time were analyzed, it was found that the resting and activity scores of VAS decreased significantly in both groups ($p<0.05$). On the other hand, when the changes of the groups over time (Group*Time) were compared after treatment, no significant difference was found between the groups for resting and activity scores of VAS. Similar changes were observed in the resting and activity scores of VAS in both groups ($p>0.05$).

Table 3 presents a comparison of the values for ROM, cervical muscle endurance, and PPT in both the SG and SMG groups before and after treatment. Analyzing changes within each group over time, a significant increase was observed in all ROM values, as well as right and left-side PPT values, and cervical flexor and extensor muscle endurance values in both groups ($p<0.05$). Upon comparing changes over time after treatment between the groups (Group*Time), a significant difference emerged in all ROM and right and left-side PPT values ($p<0.05$). However, no significant difference was found in cervical flexor and extensor muscle endurance values ($p>0.05$). Notably, it was observed that the SMG group exhibited greater increases in all ROM values and right and left-side PPT values, while similar changes were observed in cervical flexor and extensor muscle endurance values in both groups (Table 3).

Table 4 presents a comparison of the FBP and ZBP scores of SF-36 in both the SG and SMG groups before and after treatment. Upon analyzing changes within each group over time, it was observed that both main section scores of SF-36 increased significantly in both groups ($p<0.05$). Furthermore, when comparing changes over time after treatment between the groups (Group*Time), a significant difference emerged for the main section scores of SF-36. Specifically, FBP and ZBP scores exhibited greater increases in the SMG group ($p<0.05$).

DISCUSSION

In the present study, the combination of MMT and stabilization exercises demonstrated superior effectiveness in improving cervical ROM, increasing PPT, and enhancing overall quality of life in individuals with CNP compared to stabilization exercises alone. On the other hand, MMT combined with stabilization exercises had similar effects in reducing pain intensity and increasing cervical muscle endurance compared to stabilization exercises alone.

CNP represents a significant health concern affecting a substantial portion of the general population, leading to persistent pain, limited cervical mobility, reduced strength and endurance in cervical muscles, disability, and an overall decline in quality of life. Exercise therapy for the cervical region is well-established as an evidence-based and effective approach in CNP rehabilitation. The primary objective of CSE in CNP management is to reduce the overactivity of superficial neck muscles and promote the activation of deeper muscles [16]. Previous studies [4,13,26-28] have explored various manual therapy

techniques combined with exercise therapy for CNP. In Kaya and Çelenay's study [16], a significant decrease in neck pain was reported after four weeks of CSE treatment in individuals with CNP. In the study of Farooq et al. [27] in individuals with CNP, one group received a four-week routine physiotherapy program, and the other group received Maitland mobilization techniques for four weeks in addition to routine physiotherapy. Results indicated that, although both groups experienced an important reduction in pain, the group receiving Maitland mobilization in addition to routine physiotherapy demonstrated greater improvement in pain intensity.

In a study comparing the short-term effects of combining CSE with manual therapy versus CSE alone in individuals with CNP, it was observed that pain decreased in both groups following four-week treatment programs. However, the group receiving CSE combined with manual therapy did not demonstrate superior pain reduction compared to the group receiving CSE alone [4]. Similarly, in the study by Ganesh et al. [28], individuals with CNP were divided into three groups: exercise alone, Maitland mobilization in addition to exercise, and Mulligan mobilization techniques in addition to exercise. The study's conclusion indicated that pain significantly decreased in all groups, but neither the Maitland nor Mulligan mobilization techniques proved superior to exercise alone in reducing pain. Büyükturan et al. [13] conducted a study where one group received a traditional physiotherapy program, including ROM and posture exercises, while the other group received MMT in addition to traditional physiotherapy. The researchers reported a significant reduction in pain in both groups; however, the level of pain reduction was similar between the two groups. Dynamic exercises have been reported to increase blood circulation and muscle glycogen uptake and have significant effects on pain reduction in addition to their positive effects on stability and function [28]. In the current study, the decrease in pain intensity in both groups may be explained by these effects of dynamic exercises. However, the reduction in pain intensity was similar between the two groups. These findings were consistent with the results of Ganesh et al. [28] and Çelenay et al. [4]. Based on the results of the present study, which are consistent with the results of the studies in the literature, it can be said that CSE is an effective method to reduce pain intensity in CNP patients. Furthermore, we suggest that the effects of MMT applied in combination with CSE on pain intensity compared to CSE alone in patients with CNP should be investigated in future studies with longer treatment and follow-up periods.

Table 2. Comparison of pain intensity values of SG and SMG groups before and after treatment

Variables			SG (n=20)	SMG (n=20)	MD values between groups	Time	Group*Time		η2
			Mean±SD		Mean±SE	p	F	p	
VAS	During rest	BT	4.51±1.63	4.69±1.85	0.53±0.26	<0.001*	3.03	0.087	0.05
		AT	1.87±1.42	1.52±1.23					
	During activity	BT	6.95±1.94	6.61±1.72	0.19±0.24	<0.001*	0.91	0.344	0.02
		AT	2.85±1.70	2.32±1.47					

*SG: Cervical stabilization group; SMG: Cervical stabilization+Mulligan mobilization group; MD: Mean difference; SD: Standard deviation; SE: Standard error; VAS: Visual analogue scale; BT: Before treatment; AT: After treatment; η2: Effect size; p: Two-way mixed design repeated measures ANOVA; *p<0.05.*

Table 3. Comparison of ROM, cervical muscle endurance, and pressure pain threshold values of the SG and SMG groups before and after treatment

Variables			SG (n=20)	SMG (n=20)	MD values between groups	Time	Group*Time		η2
			Mean±SD		Mean±SE	p	F	p	
ROM (◦)	Flexion	BT	39.23±7.50	37.23±8.02	4.68±0.73	<0.001*	42.56	<0.001*	0.42
		AT	45.19±7.23	47.87±7.73					
	Extension	BT	30.13±5.84	29.84±5.99	4.97±0.48	<0.001*	111.30	<0.001*	0.65
		AT	35.03±5.64	39.71±6.09					
	Right lateral flexion	BT	25.55±4.41	25.35±5.02	4.46±0.37	<0.001*	149.09	<0.001*	0.71
		AT	29.61±4.44	33.87±4.15					
	Left lateral flexion	BT	25.10±3.66	24.68±4.08	5.25±0.34	<0.001*	240.51	<0.001*	0.80
		AT	28.94±3.54	33.77±3.26					
	Right rotation	BT	37.48±3.85	37.35±5.34	5.61±0.26	<0.001*	453.23	<0.001*	0.88
		AT	40.81±3.77	46.29±4.69					
	Left rotation	BT	36.77±4.20	36.81±4.65	5.22±0.38	<0.001*	192.68	<0.001*	0.76
		AT	40.58±4.32	45.84±4.03					
Cervical muscle endurance (second)	Deep cervical flexors	BT	12.46±2.31	12.85±2.34	-0.14±0.41	<0.001*	0.13	0.718	0.02
		AT	19.77±3.48	20.02±3.15					
	Deep cervical extensors	BT	15.40±2.45	15.42±2.64	0.10±0.51	<0.001*	0.03	0.862	0.01
		AT	21.99±2.92	22.11±3.15					
Pressure pain threshold (kg/cm^2)	Right upper trapezius	BT	8.25±3.01	7.86±3.17	5.19±0.69	<0.001*	44.38	<0.001*	0.69
		AT	13.02±3.08	17.82±3.09					
	Left upper trapezius	BT	8.64±3.21	7.14±3.59	5.28±0.71	<0.001*	39.28	<0.001*	0.52
		AT	14.69±2.86	18.47±3.16					

*SG: Cervical stabilization group; SMG: Cervical stabilization+Mulligan mobilization group; MD: Mean difference; SD: Standard deviation; SE: Standard error; ROM: Range of motion; BT: Before treatment; AT: After treatment; η2: Effect size; p: Two-way mixed design repeated measures ANOVA; *p<0.05*

Table 4. Comparison of PSS and MSS main section scores of the Short Form-36 scale in SG and SMG groups before and after treatment

Variables			SG (n=20)	SMG (n=20)	MD values between groups	Time	Group*Time		η2
			Mean±SD		Mean±SE	p	F	p	
Short Form-36 (point)	PSS	BT	29.03±2.60	30.71±2.98	14.79±0.79	<0.001*	121.3	0.003*	0.67
		AT	62.15±4.24	78.62±4.42					
	MSS	BT	35.69±2.87	33.93±2.61	18.27±0.82	<0.001*	102.49	0.001*	0.59
		AT	64.10±3.83	80.61±5.35					

*SG: Cervical stabilization group; SMG: Cervical stabilization+Mulligan mobilization group; MD: Mean difference; SD: Standard deviation; SE: Standard error; PSS: Physical section score; MSS: Mental section score; BT: Before treatment; AT: After treatment; η2: Effect size; p: Two-way mixed design repeated measures ANOVA; *p<0.05.*

Studies in the literature reported that CSE increased cervical ROM values in individuals with CNP [4,10,16]. In the study of Farooq et al. [27], it was noted that exercise therapy was effective in improving cervical ROM in individuals with CNP, and further increases in cervical ROM could be obtained by applying mobilization techniques in addition to exercise therapy. Another study [13] involving individuals with CNP reported that the combined application of MMT with conventional physiotherapy yielded a greater increase in cervical flexion, extension, and lateral flexion values compared to conventional physiotherapy alone. Similarly, Gautam et al. [29] found that when MMT was applied in addition to conventional physiotherapy, including isometric exercises and hot applications, it was more effective in increasing ROM compared to conventional physiotherapy alone in patients with neck pain. In the present study, in accordance with the literature, increases in cervical ROM were recorded after treatment programs in both groups in which an exercise program was applied. Moreover, the fact that the increases in ROM values were significantly higher in the SMG compared to the SG may be explained by the corrective effects of MMT on impaired arthrokinematics in the joint [12]. In light of the findings of the current study and the results in the literature, it can be concluded that CSE is effective in increasing cervical ROM values in CNP patients. In addition, further improvements in cervical ROMs can be obtained in patients with CNP by combining MMT with CSE.

Farooq et al. [27] concluded that a physiotherapy program including stretching and isometric strengthening exercises for the neck was effective in increasing cervical muscle endurance in individuals with CNP. Kuo et al. [10] applied six-week CSE exercises to individuals with CNP and reported that the cervical muscle endurance of individuals increased significantly at the end of the study. Similarly, another study [30] suggested that CSE may increase cervical muscle endurance in individuals with CNP. In a study conducted by Duymaz et al. [17] involving individuals with CNP, one group followed a home exercise program comprising ROM and stretching exercises, while the other group received MMT in addition to the home exercise program. Both groups showed increased cervical flexor muscle endurance after the treatment program; however, greater improvements in cervical muscle endurance were reported in the group that received MMT along with the exercise program compared to the group following the home exercise program alone. The authors suggested that the greater increases in cervical muscle endurance in the group that received MMT in addition to the home exercise program may have been influenced by the greater reduction in pain intensity in this group [17]. In the present study, while significant increases in cervical flexor and extensor muscle endurance were found in both groups, the amounts of increase in the groups were similar. Furthermore, the reduction in pain intensity was similar in both groups. It has been reported that the activation of deep cervical muscles may be impaired by neck pain, and the contractile capacity of the muscles may decrease [31]. Given this information, it was thought that muscle endurance may be affected by pain in CNP and that similar increases in cervical muscle endurance in the groups may be associated with similar reductions in pain intensity. Significant improvements in cervical muscle endurance can be achieved in CNP patients with CSE applications. On the other hand, it is important to investigate the effects of MMT on cervical muscle endurance compared to CSE in future studies with longer treatment and follow-up durations in order to demonstrate the possible effects of MMT on cervical muscle endurance.

Studies in the literature [4,16,32] have indicated that various exercise and manual therapy methods can provide increased PPT values in individuals with CNP. Ylinen et al. [32] found that strength and endurance exercises can increase PPT values measured from cervical muscles in individuals with CNP; in other words, they can decrease tenderness in cervical muscles. The authors also stated that PPT measurement may be a useful outcome measure for the effectiveness of rehabilitation in CNP [32]. In a study conducted on individuals with CNP [16], it was observed that the increases in PPT values measured from the upper trapezius were significantly greater in the group that received muscle relaxation training in addition to CSE compared to the group that received CSE alone. In another study [4], individuals with CNP were divided into two groups: one group received four weeks of CSE, and the other group received manual therapy consisting of Maitland and Cyriax mobilization techniques to the cervical and scapular regions for four weeks in addition to CSE. At the study's conclusion, where the PPT was measured from the upper trapezius, both groups exhibited increased PPT values, with no significant difference between them. In the present study, consistent with the literature, it was observed that both CSE alone and the combined application of CSE and MMT increased the PPT values measured from cervical muscles, in other words, decreased upper trapezius muscle tenderness. In addition, MMT combined with CSE was found to be superior in increasing PPT; that is, it was more effective in reducing muscle tenderness. This result may be explained by the knowledge that mobilization may increase the pain threshold and decrease muscle tenderness by stimulating neurophysiological mechanisms, causing hypoalgesia [33]. In individuals with CNP, an increase in PPT values of cervical muscles can be achieved with CSE treatment; however, more effective results can be obtained with the combined application of CSE and MMT.

Neck pain can reduce quality of life by negatively affecting overall health and leading to significant disability [34]. Previous studies [17,35] reported that various exercise and manual therapy methods may be effective in improving the quality of life of individuals with CNP. In a systematic review conducted by Gross et al. [36], it was reported that the application of mobilization in individuals with neck pain had positive results in reducing pain and improving quality of life and bodily functions in the short and long term. Salo et al. [35] stated that improvements in quality of life can be obtained with stretching and strengthening exercises applied to individuals with CNP. In a study involving individuals with CNP [13], greater enhancements in quality of life were observed when MMT was included along with a conventional physiotherapy program, compared to the effects of a conventional physiotherapy program alone. Another study [4] found that combining CSE with manual therapy was more effective in enhancing the quality of life compared to CSE alone. Similarly, Duymaz et al. [17] reported that MMT combined with a home exercise program was more effective in improving the quality of life in individuals with CNP compared to a home exercise program alone. In

the current study, significant increases in quality of life were recorded in both the CSE alone and CSE with MMT groups. Moreover, the improvement in quality of life was higher in the group in which MMT was applied in combination with CSE than in the group in which CSE was applied alone. The improvements in quality of life in both groups were consistent with the literature. The greater improvements in quality of life in the group that received MMT alongside CSE may be attributed to the fact that this group experienced greater improvements in ROM and PPT compared to the other group. The CSE program may improve the quality of life in patients with CNP; on the other hand, more improvements in the quality of life in patients can be achieved by combining CSE with MMT.

Limitations

The main limitation of this study was that the treatment and follow-up periods were relatively short-term, and a long-term follow-up post-treatment could not be performed. It is recommended that future research be carried out over extended treatment and follow-up periods in order to obtain more conclusive results.

CONCLUSION

The application of CSE in CNP management may improve pain intensity, ROM, cervical muscle endurance, PPT, and quality of life. However, it can be said that MMTs applied in addition to CSE are more effective in improving ROM, PPT, and quality of life compared to CSE alone in individuals with CNP. For patients with CNP, a treatment program that consists of both CSE and MMT may be more effective than CSE alone in the clinic. It should be taken into consideration that a relatively short-term treatment and follow-up program of four weeks was applied in this study. It is recommended that the present results be confirmed in further studies with longer treatment and follow-up periods.

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