Effects of Cervical Mobilization on Balance and Proprioception in Patients With Nonspecific Neck Pain

ABSTRACT

Objective: This study investigates the effect of cervical mobilization on balance and cervical proprioception in patients with non-specific neck pain.

Methods: A prospective, double-blind, randomized clinical trial was conducted involving a 3-week treatment protocol for which 66 patients were randomly assigned to 2 groups. Both groups underwent conventional physiotherapy (hot pack and TENS) twice a week for 3 weeks along with additional cervical mobilization in the mobilization group, and sham mobilization in the sham control group. Static and dynamic balance, cervical proprioception, cervical mobility, and pain intensity were evaluated using a Kinesthetic Skill Training System 3000 device, the "Joint Position Error Test", CROM (Cervical Range-of-Motion Instrument), and the Visual Analogue Scale, respectively.

Results: After treatment, significant improvements were noted in dynamic balance, mobility, pain intensity ($p < .001$, $p < .001$, $p < .001$), and proprioception in the left direction of rotation in the mobilization group ($p = .003$) that were statistically greater than those observed in the sham mobilization group ($p < .001$, $p < .001$, $p < .001$, $p = .003$). Although a significant decrease was observed in the deficits of static balance ($p = .044$), and proprioception in the right direction of rotation ($p = .011$) after mobilization, the changes were similar in both groups ($p = .192$, $p = .154$).

Conclusion: Cervical mobilization led to significant improvements in dynamic balance, pain intensity, mobility, and partial improvements to proprioception in a comparison with a sham mobilization group, while the effect on static balance was not significant.

Keywords: *physical therapy modalities; postural balance; proprioception; neck pain; range of motion.*

INTRODUCTION

Non-specific neck pain (NSNP) is a common neck disorder that occurs as a result of postural or mechanical changes in the absence of a specific musculoskeletal pathology or injury.[1] Neck pain leads to a decrease in the activity of the deep cervical muscles, which contain a large number of proprioceptors,[2] such as muscle spindles, alongside an increase in the activity of superficial cervical muscles.[1,3] Neck pain can lead to the development of chemical changes in cervical receptors and alterations in the sensitivity of muscle spindles,[4] and may affect cervical proprioception. These changes in the structures of the cervical region predispose individuals to a deterioration in cervical proprioception – an important component of balance.[5] Such disruptions to proprioceptive abilities can lead to sensory-motor defects, muscle inhibition, muscle atrophy, and muscle fatigue.[6] Disturbances in cervical proprioception may also affect balance, which is an important indicator of stability. A review comparing patients with neck pain to asymptomatic individuals reported that the presence of neck pain may increase postural sway,[7] and that increased sway was associated with dysfunction of the postural control system.[7] The cervical spine contributes to postural stability.[8] The cervical musculature is a source of proprioceptive information, as the suboccipital muscles contain a large number of mechanoreceptors[2] that are necessary for proprioception. Furthermore, the upper cervical region is connected to the central nervous, vestibular system, and visual system.[9,10] As a result of these relationships, disorders related to the cervical spine may affect also sensory integration, resulting in proprioceptive deficits.[11] Neck pain may lead to deterioration in the central sensory modulation of proprioceptive information originating from neuromuscular spindles.[4,12] It is believed that this may lead to a decrease in motor control, resulting in reduced postural stability. Several studies can be found in the literature suggesting treatment approaches to the reduction of neck pain that can positively contribute to balance and the sense of cervical proprioception in patients with NSNP. Although physical therapists make use of manual therapy to reduce pain[13] and increase cervical mobility,[14] the reported effects of such approaches on balance[15–18] and cervical proprioception[19-23] are inconsistent in the literature.

In a study investigating the effect of cervical mobilization on balance in individuals with neck pain, mobilization applications applied to both the cervical and thoracic regions resulted in no improvement in static [15] All other studies investigating the effect of spinal manual treatments on balance focused on the effect of manipulation in individuals with neck pain.[16-18] While 2 of these studies reported significant improvements after manipulation,[17,18] a further study found no statistically significant difference.[16] Furthermore, only 2 studies were found in the literature investigating the effect of cervical mobilization on proprioception in individuals with neck pain,[19,23] while manipulation was the primary intervention in all other studies investigating the relationship between spinal manual therapy and proprioception.[20-22] Of the studies in which manipulation was the primary treatment approach, 2 reported a significant improvement after manipulation,[20,21] while a third reported no statistically significant difference.[22]

Based on the outcomes of the above-mentioned studies it can be concluded that reducing pain and cervical restriction in individuals with neck pain can have a positive effect on balance and proprioception.[4,24] Spinal mobilization applied to the cervical region may thus be used to improve cervical proprioception and balance by reducing pain intensity and increasing cervical mobility. The present study investigates the effect of cervical mobilization on both balance and cervical proprioception in patients with NSNP.

METHODS

Design and Procedure

This prospective, double-blind, 2-armed, randomized clinical trial involving a 3-week treatment protocol was reported in accordance with the CONSORT guidelines.[25]

Approval for the study was obtained from the Gazi University Ethics Committee (No: 26.12.2019, dated 24074710-604.01.01).

Participants and Recruitment

Included in the study were patients who presented to the outpatient clinic of Gazi University Hospital / Physical Medicine and Rehabilitation Department between March 2021 and September 2021 with neck pain. The participants were given a detailed explanation of the procedure by the assessor, and those who agreed to participate provided consent. The data collection and intervention phases of the study were carried out by 2 researchers to ensure the blinding of the results.

The inclusion criteria were as follows: diagnosis of NSNP, aged 18-60 years, pain upon neck movement, rest pain of at least grade 2 on the Visual Analogue Scale, and cervical spine restriction ongoing for at least the past 3 weeks.

The exclusion criteria were as follows: neurological or orthopedic disease affecting balance or proprioception, presence of neurological or inflammatory symptoms, cervical instability, history of trauma or cervical surgery, severe osteoporosis, use of balance-impairing medications (e.g., antidepressants, anticonvulsants, antihistamines, sedatives), pregnancy, and visual or vestibular disorders.

Of the 99 patients identified as eligible for the study based on the inclusion criteria, 39 were excluded for various reasons. Figure 1 shows the study of the flow chart.

Insert Figure 1 here, please…

Interventions

Initially, 66 participants were randomized to either the mobilization or sham mobilization groups, however, 3 patients from each group did not complete the study after beginning treatment, and so the study was completed with 60 patients.

Both groups received conventional physiotherapy 5 days a week for 3 weeks, with a total of 15 sessions. In addition to conventional physiotherapy, 6 additional sessions of either Kaltenborn-Evjenth mobilizations or sham mobilizations were applied to the respective groups. The conventional physiotherapy included Transcutaneous Electrical Nerve Stimulation (Elettronica Pagani Class 1 type BF device with the following settings: frequency 100 Hz, pulse duration 200 μs, current intensity 20–35 mA) and the application of a hot pack to the cervical region for 20 minutes.

Mobilization group: "Occiput-atlas" and "atlas-axis rotation mobilization" were applied to the symptomatic area(s) (painful and/or restricted) after a detailed evaluation (symptom localization tests, cervical region safety tests, joint play tests, pain provocation and alleviation tests) following the Kaltenborn-Evjenth system.[26]

The Kaltenborn-Evjenth Orthopedic Manual Therapy System was developed between 1954 and 1970 for the examination and treatment of joint conditions, describing the treatment plane and translatoric movements, the concave-convex rule, 3-dimensional positioning methods, and ergonomic principles for physical therapists.[26] While traditional manipulative techniques incorporate long-lever rotational movements, which may lead to injury due to their use of compressive forces, the Kaltenborn-Evjenth system uses short-lever manipulative techniques with translatoric treatments to reduce the risk of injury.[26] The system has been taught and applied all over the world since 1973.

Occiput-atlas and atlas-axis rotation mobilization of upper cervical vertebrae (C0-2): The patient lies in a supine position with their head in a slight side-bending position to the asymptomatic side and rotated towards the symptomatic side without causing pain. The therapist stands next to the asymptomatic side of the patient. The therapist's stable hand stabilizes the upper vertebra on the asymptomatic side, while the other hand rhythmically moves the transverse process of the caudal vertebra from the symptomatic side in a ventral-caudal direction, without losing skin contact.[26] The Atlas-axis rotation mobilization approach is depicted in Figure 2.

Insert Figure 2 here, please…

"Ventral mobilization with cranial stabilization" for lower cervical vertebrae (C2-7): The patient lies in a supine position with the head in a slight side-bending position and rotated towards the symptomatic side without causing pain. The therapist stands next to the patient's asymptomatic side. While the therapist's stable hand stabilizes the upper vertebra from the asymptomatic side, while the other hand moves the transverse process of the caudal vertebra rhythmically from the symptomatic side in a ventral-caudal direction, without losing skin contact.[26] The Ventral mobilization with cranial stabilization approach is depicted in Figure 3.

Insert Figure 3 here, please…

Each patient attended 6 mobilization treatment sessions over a period of 3 weeks, in which 5 series of 45-second mobilizations were performed with 15 seconds of rest in each session.

The techniques used in the present study caused a translational motion between the 2 adjacent facets.[26] The grade of motion was adjusted according to the aim of the treatment. The Kaltenborn-Evjenth System divides the grade of motion into three levels: Grade I (loosening) and Grade II (tightening) are used to reduce pain, while Grade II and Grade III (stretching) are applied to stretch the joint capsule.[26] In the present study, the appropriate grades were applied based on an assessment of the patient.

Sham mobilization group*:* Sham mobilizations were applied to the cervical region in the same position, and with the same grip as the mobilization applications. The physiotherapist placed her hands on a randomly selected facet, and maintained this position without applying pressure or movement to the cervical segments. The duration of sham mobilization was the same as in the real mobilization group. Each patient attended 6 treatment sessions over a period of 3 weeks.

All mobilizations were applied by a physiotherapist with more than 15 years of experience in the provision of manual therapy.

Outcome Measurements

The Primary outcomes were cervical proprioception, measured with a cervical joint position error test,[27] and static and dynamic balance, measured using the Kinesthetic Ability Training System 3000 (Med-Fit Systems Inc., Fallbrook, C.A., USA).[28] All assessments were conducted at baseline and at the end of the third week.

The Secondary outcomes were cervical mobility, measured using the CROM,[29] and pain intensity, measured using the Visual Analogue Scale.[30]

Sample size

In the sample size calculation, 30 patients were required in each group to achieve a significant difference of 2.6 degrees in the improvement in cervical proprioception between the 2 groups with a standard deviation of 3.5,[31] using a 2-sided alpha of 5% and 80% power. Subsequently, 30 patients with NSNP were assigned to each of the 2 groups, considering a 10% drop-out rate.

Randomization and blinding

The participants were randomly divided into the 2 treatment groups - the mobilization group and the sham mobilization group - using Random Allocation Software 2.0.

Throughout the study, one physiotherapist was responsible for assessments and was blinded to the treatment allocation, while the other physiotherapist handled the interventions. The participants were not informed about their group allocation.

Data Collection

Demographic data were recorded as age (years), height (cm), body weight (kg), body mass index (BMI; kg / m^2), occupational status, smoking status, and duration of neck pain (subacute or chronic period) by the assessor.

For the evaluation of cervical proprioception, a cervical “joint position error test” was conducted using a CROM device in the transverse plane (right and left rotation).[27] The patients were blindfolded using a travel eye mask throughout the procedure. The examiner held the subject’s head and slowly moved it to the target head position, being 50 percent of the maximum cervical range of motion (previously recorded by the examiner) and held it there for 3 seconds. The subjects memorized the target position, and the examiner slowly brought the subject’s head back to the neutral position. The subjects were instructed to actively reach the target position by moving their head. When the subject reached the target position, the reposition accuracy error was determined in degrees. The test was performed 3 times in each direction, and the mean error was used for the analysis.[32]

Balance was measured using the Kinesthetic Ability Training System 3000 (Med-Fit Systems Inc., Fallbrook, CA, USA), with both static and dynamic balance assessed.[28] A greater balance index indicates a deterioration in balance, while a lower index represents an improvement in stability.

Cervical mobility, or the active cervical range of motion, was assessed using a CROM device (Cervical Range of Motion-Performance Attainment Associates, St. Paul, MN, 55117, USA), with measurements made in each direction (flexion, extension, right and left lateral flexion, right and left rotation). The CROM device is an inclinometer system that utilizes gravity and magnetic effects.[29]

The intensity of neck pain was assessed using the Visual Analogue Scale (VAS).[30]

Data Analysis

Statistical analyses were completed using IBM SPSS Statistics (Version 23.0. Armonk, NY: IBM Corp.). Normality assumptions of numerical variables were analyzed with a Kolmogorov-Smirnov test. For the comparison of baseline and post-treatment evaluation results, a Paired t-test was used for variables with normal distribution and a Wilcoxon test for variables that did not follow a normal distribution. Differences between the 2 independent groups were analyzed with an independent sample t test for variables with a normal distribution and a Mann-Whitney U test for variables that did not follow a normal distribution. Chi-square and Fisher's exact tests were used for the comparison of categorical variables between the 2 independent groups. Statistical significance was set at $p < .05$.

RESULTS

The sociodemographic characteristics of the study participants and the pain durations are presented in Table 1. There were no significant differences between the 2 groups in terms of age, height, body weight, body mass index (BMI), smoking status, or occupational status ($p > .05$) before treatment.

Insert Table 1 here, please…

A significant improvement in static balance after treatment was noted in the mobilization group ($p = .04$), while no such improvement was observed in the sham group ($p = .94$). In contrast, a comparison between the 2 groups revealed similar static balance outcomes ($p = .19$). A significant improvement in dynamic balance was noted after treatment in the mobilization group ($p < .001$), while no difference was observed in the sham mobilization group ($p = .62$).

A comparison of the 2 groups revealed a greater improvement in dynamic balance in the mobilization group than in the sham mobilization group ($p < .001$) (Table 2).

Insert Table 2 here, please…

After treatment, cervical proprioception improved significantly in all directions in the mobilization group ($p = .011$, $p = .003$), whereas no change was observed in the sham mobilization group ($p = .222$, $p = .946$). A comparison of the 2 groups revealed a greater increase in cervical proprioception in the left direction of rotation in the mobilization group than in the sham mobilization group ($p = 0,003$), while cervical proprioception in the right direction of rotation was similar in the 2 groups ($p = .154$).

Insert Table 3 here, please…

Cervical mobility was significantly improved in all directions from baseline to post-treatment in both groups ($p < .001$), with a greater improvement noted in the mobilization group ($p < .001$) (Table 4).

Insert Table 4 here, please…

As can be seen in Table 5, the decrease in pain intensity after treatment was significant in both groups ($p < .001$), although the reduction in pain intensity was greater in the mobilization group than in the sham group ($p < .001$).

Insert Table 5 here, please…

DISCUSSION

In the present study of patients with NSNP, the mobilization applied to the cervical region coupled with conventional physiotherapy approaches led to significant improvements in dynamic balance, cervical mobility, and pain intensity, while the effect on cervical proprioception was limited and there was no improvement in static balance.

Spinal manipulative therapies, according to the World Health Organization, can take the form of both mobilizations and manipulations of the spine and paraspinal tissues.[3] Cervical manipulations have been performed for centuries, and have maintained their relevance as a common spinal manipulative therapy,[34] but can have serious adverse effects, such as cerebrovascular insult, if not preceded by the appropriate clinical assessment.[35,36] Although cervical mobilizations may be much safer than cervical manipulations for the avoidance of life-threatening adverse effects, there have been only 3 studies to date investigating the use of cervical mobilization for the improvement of balance or proprioception,[15,19,23] while the majority of studies have described approaches to manipulation in patients with neck pain.[16-18,20-22]

There have also been few studies to date investigating the effect of spinal manipulative treatments on balance, with only 1 study identified investigating the effect of mobilization on balance in individuals with neck pain,[15] while all other studies focused on manipulation.[16-18] In a previous study of 18 individuals with neck pain,[15] Maitland mobilizations were applied to both the cervical and thoracic regions. In contrast, Kaltenborn-Evjenth joint mobilizations were applied only to the cervical region in the present study, which is the first in the literature to use Kaltenborn-Evjenth joint mobilizations to improve balance and proprioception in patients with neck pain.

In a study by Lee, no improvement was observed in static balance [15] In the present study, static balance was tested on a firm surface with the eyes open, and our findings were consistent with those of Lee.

All other previous studies assessing the relationship between spinal manual therapy and balance have used manipulation as the primary intervention.[16-18] In a study including a limited number of NSNP patients (n: 10) investigating the effect of a single manipulation of the dysfunctional cervical segment on postural sway, no significant difference was noted between the results before manipulation and immediately after manipulation.[16] The authors of the study attributed the inefficacy of the interventions on balance parameters to the low sample size, although in 2 earlier studies postural sway was reported to be significantly improved after upper cervical manipulation in patients with neck pain.[17,18]

In the present study of 66 patients with neck pain, dynamic balance was improved significantly in those undergoing cervical mobilization when compared to the sham group, which may be attributed to the reduction in both cervical stiffness and pain intensity. The reduction of neck pain[13] and the increase in cervical mobility after cervical mobilization[14] reported in earlier studies, as in the present study, may have contributed to the regulation of afferent impulses from the cervical region and improved the postural control mechanism. Moreover, there is evidence in the literature that manual therapies reduce the excitability of muscle spindles.[37,38] There have also been studies reporting that mobilization reduces the activity of hyperactive skeletal muscles.[39] It can thus be suggested that the mobilization techniques used in the present study may have led to a decrease in hyperactive muscle activity, resulting in improved dynamic balance.

It is worthy of note that in the present study, mobilization had no significant effect on static balance, in contrast to the significant effect noted on dynamic balance. That said, dynamic balance tests have been reported to be more sensitive than static balance tests in cases with neck pain,[40] which may explain why the greater statistical significance of dynamic balance than static balance in the present study. Future studies could benefit from more sensitive and specific evaluations, such reductions in visual stimulation or narrowing of the support surface by revealing the effect of mobilization on static balance.[15] It should be noted that the effects of cervical mobilization on the central nervous system may not be fully revealed in the early period, and so there is a need for studies investigating the effect of mobilization approaches on balance in the mid and late periods, which could make significant contributions to the literature. More time or additional stimulation may be necessary for the difference in static balance to become apparent.

Another parameter evaluated in the present study was cervical proprioception. After mobilization, significant improvement was noted in proprioception in the left direction of rotation, and the benefit was greater than that observed in the sham mobilization group. One possible explanation for this improvement was the significant reduction in neck pain in the mobilization group. Neck pain might can lead to deviations in cervical proprioception,[27] and such a reduction in pain may contribute to improved cervical joint position sense. Another possible explanation was that the mobilization increased cervical mobility. A previous review, manual therapy approaches were noted to significantly increase cervical mobility,[14] and the results of this were consistent with our findings. Reducing the stress on cervical structures through increased mobility might have contributed to the healing of cervical afferent changes, leading to overall improvement.[41]

In the present study, although significant improvements were noted in proprioception in the right direction of rotation following mobilization, the outcomes were not significant when compared to the results of the sham control group. We thus concluded that cervical mobilization had a limited effect on cervical proprioception in patients with NSNP, with one possible explanation for these findings being the adaptive reweighting of the information of other sensory modalities, such as the cerebellar or vestibular inputs in patients with neck pain.[16,42]

A review of the literature uncovered only 2 previous studies investigating the effect of cervical mobilization on cervical joint position sense. One such study, assessing whether real-time visual feedback during mobilization provided additional improvements to pain intensity and cervical proprioception in a sample of 29 patients, reported that cervical mobilization had no significant effect on proprioception in those with chronic neck pain.[19] The authors reported that mobilization decreased cervical joint position sense acuity immediately after intervention, although the participants underwent only one mobilization session. In the present study, attended 6 mobilization sessions over 3 weeks.

Rehab et al investigated and compared the effects of Mulligan sustained natural apophyseal glides, Maitland mobilization, and deep cervical flexor training on cervical joint position sense, neck pain, and dizziness in a study of 56 patients with cervical spondylosis.[23] The authors reported Mulligan sustained natural apophyseal glides and Maitland passive mobilization to have similar positive effects on cervical joint position sense, neck pain, and dizziness, and to be more effective than deep cervical flexor training for the treatment of these issues.[23]

In the present study, cervical mobilization had a limited effect on proprioception, while 2 previous studies[19,23] investigating the effects of cervical mobilization on proprioception in patients with neck pain produced conflicting results.

Cervical manipulation has been the primary intervention in all previous studies investigating the relationship between spinal manual therapy and proprioception.[20-22] While 2 of these reported significant differences,[20,21] a further study reported no statistical improvement after manipulation [22].

In the present study, the improvements in pain intensity and cervical mobility were greater in the mobilization group, concurring with the findings of previous studies in the literature.[43,44] Manual treatments normalize the excitability of the stretch reflex by reducing nociceptive input and excitatory input to gamma motor neurons.[45] When the reduced stretch reflex is combined with decreased nociceptive input, excitatory input in the alpha motor neuron pool decreases, leading to a reduction in muscle spasm.[45]

Among the available manual therapy techniques, joint mobilization targets the neurophysiological and mechanical aspects of pain, pain arcs, or muscle spasms, and is effectively used to treat joints with hypomobility.[46] The modulatory effects of joint mobilization on joint pain mechanisms have been demonstrated experimentally in an animal models.[47] The effects of joint mobilization were likely multimodal. After the joint mobilization of the affected joint, modulation of involuntary, nociceptive responses [48] and changes to the conditioned pain modulation[49] were achieved, as evidenced by a global decrease in deep tissue pressure sensitivity and resulting in analgesic effects.

Most studies of manual therapies in the literature have failed to identify the main effect of the applied therapies due to the absence of control groups and insufficient sample sizes.[50] Furthermore, the lack of clarity in the explanation of the adopted manipulative techniques have further reduced the evidence value of these studies. Moreover, the use of several techniques together in the same study (soft tissue mobilization, facet joint mobilization/manipulation, fascia mobilization techniques, etc.) makes it difficult to determine which technique was more effective.[51] In the present study, adopting a randomized, sham-controlled, and double-blind trial design, only Kaltenborn-Evjenth joint mobilization techniques were used, and the procedure was clearly defined.

Limitations

In the present study, the mid- and long-term outcomes of mobilization were not measured, and different parameters of proprioception, such as kinesthesia and sense of strength, were not investigated. Furthermore, the posture, mood, and kinesiophobia of the patients was not assessed, all of which affect balance and proprioception.

CONCLUSION

Cervical mobilization, when combined with conventional physiotherapy, contributed significantly to improvements in dynamic balance, cervical mobility, and pain intensity, while limited effects were noted in cervical proprioception, and no effect on static balance. Given the limited data in the literature, this study may serve as a guide to clinicians and researchers assessing the effects of cervical mobilization on balance and cervical proprioception in patients with NSNP.

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Table 1. Socio-demographic characteristics of groups

	Mobilization group (n=30)	**Sham mobilization group (n=30)**	**Mean difference (95% CI)**	**p**
	Mean ± SD	**Mean ± SD**		
Age (year)	45.43 ± 13.11	43.60 ± 13.66	1.83 (-5.08 – 8.75)	.598
Height (cm)	163.60 ± 7.22	162.23 ± 5. 75	1.36 (-2.00 – 8.75)	.421
Weight (kg)	68.13 ± 10.34	64.57 ± 12.20	3.56 (-2.28 – 9.41)	.227
BMI (kg/m²)	25.47 ± 3.71	24.55 ± 4.64	.92 (-1.25 – 3.09)	.399
Smoking status (n)	2 / 30	7 / 30		.071
Occupational status (n)				
Employed	16 / 30	19 / 30		.865
Retired	4 / 30	3 / 30		
Unemployed	7 / 30	5 / 30		
Student	3 / 30	3 / 30		
Duration of the pain (n)				
Chronic (>3 months)	18 / 30	20 / 30		.592
Subacute (3 weeks-3 months)	12 / 30	10 / 30		

*p < .05 (Statistically significant)
SD: Standard deviation
CI: Confidence Interval

Table 2. Comparison of balance within and between groups

		Mobilization group (n=30)	**Sham mobilization group (n=30)**	
		Mean ± SD	**Mean ± SD**	**p**
SBI	Baseline	147.10 ± 54.01	131.66 ± 50.01	.256
	3rd week	117.10 ± 54.25	130.50 ± 85.54	
	Mean difference	30.00 ± 77.86	1.16 ± 90.91	.192
p		**.044***	.944	
DBI	Baseline	858.40 ± 253.62	800.56 ± 163.23	.298
	3rd week	718.56 ± 143.00	812.76 ± 194.66	
	Mean difference	139.83 ± 150.79	12.58 ± 163.23	**<.001***
p		**< .001***	.623	

*p < 05 (Statistically significant)
SBI: Static balance index
DBI: Dynamic balance index
SD: Standard deviation

Table 3. Comparison of proprioception within and between groups

		Mobilization group (n=30)	Sham mobilization group (n=30)	p
		Mean ± SD	**Mean ± SD**	
RJPS (degree)	Baseline	4.70 ± 5.63	5.31 ± 5.31	.664
	3rd week	2.11 ± 3.02	4.51 ± 4.36	
	Mean difference	2.58 ± 5.67	.80 ± 3.67	.154
p		**.011***	.222	
LJPS (degree)	Baseline	4.15 ± 4.27	4.01 ± 3.50	.104
	3rd week	1.65 ± 2.99	3.74 ±3.85	
	Mean difference	2.50 ± 4.09	0.15 ± 3.62	**.022***
p		**.003***	.946	

*p < .05 (Statistically significant)
RJPS: Right joint position sense
LJPS: Left joint position sense
SD: Standard deviation

Table 4. Comparison of cervical mobility within and between groups

		Mobilization group (n=30)	**Sham mobilization group (n=30)**	**p**
		Mean ± SD	**Mean ± SD**	
Flexion (degree)	Baseline	56.65 ± 16.70	61.41 ± 15.57	.258
	3rd week	75.93 ± 11.75	68.86 ± 15.92	
	Mean difference	19.28 ± 16.04	7.45 ± 9.68	**<.001***
p		**< .001***	**< .001***	
Extension (degree)	Baseline	49.86 ±17.92	57.91 ±13.45	.054
	3rd week	70.73 ± 13.40	63.70 ±15.86	
	Mean difference	20.86 ± 14.35	5.78 ± 11.08	**< .001***
p		**< .001***	**< .008***	
Right lateral flexion (degree)	Baseline	36.40 ± 9.68	42.20 ± 9.52	**.023***
	3rd week	52.76 ± 10.75	47.70 ± 10.21	
	Mean difference	16.36 ± 7.68	5.10±6.53	**< .001***
p		**< .001***	**< .001***	
Left lateral flexion (degree)	Baseline	36.25 ± 8.70	43.20 ± 12.66	**.016***
	3rd week	52.43 ± 8.02	48.26 ± 10.97	
	Mean difference	16.18 ± 8.42	5.06 ± 6.43	**< .001***
p		**< .001***	**< .001***	
Right rotation (degree)	Baseline	64.10 ± 17.09	73.90 ± 14.07	**.034***
	3rd week	86.70 ± 14.22	83.30 ± 14.07	
	Mean difference	21.60 ± 10.68	9.40 ± 11.56	**< .001***
p		**< .001***	**< .001***	
Left rotation (degree)	Baseline	62.56 ± 19.91	70.16 ±1 5.44	.104
	3rd week	86.40 ± 15.79	78.33 ± 17.97	
	Mean difference	23.83 ± 15.74	8.16 ± 11.92	**< .001***
p		**< .001***	**< .001***	

*p < .05 (Statistically significant) SD: Standard deviation

Table 5. Comparison of pain intensity within groups and between groups

		Mobilization group (n=30)	**Sham mobilization group (n=30)**	**p**
		Mean ± SD	**Mean ± SD**	
Pain intensity (VAS)	Baseline	8.83 ± 1.46	8.13 ± 2.47	187
	3rd week	1.46 ± 1.67	3.35 ± 2.10	
	Mean Difference	7.36 ± 2.34	4.74 ± 2.683	**< .001***
p		**< .001***	**< .001***	

*p < .05 (Statistically significant)
SD: Standard deviation
VAS: Visual Analogue Scale