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The effect of cervical mobilization on joint position sense, balance and gait in patients with multiple sclerosis: a randomized crossover study

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ABSTRACT

Objective: To investigate the effect of cervical mobilization on joint position sense, balance and gait in multiple sclerosis (MS) patients.

Methods: Sixteen MS patients received traditional rehabilitation and traditional rehabilitation +cervical mobilization treatments in different orders, 2 days a week for 4 weeks. For the cervical mobilization, joint traction and shifts with myofascial release techniques were applied. Joint position sense was evaluated from the bilateral knee and ankle joints with a digital goniometer, balanced with the Berg Balance Test (BBT), the Functional Reach Test, and gait with the Dynamic Gait Index (DGI) and the Timed 25-Foot Walk Test.

Results: Improvements were determined in joint position sense, balance, gait with both treatment methods ($p < 0.05$). With the addition of cervical mobilization to traditional treatment, there was observed to be an increased effect carried over in knee joint position sense and BBT ($p < 0.05$). The BBT and DGI scores improved in the group applied with cervical mobilization following the washout period ($p < 0.05$).

Conclusions: Cervical mobilization could be effective in improving joint position sense, balance and gait, and accelerated improvements in a short time. The application of cervical mobilization could be a supportive treatment method to improve position sense, balance and gait in patients with MS.

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KEYWORDS
Multiple sclerosis; manual therapy; cervical region; proprioception; postural control

Introduction

Multiple sclerosis (MS) is a chronic, inflammatory, demyelinating, and neurodegenerative, central nervous system (CNS) disease. Motor findings such as spasticity and loss of strength, sensory disorders, and balance and co-ordination problems can be seen in MS patients [1]. The sensory system plays an important role in providing balance and postural control. By providing feedback in motor activities, the senses received from the visual, vestibular, and somatosensorial system form the basis of balance and postural control [2]. Proprioception, which is a part of the somatosensorial system, is important in providing and maintaining balance. This sense is formed of the perception of the position of the body and extremities obtained from the receptors in joints, muscles, tendons, and ligaments. Proprioceptors are found at different rates in different structures and tissues of the body, and the cervical region is extremely rich in these [3]. Previous studies in literature have proven that the proprioceptive system is stimulated by different treatment methods such as vibration and kinesiotape applied to the cervical region, and these methods have developed visual and vestibular associations [4–6]. Receptors in the cervical region are responsible for the reflex cycle by connecting the visual and vestibular systems [7]. In this way, the regulation of head, eye and postural stability is provided [8].

One of the treatment approaches applied to the cervical region is manual therapy (MT). The mechanical stimulations obtained with manual therapy can change the mechanical and chemical properties of sensory neurons in paraspinal tissues [9]. Thus, the neurophysiological effects occurring develop central nervous integration [9]. The accumulation in afferents occurring with spinal applications can reduce gamma motor neuron stimulation through various neural pathways. The greater number of mechanoreceptors containing proprioceptors in paraspinal tissues increases the importance of the spinal region [10]. The mechanical stimulation of proprioception transmitted from the cervical vertebra segment to the central nervous system increases motor control [10]. By increasing short-term motor neuron activity, these techniques create developments in activities associated with proprioception [11]. When manual therapy is applied to the neck area, MT activates the visual and vestibular systems as well as the proprioceptive system [7,8]. Thus, the neurophysiological effects of mobilization techniques play a role in the development of balance and gait [9,12]. The development of the proprioceptive system will improve balance,

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thus the parameters of walking will be improved. In this cause-effect chain, the basis of the system is the joint position sense, that is, the proprioceptive system.

Although the neurophysiological effects of MT, such as changes in neuron activities with mechanical stimulation and increased sensory input in the paraspinal region, are known in healthy individuals or individuals with orthopedic problems, the neurophysiological effects of MT in neurological diseases in which the nervous system is affected are not yet known. In addition, the effects on MT have been examined on parameters such as pain, range of movement, quality of life, and functionality, and the effects of different MT techniques on balance have been examined [13,14]. However, to the best of our knowledge, there has been no study that has examined the effects of MT on MS patients.

When the importance of the neurophysiological effects of MT and the cervical region are considered, the effects of MT techniques on neurological diseases should be investigated. MT techniques in addition to traditional treatments could be a treatment option in MS patients who often have sensory, balance, and gait problems. Therefore, the aim of this study was to investigate the effect of MT on position sense, balance and gait in MS patients.

Materials and methods

Study design

This randomised, controlled, crossover study was conducted at Hasan Kalyoncu University. Approval for the study was granted by the Non-Interventional Ethics Committee of Hasan Kalyoncu University (protocol no: 2019/106, dated: 1 October 2019). The study participants were given full explanations of the content and context of the study, the treatment to be applied and the evaluations. All those included in the study provided signed informed consent for participation. The study was conducted in accordance with the Declaration of Helsinki. This study was registered on ClinicalTrial.gov and the clinical trial number was NCT04201691.

Participants

Study Inclusion Criteria; (1) Expanded Disability Status Scale [EDSS] points 2–5, (2) spasticity of 1–3 according to the Modified Ashworth Scale for lower extremity muscles (adductor, gastrocnemius and quadriceps femoris muscles e.g.), (0- no increase in muscle tone, 4-affected part(s) rigid in flexion or extension), (3) EDSS cerebellar system subscale, functional system points > 1, (4) stable medical condition, (5) no change of medication within the last month, (6) no other neurological disorder, (7) no orthopaedic problem that would prevent participation in the study, and (8) at least 24 points in the Mini Mental Test [15]. *Study Exclusion Criteria*: (1) the presence of any psychiatric or serious cognitive dysfunction, (2) vertebro-basilar test positivity, (3) positivity in cervical ligament instability tests (alar ligament, transverse ligament tests), (4) pregnancy, (5) an attack in the previous 3 months, (6) botulinum toxin application within the last 6 months, (7) participation in a physiotherapy program within the last 6 months.

Study protocol and randomization-blinded

The subjects included in the study received the traditional rehabilitation and cervical mobilization treatments in different orders. The research randomizer (www.randomizer.org) was used to determine which treatment would be applied first. All the treatments were applied for two sessions a week for 4 weeks. A break of 4 weeks was given between treatments for a washout effect. During the 4-week washout period, the subjects rested and did not undertake any home exercise or treatment. During the washout period, phone calls were made to monitor the activities and it was ensured that the patients did not exercise. Then the subjects completed the study with the other treatment. All the subjects were evaluated a total of four times, before and after the two treatment periods (Figure 1). As the evaluations could be tiring, they were conducted on a different day to the treatments. The treatments and evaluations were conducted face-to-face individually by the same physiotherapist. The researcher making the statistical analyses of the study was blinded to the groups. This paper has been reported in accordance with the Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) (Figure 2) [16].

Treatments

The traditional treatment program included co-ordination exercises, balance, strengthening, and lower extremity stretching exercises according to the functional level of the subjects. The participants had two sessions of treatment a week for a period of 4 weeks. Each treatment session comprised 5 min of non-balance co-ordination, 30 min of balance, and 10 min of stretching and strengthening exercises.

For the cervical mobilization program, 30 min of cervical mobilization techniques were applied in addition to the traditional treatment program. At the beginning of the treatment, the patient was positioned supine, general and segmental traction was applied to the cervical vertebrae. Myofascial relaxation techniques were applied to the levator scapula and scalene muscles with suboccipital stretching in the supine position and to the trapezius muscle in the lateral position. Segmental rotational mobilizations were applied to the patient in a sitting position. Starting with five repetitions, the mobilization and relaxation techniques were increased to 10 repetitions. For general traction, the physiotherapist's hand

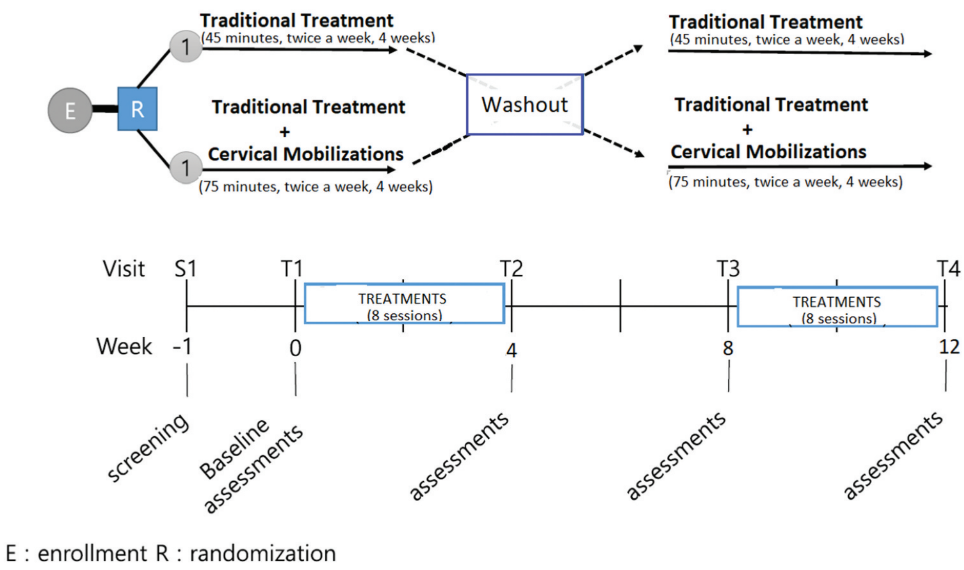

Figure 1. Study design and method.

grasps the occiput and gently applies traction to the cervical vertebrae in a cranial direction. For segmental traction, one hand of the physiotherapist remains stable on the lower segment vertebra, and the other hand moves the vertebra of the upper segment in mild traction in the cranial direction. In segmental rotation techniques, while the patient is seated, the physiotherapist places one hand on the upper segment and takes the weight of the patient's head and holds the lower vertebra stable with the other hand. The upper hand moves the upper vertebra rotationally for mobilization [17]. While applying the suboccipital stretching technique, the fingers of the physiotherapist are in flexion and grasp the occiput behind the atlas. Force is applied by the fingers to the atlas for 2 min cranially. While compression is applied to the midpoint of the muscle for myofascial relaxation techniques, the muscle is moved towards the longest/most stretched position [18] (Appendix).

Outcome measures

Joint Position Sense was measured using a Baseline Digital Goniometer with the reposition method [19]. The Baseline Goniometer is a device which is used in the clinic in the measurement of joint range of movement and position sense, which can be calibrated with a margin of error of 1 degree. While the subject has the eyes closed, the joint is brought to a certain angle by the physiotherapist, kept in that position for 3 s and the subject is asked to define and feel this point. The patient is asked to bring the joint to the point shown, and the measurement is taken with the digital goniometer. The absolute value was recorded as the difference between the point shown and the point to which it was brought when the patient's eyes were closed [20]. To avoid distraction of the patient, the measurements were taken in a quiet environment. The measurements were taken bilaterally three times, and the average value was taken for analysis.

For the lower extremity knee measurement, the position sense measurements were taken with the patient sitting upright on the bed, with the hips and knees in 90° flexion, and the physiotherapist moved the knee into 30° extension. The ankle measurement was taken with the patient lying supine with the ankles hanging from the bed, and the ankle was moved from neutral to 30° plantar flexion.

To test the ability to maintain balance when performing functional activities, the Berg Balance Test (BBT) was used. The BBT is a valid and reliable test in individuals with impaired balance [21]. Daily activities are evaluated in 14 items including transfers, turning, and taking an object from the floor together with static sitting and standing balance. Points are given from 0 to 4, where 0 indicates that the movement cannot be made and 4 indicates normal performance, that the individual can perform it safely and independently as wished. The maximum total score is 56 [22], with total points of 0–20 evaluated as high risk, 21–40 as moderate risk, and 41–55 as low risk [23]. The BBT has been shown to be a valid and reliable tool in MS patients [23].

The Functional Reach Test (FRT) was applied to evaluate dynamic balance. The FRT is a performance-based, rapid, and simple method to determine the limits of stability and risk of falling [24]. At the beginning of the test, the subject was positioned upright side-on to a wall on which a measure was fixed, with the dominant arm against the wall. The dominant arm was positioned with the shoulder in 90° flexion, the elbow in full extension, and the hand in a fist position was placed on the wall. After marking the starting point on the wall, the subject was instructed to move forward without raising the heels from the floor and keeping the arm parallel to the floor. The difference between the starting point and the point reached by the subject was recorded in cm. The test was repeated three times and the average value was taken for analysis [25].

	STUDY PERIOD						
	Enrolment	Allocation	Post-allocation				
TIMEPOINT*	$-t_1$	0	t_1	t_2		t_3	t_4
ENROLMENT							
Eligibility screen	X						
Informed consent	X						
Allocation		X					
INTERVENTIONS							
[Traditional Treatment]			◆———	———◆		◆- - -	- - -◆
[Traditional treatment+Cervical Mobilization]			◆- - -	- - -◆		◆———	———◆
Washout					X		
ASSESSMENTS							
Inclusion criteria	X	X					
Outcome Measurements							
Knee Joint Position Sense			X	X		X	X
Ankle Joint Position Sense			X	X		X	X
Berg Balance Test			X	X		X	X
Functional Reach Test			X	X		X	X
Dynamic Gait Index			X	X		X	X
Timed 25-Foot Walk Test			X	X		X	X

Figure 2. SPIRIT: Description of the study protocol, schedule of enrolment, interventions, and assessments. *List of specific timepoints in this row.

Gait function was evaluated with the Dynamic Gait Index (DGI), which is a valid and reliable test [26]. In the test which measures adaptation to changes when walking, activities such as slow walking, fast walking, head movements while walking, turning, climbing steps, and overcoming obstacles are scored from 3 (successful) to 0 (poor). The scale is formed of eight items with a possible maximum score of 24. Higher points indicate a better condition and points of ≤ 19 indicate a risk of falling [27].

Mobility and leg function were evaluated with the Timed 25-Foot Walk Test (T25W), which has proven validity and reliability [28]. The subject is instructed to walk 25 feet as quickly as possible in a safe manner and the time taken is recorded. Subjects requiring a walking aid are permitted to use it during the test, which is performed twice, and the average time is calculated. The test has high validity and reliability for MS patients [29].

Statistical analyses

The sample size using G-power package version 3.1.9 (Heinrich Heine University, Germany) was calculated as 15 subjects according to the results of the BERG Balance Scale, in which the power of the study was defined as 80% (α: 0.05, β:0.20) [30].

Data obtained in the study were analysed statistically using SPSS vn. 22.0 software (Statistical Package for the Social Sciences). Conformity of the data to normal distribution was assessed with the Shapiro–Wilk test. For descriptive statistics, the variables determined with numerical measurements were stated as arithmetic mean ± standard deviation (SD) values and categorical variables as number (n) and percentage (%). In the comparisons of subjects before and after treatments in the same order, the Wilcoxon test was used, and for the comparison of values after treatment in a different order, the Mann Whitney U-test was applied. In the examination of the difference between the first and third evaluations, the presence or not of a washout effect was determined with the Wilcoxon test. To determine the washout period effect with comparison of the fourth evaluations of the subjects who received the treatments in different orders, the Mann Whitney U-test was used. In all analyses, a value of $p < 0.05$ was accepted as statistically significant.

Results

The demographic and basic characteristics of the subjects according to the order of the treatments are shown in Table 1.

Joint position sense

When the 4th evaluations were compared according to the treatment order, no difference was observed in any of the parameters and the order was not determined to have had a significant effect ($p > 0.05$). With the addition of cervical mobilization to traditional treatment, there was determined to be a carryover effect in the knee joint position sense ($p < 0.05$) (Table 2). In the first period, an improvement was observed for left knee joint position sense in both treatments ($p < 0.05$) (Figure 3). In the second period after the washout period, subjects who started with cervical mobilization were determined to have significant improvements in bilateral ankle joint position sense ($p < 0.05$) (Figures 3 and 4).

Balance and gait

The effect of the traditional treatment on the BBT and FRT was not lost in the washout period, as there was seen to be a significant difference between the 1st and 3rd evaluations ($p < 0.05$) (Table 2). With the addition of cervical mobilization to traditional treatment, there was determined to be a carryover effect in the BBT ($p < 0.05$) (Table 2). In the first period, an improvement was observed for balance tests and DGI (Figure 4) in both treatments ($p < 0.05$).

In the second period after the washout period, subjects who started with cervical mobilization were determined to have significant improvements in the BBT ($p < 0.05$) (Figures 3 and 4). In the subjects who started with the traditional treatment, a significant improvement was determined in the second period in the BBT and the DGI ($p < 0.05$) (Figure 4). When

Table 1. Demographics and baseline characteristics.

Characteristics	Traditional Treatment first ($n = 9$)	Cervical mobilization + Traditional Treatment first ($n = 7$)
Age (years)	39.66 ± 7.82	33.85 ± 9.04
Gender (male/female)	1/8	1/6
Body Mass Index (kg/m^2)	24.19 ± 4.14	25.34 ± 3.20
Disease Duration (years)	8.55 ± 4.90	8.83 ± 5.67
EDSS score (0–10)(median)	3.00 ± 1.17 (3.5)	2.21 ± 1.07 (2.0)
R-Knee Joint Position Sense (angle)	5.82 ± 3.26	5.31 ± 2.14
L-Knee Joint Position Sense (angle)	6.97 ± 4.21	5.44 ± 2.31
R-Ankle Joint Position Sense (angle)	7.76 ± 4.79	8.19 ± 5.17
L- Ankle Joint Position Sense (angle)	7.42 ± 4.90	6.92 ± 5.84
Berg Balance Test (score)	49.55 ± 4.03	48.14 ± 6.56
Functional Reach Test (cm)	24.81 ± 4.89	24.09 ± 5.91
Dynamic Gait Index (score)	18.44 ± 3.74	20.00 ± 3.00
Timed 25-Foot Walk Test (sn)	6.27 ± 1.48	5.63 ± 1.11

R: Right, L: Left.

Table 2. Carryover effect according to order.

	Traditional Treatment first ($n = 9$)				Cervical mobilization+Traditional Treatment first ($n = 7$)			
	First	Third	z	p	First	Third	z	p
R-Knee Joint Position Sense (angle)	5.82 ± 3.26	4.79 ± 3.87	0.533	0.594	5.31 ± 2.14	3.89 ± 2.95	2.028	0.043*
L-Knee Joint Position Sense (angle)	6.97 ± 4.21	4.29 ± 3.10	0.178	0.859	5.44 ± 2.31	2.79 ± 0.78	1.859	0.063
R-Ankle Joint Position Sense (angle)	7.76 ± 4.79	7.90 ± 4.64	0.652	0.515	8.19 ± 5.17	6.64 ± 3.93	1.352	0.176
L- Ankle Joint Position Sense (angle)	7.42 ± 4.90	6.21 ± 3.58	0.533	0.594	6.92 ± 5.84	4.70 ± 2.80	0.676	0.499
Berg Balance Test (score)	49.55 ± 4.03	53.77 ± 2.04	2.232	0.026*	48.14 ± 6.56	53.28 ± 3.68	2.207	0.027*
Functional Reach Test (cm)	24.81 ± 4.89	28.24 ± 4.31	2.075	0.038*	24.09 ± 5.91	30.23 ± 7.86	1.863	0.063
Dynamic Gait Index (score)	18.44 ± 3.74	20.66 ± 2.17	0.359	0.719	20.00 ± 3.00	22.42 ± 1.51	1.633	0.102
Timed 25-Foot Walk Test (sec)	6.27 ± 1.48	6.02 ± 0.63	0.178	0.859	5.63 ± 1.11	5.42 ± 0.83	0.676	0.499

R: Right, L: Left.
*$p < 0.05$.

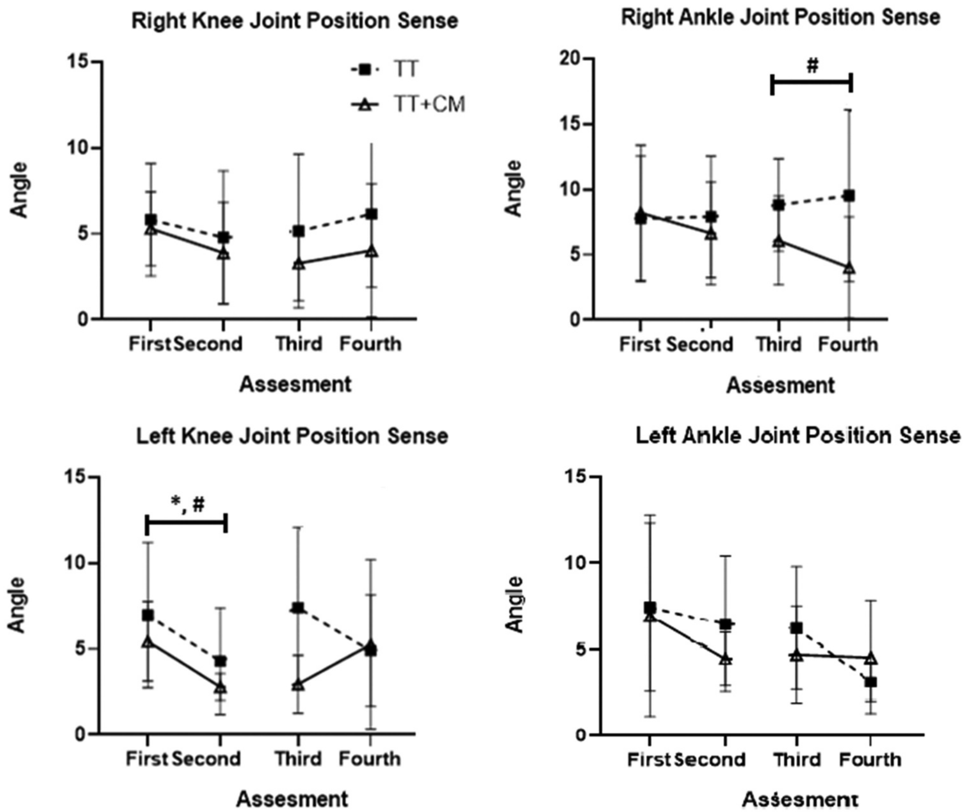

Figure 3. Differences in joint position sense outcomes according to TT (Traditional Treatment) and TT+CM (Traditional Treatment + Cervical Mobilization). *$p < 0.05$ in Traditional Treatment #$p < 0.05$ in Traditional Treatment+Cervical Mobilization

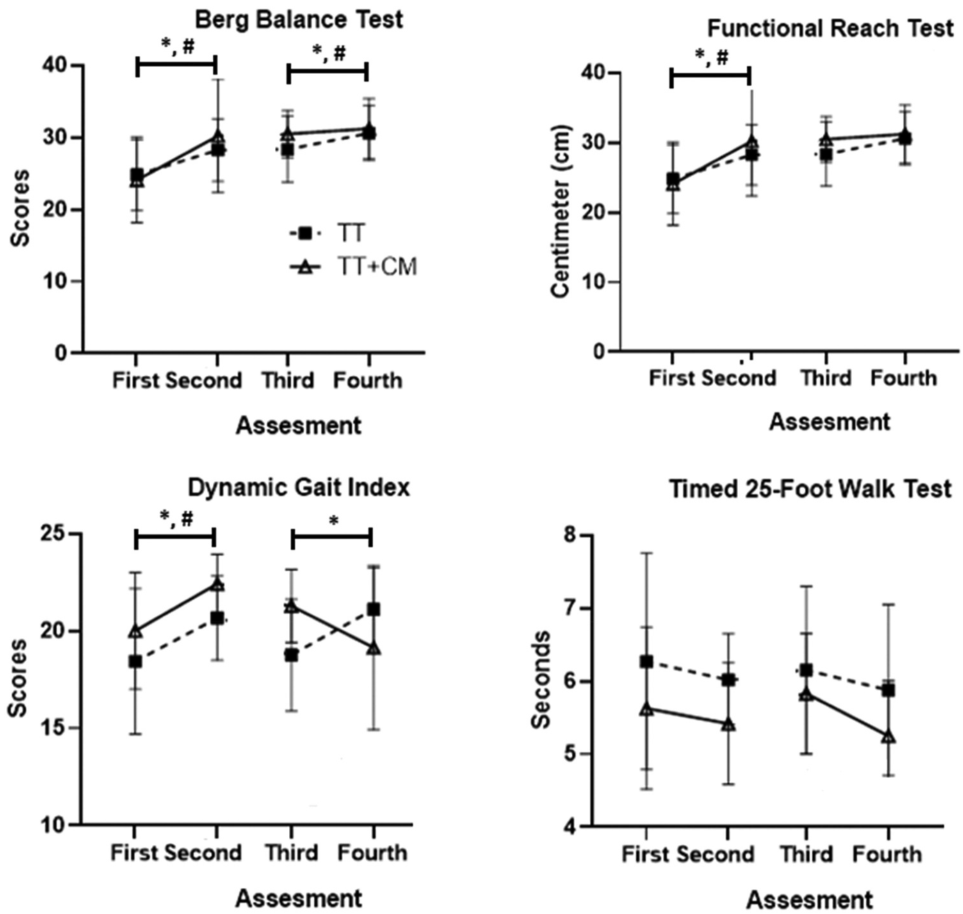

Figure 4. Differences in balance and gait outcomes according to TT (Traditional Treatment) and TT+CM (Traditional Treatment + Cervical Mobilization). *$p < 0.05$ in Traditional Treatment #$p < 0.05$ in Traditional Treatment+Cervical Mobilization

the 4th evaluations were compared according to the treatment order, no difference was observed in any of the parameters and the order was not determined to have had a significant effect ($p > 0.05$).

Discussion

In this study, examining the effects of manual therapy on position sense, balance and gait in MS patients, the results demonstrated that cervical mobilization together with traditional treatment was effective in improving joint position sense, balance and gait, and accelerated improvements in a short time. No effect was seen of the order of treatments, while in the group that started with traditional treatment, the effect of the treatment was only carried over to balance parameters, while in the group that started with cervical mobilization, the treatment effect was carried over to both balance and ankle joint position sense. Thus, it can be said that the addition of cervical mobilization to traditional treatment increased the duration, diversity and range of the effect.

The application of cervical mobilization is known to develop proprioception by stimulating cutaneous afferent fibres [31]. In a previous study, it was reported that developments in joint position sense of the cervical region were obtained with applications of one session of manipulation and massage to the cervical region [32]. Basically, every intervention to be made to the cervical region which is connected to the posterior column where the position sense is felt, could develop the position sense. In another study, the immediate effect on position sense was examined of the application of a single mobilization session to the C5-C6-C7 segments of a male patient with neck pain, but the amounts of deviation of the patient before and after the treatment were found to be similar [33]. Different results have been reached in studies related to the effects of cervical mobilization on proprioception [32,33]. In the current study, the positive improvement seen in ankle joint position sense was not seen in the knee joint in the patients applied with cervical mobilization first. This can be explained by the active role of the ankle in providing plantar sense and protective strategies, whereas the improvement in knee joint position sense did not reach a level of statistical significance. This could be increased with the effect of a more intense treatment program.

In the provision and maintenance of a normal postural control mechanism, visual, vestibular and proprioceptive inputs are important. In MS patients with impaired somatosensorial sense, the postural control mechanism is affected associated with proprioceptive losses and those with impaired balance experience gait problems and falls [34]. Karanfil et al. investigated the immediate effect on balance of cervical mobilization in MS patients. Balance was evaluated with single-leg stance duration and posturography. The application of a single session of cervical mobilization techniques was reported to increase the single-leg stance duration and the combined balance score [30].

There are different studies in literature which have investigated the effects of cervical mobilization techniques in the elderly or in healthy individuals [12,35]. Upper cervical mobilization (C1–2) was applied to a group with a painful neck, and C3–4, C7-T1 and T5–6 mobilizations were added to the treatments for other groups, then balance was evaluated after the treatments. No difference was determined in the efficacy of the treatment applied to the upper cervical vertebrae and the efficacy of the combined treatment. However, in the balance evaluations made after 15 days, the effect of the mobilizations applied to the upper cervical vertebrae was reported to be maintained [36]. In the current study, the improvements in balance of the subjects applied with cervical mobilization were better and was determined to be preserved in the rest period. The fact that the cervical region is rich in muscle spindles and proprioceptors was considered to be effective in this result, which was consistent with findings in literature.

There are studies in literature that have examined the effects on balance and gait of applications with different techniques to the cervical region, which is important in respect of sensory and vestibular reflexes. One of these methods is the application of segmental vibration. Leplaideur et al. applied vibration to the neck muscles contralateral to the affected hemisphere in hemiplegic patients and reported an immediate improvement in postural asymmetry, body image and balance [4]. However, in another study, the balance results following segmental vibration treatment applied to the cervical region of Parkinson's patients were found to be the same as those of the healthy control group [5]. Another treatment applied to the neck region is kinesio tape. The efficacy of kinesio taping applied to the paraspinal muscles of the neck region for head posture in 23 individuals with forward head posture was investigated with the Y balance test, and there was seen to be an improvement in balance [6]. Another technique is transcutaneous electrical stimulation. Perenneou et al. applied transcutaneal electric stimulation to the neck muscles of hemiplegic patients and proved that the treatment reduced instability in the sitting position [37]. Another study examined the balance of hemiplegic patients by giving proprioceptive education for the neck region, and the balance and gait speed improved in these individuals [38]. The mobilizations by stimulating proprioceptors activate the gate control mechanism, reduce pain, regulate muscle tone, and increase the function [39]. In the current study, the mechanism of the improvement in balance obtained with cervical mobilization techniques, consistent with the literature, was interpreted as the techniques having increased afferent stimulations. In our study, it was observed that somatasensory senses and sensory inputs were increased and the integration of the vestibular system was facilitated and gait, which is a dynamic balance, was improved. We believe that cervical mobilization techniques can improve walking performance in creating postural responses and processing them in the central nervous system. With the regular application of afferent stimulations throughout treatment, sensory components in the postural control mechanism were activated and improved the somatosensorial, visual, and vestibular losses that are seen in MS patients.

This study had the specific characteristic of investigating the long-term effect of cervical mobilization in MS patients. With the cervical mobilization techniques applied in this study, improvements were seen in balance and gait and the development of proprioception of patients with neurological disease through mechanotransduction of receptors functioning in ocular, colic, and tonic reflexes, and stimulation of mechanoreceptors and muscle spindles in the suboccipital region, and thus a new perspective on the current literature can be considered to have been gained.

The most important limitation of this study was that evaluation of the balance and gait parameters was only made with clinical scales. For balance evaluation, more sensitive measurement methods such as posturography or Biodex could have been used, and for position sense, the target angle could have been held for 5 s. Adding manual therapy applications to traditional treatment and prolonging the session duration may cause fatigue in MS patients. However, in this study, most of the manual techniques were applied in the lying position and fatigue was ruled out by offering rest options to the patients. Fatigue should be taken into account in studies where techniques will be applied intensively and repeatedly in different positions.

This study provides further evidence for literature that cervical mobilization techniques can be used to improve position sense, balance and gait. There is a need for further studies examining the effects on position sense, balance and gait of a 6–12 weeks treatment program of cervical mobilization techniques in MS patients. By increasing the treatment frequency, the effects on the same parameters can be examined in the short and the long term. With the development of manual therapy protocols for the cervical region, examination of the efficacy of the applications and how long the effects last will be useful in increasing the value of the evidence. Further studies examining the effects of cervical mobilization techniques in different neurological diseases will contribute to the generalizability of the applications.

In conclusion, mobilization applications to the cervical region, which have positive effects on the peripheral sensation system, balance and gait, can be applied together with traditional treatment as a supportive method in the treatment of MS patients.

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Appendices

Technique	Description of Technique
General Traction in CM	The patient was supine, and whereas the Physiotherapist was seated, the Physiotherapist's hands grasped the patient's head. The force was applied with hands over the occiput in the ceiling direction with slight traction in the cranial direction.
Segmental Traction in CM	The patient was supine and whereas the Physiotherapist was seated. The Physiotherapist's hands fixed the inferior vertebra, and the force was applied with the superior vertebra in the direction of the ceiling with slight traction in the cranial direction.
Suboccipital Relaxation in CM	The patient was supine, and whereas the Physiotherapist was seated, the patient's head with the elbows resting on the surface of the table. The Physiotherapist's fingers flexed, and finger pads positioned on the posterior arch of the atlas to allow the occiput to rest in the palm of hands. A force was applied with the finger pads over the atlas in the direction of the ceiling with slight traction in the cranial direction.
Myofascial Relaxation for Levator Scapula in CM	The patient was supine. The Physiotherapist was standing at the edge of the table. Physiotherapist used to active release technique. The ischemic compression is applied in the middle of the muscle during the muscle stretching.
Myofascial Relaxation for Trapezius in CM	The patient was side-lying. The Physiotherapist was standing at the edge of the table. Physiotherapist used to active release technique. The ischemic compression is applied in the middle of the muscle during the muscle stretching.
Myofascial Relaxation for Scalenius in CM	The patient was supine. The Physiotherapist was standing at the edge of the table. Physiotherapist used to active release technique. The ischemic compression is applied in the middle of the muscle during the muscle stretching.
Segmental rotation mobilization in CM	The patient was sitting and whereas the Physiotherapist was standing. The Physiotherapist's hands grasped the patient's head, and the inferior vertebra was fixed. The superior vertebra was rotated to the right and left direction by the Physiotherapist.
Non-balance coordination exercise in TT	The Physiotherapist was standing. The patient was asked to make voluntary movements for the upper and lower extremities on different grounds (stable and unstable surface etc.)
Balance exercises in TT	The Physiotherapist was standing to ensure safety. Static and dynamic balance exercises were trained on different sizes of the support surface and different surfaces.
Strengthening exercises in TT	The Physiotherapist was standing. Therabants were used to strengthen upper extremity muscles. The exercises were performed on different surfaces like bad, Bobath ball. The exercises were chosen according to the individual's level.
Stretching exercises in TM	The patient was supine. The Physiotherapist was standing. Gastrocnemius, Hamstring and adductor muscles were stretched by Physiotherapist.