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Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2019 16(4): 3962-3972. **OPEN ACCESS**

Effect of cervical mobilization on nerve root function in cervical radiculopathy: a randomized trial

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The evidence regarding the effectiveness of cervical mobilization (CM) for treatment of cervical radiculopathy (CR) is scarce. This study investigated the effect of CM on nerve root function using somatosensory evoked potential (SSEP), neck pain and functional disability in CR patients to provide an evidence supporting its use. Fifty subjects with CR were randomly assigned to either "experimental" group who received CM and conventional rehabilitation program, or to "control" group that received conventional rehabilitation program only. The outcome measures were the SSEP, neck disability index and pain visual analogue scale (VAS). All outcomes were recorded at baseline, end of the treatment, and 4 weeks following the end of treatment. Both groups were found to significantly improve in all outcomes after 4 weeks of treatment, but the CM group proved to be superior over the control group. Furthermore, no significant changes occurred in the measured variables at follow up when compared to post treatment values in both groups. Cervical mobilization could be utilized as an effective physical therapy program design for patients with CR for improvement of pain level, functional disability and nerve root function.

Keywords: Cervical radiculopathy, cervical mobilization, nerve root, somatosensory evoked potential, functional disability.

INTRODUCTION

Cervical or neck pain is designated as a common, disabling and a costly musculoskeletal disorder in the cervical region (Côté et al., 2008, Yoon, 2011, Langevin et al., 2012). Cervical radiculopathy (CR) is a cervical nerve root disorder common in the general population forming an important subgroup of neck disorders which leads to more severe pain and disability than regular neck pain (Rubinstein et al. 2007, Manchikanti et al., 2009).

The most commonly involved nerve roots in CR are C6 and C7 (Bogduk, 2003, Cleland et al. 2005, Waldrop, 2006).Cervical radiculopathy is commonly caused by space occupying lesions that cause intervertebral foramen reduction such as cervical disc herniation, spondylosis, or osteophytosis resulting in nerve root compression, inflammation or both (Kim and Kim, 2010, Boyles et al., 2011, Savva and Giakas, 2013). Typical symptoms of CR include pain in the cervical or periscapular region and in the upper limb, as well as neurological signs such as paresthesia, numbness, weakness and loss of reflexes in the affected nerve root distribution (Greathouse et al., 2010, Boyles et al., 2011, Savva and Giakas, 2013).

Somatosensory evoked potentials (SSEP) is

one of electrodiagnostic techniques that plays a critical role in providing physiologic evidence of nerve dysfunction in patients with signs and symptoms of CR. It evaluates the abnormality of the somatosensory tract, which extends from the peripheral nerve to the cerebral cortex (Le Pera et al., 1998, Bono et al., 2011, Hakimi and Spanier, 2013, Imam and Hassan, 2013).

The interest in using SSEP for the evaluation of radiculopathies is based on the fact that signs and symptoms in radiculopathies can usually be related to injury to afferent fiber, and SSEP can monitor injury to these fibers. Furthermore, the SSEP test could be helpful for determining the severity and the prognosis of diseases (Burke et al., 1981, Han et al., 1991, Fisher, 2002, Sohn et al., 2012, Imam and Hassan, 2013).

There is controversy among researchers and clinicians in CR treatment, with evidence showing effectiveness of conservative treatment over surgical options (Costello, 2008, Boyles et al., 2011).Cervical radiculopathy conservative treatment may include therapeutic exercise, manual therapy, modalities, massage therapy, medication, and cervical collar (Wainner and Gill,2000 , Waldrop, 2006, Cleland et al., 2007, Costello , 2008, Boyles et al., 2011). The studies evaluating the effectiveness of rehabilitation interventions for CR remain sparse (Miller et al., 2010, Gross et al. 2010, Langevin et al,. 2012, Langevin et al. 2015) and there is little evidence supporting the use of specific intervention in the treatment of CR (Miller et al., 2010, Langevin et al., 2012, Langevin et al., 2015).

Although a definitive progression for treating CR has not been developed, literature review generally agrees that using manual therapy techniques especially mobilization with exercise is effective to improve function and active range of motion, while reducing levels of pain and disability (Miller et al., 2010, Boyles et al., 2011, Langevin et al., 2015). Up to our best of knowledge there is lack of evidence regarding the mechanism behind the improvement associated with cervical mobilization.

Due to the important incapacities related to CR, and to the few studies pertaining to the efficacy of rehabilitation in this population, and insufficient evidence from which strong conclusions may be drawn about the mechanism behind the improvement associated with cervical mobilization, we believe in the importance of better understanding of the potential of cervical mobilizations and exercises that lead to the improvement of patient disability. There is a need to conduct high quality randomized control trials using control groups with specific treatment techniques to develop effective CR treatment protocols (Boyles et al., 2011, Langevin et al., 2012, Langevin et al., 2015). So, the objective of this randomized control trial was to investigate the effect of cervical mobilization on nerve root function for relieving the compression of cervical nerve root, neck pain level and functional disability in patients with CR and to provide an evident supporting its use by using SSEP as an objective method for assessment.

MATERIALS AND METHODS

This study is a randomized control trial conducted from May 2018 till June 2019 at outpatient's clinic, Department of Physical Therapy, King Khalid hospital, Tabuk, Kingdom of Saudi Arabia. Fifty CR patients out of 84 volunteers who expressed a desire to participate in the study and met the selection criteria undergone 4 weeks of treatment and were randomly assigned into two equal groups as 25 patients in the experimental group (who received cervical mobilization technique and conventional rehabilitation program) and another 25 patients in the control group (who received conventional rehabilitation program only). The number of participants was determined by conducting a power analysis depending on SSEP data obtained from a preliminary pilot study conducted on 6 patients with cervical CR. A statistical power analysis suggested that a sample size of 25 participants in each group was required to achieve 80% power.

The study included patients who met the following inclusion criteria: age ranging from 18 to 60 years; diagnosed as unilateral C5-6 or C6-7 disc herniation causing CR confirmed by imaging (magnetic resonance imaging and/or computed tomography) with symptoms and signs of cervical root involvement as pain, paresthesia or numbness in the dermatomes of C6 or C7 with cervical or periscapular pain, stiffness in the neck, dermatomal sensory impairment, weakness and muscle atrophy in myotomal distribution, and depressed or absent reflexes for more than 3 months.

Patients with cervical spine surgery, signs of upper motoneuron impairments (bilateral paresthesia, hyperreflexia, and spasticity), thoracic outlet syndromes, carpal tunnel syndrome, metabolic systemic disorders, cancer, and cardiovascular insufficiency were excluded from the study. To avoid bias, participants were

randomly assigned to either experimental or control group by opening an envelope prepared by an independent subject with random number generation of 25 participants in each group with allocation ratio 1:1. The study was approved by the Tabuk University Research Ethical Committee. Each participant signed an informed consent form, agreeing to participate in the study.

Outcome measures

The visual analogue scale (VAS) which is valid (Scrimadhow and Maher, 2001) and reliable (Roach et al., 1997, Lunderberg et al., 2001) was used to assess the pain intensity. The valid and reliable (Shaheen et al., 2013) Arabic version of neck disability index (NDI) was used for assessment of functional disability. SSEP was used to asses cervical nerve root function at Erb's point, C7 and cortical C3' and C4'. Participants were evaluated on three different occasions: at baseline (before starting the treatment), at the end of the 4th week of treatment program (week 4), and four weeks following the end of the program (week 8 as a follow up).

Evaluation procedures

Pain assessment

The VAS was used to assess patient's pain intensity. Patients were requested to describe their current pain by using a 10 cm line with 0 (no pain) on one end and 10 (worst pain) on the other end. Patients were asked to place a mark along the line to dente their level of pain.

Functional disability assessment

Arabic version of NDI was used to evaluate the level of neck functional disability. The patients were requested to read the instructions and answer a 10 item self-report measure related to pain, and different activities. Each item is rated on a 6 point scale (0-5). The results were calculated and expressed on a scale ranging from 0% (no disability) to 100% (maximum disability).

SSEP

Computerized Electromyography Toenneis Neuroscreen plus instrument was used to asses cervical nerve root function by measurement of SSEP latency through cortical recording for both groups. Cleaning and scarifying the skin was done carefully before the attachment of the recording electrodes in the scalp. The hair was separated and the skin in between was cleaned by methylated alcohol and sand paper was used to gently abrade the skin site by removing several superficial layers of the skin and skin oils (Dumitru,1995).

A bipolar electrode was used for stimulation with inter electrode distance of 2.5cm with stimulation cathode placed proximally. Electric stimuli were applied to median nerve in the wrist of the upper extremity. Stimulation was accomplished with constant current rectangular wave pulse, 0.2 ms duration, delivered at 3.1Hz. The sensory threshold for electrical stimulation was determined by increasing the intensity of electrical current until the patient reported its sensation and then a tolerable and painless stimulus was set at 2.5 times above this level (Dumitru, 1995).

Recording was made with 9mm diameter tin/lead electrodes affixed with cream to abraded skin. For median nerve SSEP, the most popular locations used to record the response along the sensory pathway are ipsilateral erb's point, ipsilateral lower cervical area (C7) and contralateral cortical sensory cortex (C3' or C4') (Dumitru,1995).

The location of (C3' or C4') could be detected by determining the point at which the line extending between the 2 ears cross the midpoint of sagittal line joining the nasion (bridge of nose) and inion (posterior bony protuberance over inferior aspect of occiput) designates the vertex of the skull. One cm lateral to the vertex of the skull either on the right or left sides are the cortical sensory areas C3' or C4' consecutively. The reference electrode was placed on the forehead between the eyebrows and ground electrode was placed between stimulating and recording electrodes but as close as possible to the recording electrodes(Dumitru,1995) .

Treatment procedures

Conventional treatment

The patients in both groups received the conventional treatment of therapeutic ultrasonic and exercise program. Therapeutic ultrasonic was applied at an intensity of 1.0 W/cm^2, frequency 1MHZ and 100% duty cycle for a duration of 5 minutes/session, three times/week for a total of 4 weeks and it was applied on the paraspinal muscles of the neck and on trapezius muscle.

The exercises program included stretching exercise for scalene, upper trapezius, levator scapulae, sternocleidomastoid, and pectoralis major muscles according to Ylinen et al., (Ylinen et al., 2007). Strengthening of shoulder retractors

muscles and deep cervical flexors according to Harman et al (Harman et al., 2005), and isometric neck strengthening and stabilization exercises for neck flexors, extensors, lateral flexors and rotators muscles according to Ylinen et al., (2003). The exercise program was applied three times/week for a total of 4 weeks.

Mobilization technique

The patients in experimental group received postero-anterior and rotation oscillatory mobilization techniques as described by Maitland et al., (Maitland et al., 2005) for C6 and C7 segments. Each mobilization technique was applied (10 repetitions for 30 seconds for each technique) each treatment session. The mobilization techniques were applied three times/week for a total of 4 weeks.

Postero-anterior oscillatory mobilization technique

The patient lied prone and rested the forehead in the palms of the hands with chin tucked well in. The physiotherapist stood at the head of the patient with the thumbs held in opposition and back to back and the tips of the thumb pads on the spinous process of the vertebra to be mobilized. The fingers straddled the sides of the patient's neck and head. The therapist applied pressure through the tips of the thumbs against the spinous processes in a downward direction. Two or three oscillatory postero-anterior movements were performed at each level in turn, moving fairly quickly up and down the spine.

Rotation oscillatory mobilization technique

The patient lied supine with the head beyond the end of the couch, while the physiotherapist crouched at the end of the couch below the level of the patient. The therapist held the patient's occiput near the heel of the right hand, while the fingers and thumb pointed forwards over the crown of the head. Then the left hand was placed against the left side of the patient's neck with the tip of the thumb between the sides of two spinous processes of C6 and C7, and the tip and adjacent lateral margin of the index finger palpated the margin of the zygoapophyseal joint. The head was pivoted away from the side of palpation, around an imaginary central axis passing through the joint being mobilized. The physiotherapist's hands produced movement in a steady oscillatory fashion, giving movement down to the joint but not beyond it. The palpating finger followed the movement of the joint, assessing the extent of sliding or opening between the two adjacent articular processes.

Statistical analysis

The IBM SPSS statistics 22 software was used for statistical analysis. The analysis of data for this randomized controlled trial was done using descriptive statistics and a 2×3 mixed model Analysis of Variance (ANOVA) with two groups (control vs. experimental) as the between subjects factor and three times for measuring the dependent variables (pre-treatment, post-treatment, follow up) as the within subjects factor. Post hoc Bonferroni-corrected tests were used to identify significant differences between each of the three time of measurements. The P-value was set at 0.05. Prior to data analysis Shapiro–Wilk test and Levene's test were used to test the normality of the data and the equality of variances, respectively. The differences in demographic characteristics for both groups were assessed using unpaired t-tests and Chi-square test. A sample size of 25 participants in each group was determined by conducting a preliminary power analysis with a power 80%.

RESULTS

There were 25 Participants in each group and their demographic data is represented in Table (1). There was no statistical significant difference between both groups in demographic data. Shapiro–Wilk test and Levene's test revealed no violations of the assumptions of normality and homogeneity of variance for any of the dependent variables. Descriptive statistics of pain level, functional disability and SSEP are presented in Table (2). All pretreatment dependent variables showed no significant difference between the two groups ($P>0.05$).

The 2×3 mixed-model ANOVA analysis demonstrated significant improvements in the pain level for both groups after treatment as the main effect of time was statistically significant ($p<0.0001$), but experimental group showed significant improvement than the control group post treatment and at follow up as the main effect of group was statistically significant ($p<0.0001$) and time × group interaction effect was also significant ($p<0.0001$) as shown in Table (3). Post hoc comparisons (pre-treatment vs. post-treatment, pre-treatment vs. follow up, & post-treatment vs. follow up) were computed using a Bonferroni correction.

Table 1: Demographic characteristics of the participants

Characteristics		Control group	Experimental group	P-value
Age		43.92±5.37 (year)	43.12±4.95 (year)	0.58
Weight		78.52±6.84 (Kg)	79.28±7.61 (Kg)	0.71
Height		167.92±6.6 (Cm)	168.88±7.08 (Cm)	0.62
Gender	Male	14 (56%)	13 (52%)	0.77
	Female	11 (44%)	12 (48%)	

Table 2: Descriptive statistics of pain level, functional disability and somatosensory evoked potential for both groups pre-treatment, post-treatment and at follow up

Variables	Group	Pre treatment	Post treatment	Follow up
Pain level	Control	7.32±1.34	4.04±1.39	4.32±1.24
	Experimental	7.92±1.03	2.28±0.67	2.44±0.76
Functional disability (NDI)	Control	47.2±12.27	17.12±6.99	17.68±6.52
	Experimental	49.44±12.26	8.28±4.86	8.72±4.55
SSEPs at Erb's Point	Control	11.34±0.88	10.98±0.83	11.06± 0.8
	Experimental	11.29±0.67	10.28±0.51	10.33±0.51
SSEPs at C7	Control	14.94±0.73	14.58±0.65	14.63±0.64
	Experimental	14.83±0.44	13.91±0.31	13.95±0.3
SSEPs at C3'	Control	21.37±0.97	20.94±0.84	21.02±0.88
	Experimental	21.24±0.99	19.94±0.53	19.98±0.55
SSEPs at C4'	Control	21.72±0.95	21.2±0.84	21.29±0.92
	Experimental	21.59±0.85	20.17±0.43	20.21±0.45

*SD: standard deviation

Table 3: Results of a 2 X 3 mixed-model ANOVA

Source of variance		F-value	P-value
Pain level	Between subjects (Group)	13.96	<0.0001*
	Within subjects (Time)	652.62	<0.0001*
	Time X group	50.49	<0.0001*
Functional disability (NDI)	Between subjects (Group)	6.07	<0.01*
	Within subjects (Time)	793.29	<0.0001*
	Time X group	19.67	0.001*
SSEPs at Erb's Point	Between subjects (Group)	6.16	<0.01*
	Within subjects (Time)	187.44	<0.0001*
	Time X group	47.18	<0.0001*
SSEPs at C7	Between subjects (Group)	10.47	<0.0001*
	Within subjects (Time)	276.24	<0.0001*
	Time X group	58.75	<0.0001*
SSEPs at C3'	Between subjects (Group)	10.78	<0.002*
	Within subjects (Time)	116.81	<0.0001*
	Time X group	33.15	<0.0001*
SSEPs at C4'	Between subjects (Group)	12.95	<0.001*
	Within subjects (Time)	148.45	<0.0001*
	Time X group	36.18	<0.0001*

The pain significantly improved in both groups with pre-treatment versus post-treatment ($p<0.0001$); pre-treatment versus follow up ($p<0.0001$) but there was no significant difference between post-treatment pain level versus follow up pain level ($p>0.1$).

The functional disability measured by NDI significantly improved following treatment in both groups as the main effect of time was statistically significant ($p<0.0001$). Also, the experimental group showed significant improvement in the functional disability than the control group at post-treatment and at follow up as the main effect of group was statistically significant ($p<0.01$) and

time × group interaction effect was also significant (p<0.0001) as shown in Table (3). Post hoc comparisons revealed that the functional disability significantly improved in both groups pre-treatment versus post treatment (p<0.0001); pre-treatment versus follow up (p<0.0001); but there was no significant difference between post-treatment versus follow up functional disability (p>0.15).

The SSEPs at Erb's Point showed significant improvements in both groups after treatment as the main effect of time was statistically significant (p<0.0001) and also, the experimental group showed significant improvement than the control group at post treatment and at follow up as the main effect of group was statistically significant (p<0.01) and time × group interaction effect was also significant (p<0.0001) as shown in Table (3). Post hoc comparisons for SSEPs at Erb's Point showed significant improvement in both groups pre-treatment versus post-treatment (p<0.0001); pre-treatment versus follow up (p<0.0001); but there was no significant difference between post-treatment versus follow up SSEPs at Erb's Point (p>0.1).

Similar results were obtained for SSEPs at C7 as there was significant improvement in the SSEPs at C7 for both groups following treatment as the main effect of time was Statistically significant (p<0.0001) and also, experimental group showed significant improvement than control group at post treatment and at follow up as the main effect of group was statistically significant (p<0.0001) and time × group interaction effect was also significant (p<0.0001) as shown in Table (3). Post hoc comparisons for SSEPs at C7 showed significant improvement in both groups with pre-treatment versus post-treatment (p<0.0001); pre-treatment versus follow up (p<0.0001); but there was no significant difference between post-treatment versus follow up SSEPs at C7 (p>0.1).

Furthermore, SSEPs at C3' was significantly improved following treatment in both groups as the main effect of time was statistically significant (p<0.0001). Also, the experimental group was superior to control group at post treatment and at follow up as the main effect of group was statistically significant (p<0.002) and time × group interaction effect was also significant (p<0.0001) as shown in Table (3). Post hoc comparisons revealed that the SSEPs at C3' significantly improved in both groups pre-treatment versus post-treatment (p<0.0001); pre-treatment versus follow up (p<0.0001); but there was no significant difference between post-treatment versus follow up SSEPs at C3' (p>0.1).

Similarly, the SSEPs at C4'showed significant improvements in both groups after treatment as the main effect of time was statistically significant (p<0.0001) and also, the experimental group was superior to control group at post-treatment and at follow up as the main effect of group was statistically significant (p<0.001) and time × group interaction effect was also significant (p<0.0001) as shown in Table (3). Post hoc comparisons for SSEPs at C4' showed significant improvement in both groups pre-treatment versus post treatment (p<0.0001); pre-treatment versus follow up (p<0.0001); but there was no significant difference between post treatment versus follow up SSEPs at C4' (p>0.27).

All participants in both groups did not report any complications or side effects at the end of treatment or at follow up.

DISCUSSION

The purpose of this study was to examine the effect of cervical mobilization for management of pain intensity, functional disability, and nerve root function in patients with CR. The findings of the present study revealed that both groups were found to significantly improve in pain level, functional disability, and nerve root function as measured by SSEP at Erb's point, C7 and cortical C3' and C4' after 4 weeks of treatment in patients with CR. The cervical mobilization (experimental) group proved to be superior over the control group. Furthermore, no significant changes occurred in the measured variables at follow up when compared to post-treatment values in both groups.

Different neurophysiological and biomechanical mechanisms lie behind the improvement of pain level, functional disability, and nerve root function in experimental group caused by cervical mobilization. Various neurophysiological mechanisms explained the reduction of pain following mobilization. One of the possible mechanisms is that mobilization reduces pain by affecting the inflow of sensory information to the central nervous system. The non-noxious mechanical inputs of the mobilization reduce pain through the gate control theory of Melzack and Wall, as they travel by means of the large myelinated fiber neurons then inhibit the response of dorsal horn neurons to nociceptive stimuli from C fibers and this reduces pain and increases pain threshold levels (Melzack and Wall, 1965, Joel and Pickar, 2002, Malisza et al.,

2003, Bialosky et al., 2009).

Furthermore, the effect of manual therapy on pain could also be mediated by the neuroendocrine system. Mobilization techniques have been shown to increase the circulating levels of β-endorphin and N-palmitoylethanolamide which is an important reliever of pain and has a role in diminishing nociceptive stimuli in ascending pain pathways (Degenhardt et al., 2007).

In addition, the release of different inflammatory and nociceptive mediators have been denoted to diminish after the application of manual therapy as blood and serum level cytokines were reported to be reduced by Teodorczyk-Injeyan et al., (Teodorczyk-Injeyan et al., 2006). Finally, manual therapy may reduce pain through supraspinal descending inhibition mechanism by decreasing the activation of the supraspinal regions responsible for central pain processing such as the anterior cingulate cortex, amygdala, periaqueductal gray, and rostral ventromedial medulla due to associated changes in the opioid system, and dopamine production (Malisza et al., 2003, Sauro and Greenberg, 2005, Fuente-Fernandez et al., 2006, Bialosky et al., 2009).

The improvement of pain and functional disability in mobilization group may also be due to the biomechanical effects produced by manual therapy (Colloca et al., 2006). The biomechanical changes caused by the manual therapy lead to restoration of mobility through improvement in connective tissues structure length such as joint capsule of the zygoapophysial joints, muscles and ligaments. Those biomechanical changes are thought to have physiological consequences by means of their effects on the inflow of sensory information to the central nervous system**.** Biomechanical alteration and restoration of mobility between vertebral segments alter the signaling properties of mechanically or chemically sensitive neurons in paraspinal tissues. These changes in sensory input are thought to modify neural integration either by directly affecting reflex activity and/or by affecting central neural integration within motor neuronal pools. Either of these changes in sensory input may elicit changes in efferent somatomotor. Eventually, manual therapy alters the inflow of sensory signals from paraspinal tissues in a manner that improves physiological function (Joel and Pickar, 2002, Colloca et al., 2004, Bronfort et al., 2008, Farooq et al., 2018).

Several mechanisms have been postulated behind the improvement of nerve root function after mobilization. The first possible mechanism is that manual therapy creates a negative pressure in the disc and somehow sucks the herniated nucleus pulposus back in or repositions the annular fragments of the disc and thus reduces compression of the disc on nerve root and other innervating paraspinal tissues (BenEliyahu, 1996, Zhao and Feng, 1996, Snelling, 2006). The second possible mechanism is that manual therapy releases adhesions and trapped meniscoids and reduces deformation of the intervertebral disc leading to improvement of nerve function (Farfan, 1980, Vernon et al., 1997, Ojoawo et al., 2016).

The third possible mechanism is that axoplasmic flow and the circulation within the nerve are hindered when the nerve is exposed to compressive stress, shear or tensile forces that surpassed its ability to withstand it, and this leads to ischemia and impaired function (Topp and Boyd, 2006, Efstathiou et al., 2015). Compressions of the nerve root as in radiculopathy obstruct nerve root blood flow and produce some changes in nerve microvascular circulation (Kobayashi et al., 2003, Kobayashi et al., 2004), thus, leading to both motor and sensory dysfunction (Mulleman et al., 2006, Bogduk ,2009).Cervical mobilization enhances axoplasmic flow and circulation within the nerve, so it helps in reduction of local hypoxia and thus improves nerve function (Butler et al., 2000, Nee and Butler, 2006, Whelan et al., 2018). Finally,manual therapy of dysfunctional cervical joints may alter sensorimotor integration through adjustment of transmission in neuronal circuitries at the spinal level as well as at cortical level. Thus, manual therapy is thought to reverse the maladaptations in sensorimotor integration and improve motor control (Taylor and Murphy, 2007, Taylor and Murphy, 2008).

The findings of this study reinforce that mobilization technique has beneficial effects on reduction of pain and functional disability and improvement of nerve root function in patients suffering from cervical radiculopathy. This is consistent with the findings of several studies which reported reduction of pain and functional disability following mobilization in patients with neck pain (Hoving et al., 2002, Hoving et al. 2006, Ylinen et al., 2007, Walker et al., 2008, Ko et al., 2010, Perez et al., 2014, Farooq et al., 2018) .

Moreover, the results of the present study regarding improvement in nerve function as measured by SSEP were in consistent also with Taylor and Murphy (Taylor and Murphy, 2007,

Taylor and Murphy, 2008) who reported that manual therapy of cervical spine may alter cortical somatosensory processing and sensorimotor integration and improve motor control.

This study was limited by the improvement obtained in the experimental group due to the effect of two techniques of cervical mobilization as a complete regimen performed on the patients, thus the effect of every single technique of cervical mobilization was not demonstrated but the improvement reported was attributed to the entire regimen. In the future, studies need to investigate the effect of single cervical mobilization technique isolated from the effect of other techniques and exercises on pain level, functional disability and nerve root function in patients with cervical radiculopathy.

CONCLUSION

The results of the current study provide weight into promoting functional activities in patients complaining from cervical radiculopathy. Cervical mobilization could be utilized as an effective physical therapy program design for patients with cervical radiculopathy for improvement of pain level, functional disability and nerve root function.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

ACKNOWLEGEMENT

This study was supported by grants from the Deanship of Scientific Research, University of Tabuk, Tabuk, Saudi Arabia (Grant no. S-1437-0101).

AUTHOR CONTRIBUTIONS

All authors contributed equally in all parts of this study. All authors read and approved the final version.

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