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The Effects of Thoracic Manipulation Versus Mobilization for Chronic Neck Pain: a Randomized Controlled Trial Pilot Study

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Abstract. [Purpose] To investigate effects of thoracic manipulation versus mobilization on chronic neck pain. [Methods] Thirty-nine chronic neck pain subjects were randomly assigned to single level thoracic manipulation, single level thoracic mobilization, or a control group. The cervical range of motion (CROM) and pain ratings (using a visual analog scale: VAS) were measured before, immediately after and at a 24-hour follow-up. [Results] Thoracic manipulation significantly decreased VAS pain ratings and increased CROM in all directions in immediate and 24-hour follow-ups. The thoracic mobilization group significantly increased in CROM in most directions at immediate follow-up and right and left rotational directions at the 24-hour follow-up. Comparisons between groups revealed the CROM for the manipulation group to increase significantly more than for control subjects in most directions at immediate follow-up and flexion, left lateral flexion and left rotation at the 24-hour follow-up. The CROM for the thoracic mobilization group significantly increased in comparison to the control group in flexion at immediate follow-up and in flexion and left rotation at the 24-hour follow-up. [Conclusion] The study demonstrated reductions in VAS pain ratings and increases in CROM at immediate and 24-hour follow-ups from both single level thoracic spine manipulation and thoracic mobilization in chronic neck pain.

Key words: Single level thoracic manipulation, Single level thoracic mobilization, Chronic neck pain

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INTRODUCTION

Neck pain is one of the most common health problems in the general population, particularly among people of working age. The prevalence of neck pain has generally been reported to be 45–54% and approximately 50% for workers[1, 2)]. Related to this, approximately 25% of out-patient physical therapy visits concern presentations of pain in the neck region[3, 4)]. Furthermore, over 33% of neck pain patients develop chronic symptoms[5)] and the economic expense associated with chronic mechanical neck pain is very high[6)].

The source of mechanical neck pain is related to various pain-sensitive structures, including the zygapophyseal joints, ligaments, muscles, uncovertebral joints, intervertebral discs, or neural tissues around the cervical spine[7)]. Additionally, it can be related to mechanical dysfunction of the cervical spine[8)], which results in reduced neck mobility[7–9)].

Treatment of mechanical neck pain includes medication and physical therapy such as traction, massage, and other physical interventions, including spinal manipulation/mobilization. The aim of treatment is to reduce pain and to increase range of motion of the cervical spine. Cervical manipulation has been commonly used to treat mechanical neck pain[10, 11)]. However, complications with this technique have been reported, particularly risk of vertebro-basilar artery insufficiency after cervical manipulation[12)]. For this reason, it has recently been suggested that thoracic spine manipulation and mobilization could reduce symptoms of mechanical neck pain in patients, but with fewer complications[13)].

Recent studies have shown that performing thoracic spine manipulations (multiple levels) on mechanical neck pain patients can result in immediate improvements in symptoms and neck function[13–15)]. It has been found that thoracic spine manipulation can activate descending inhibitory mechanisms resulting in hypoalgesia in distant areas, and may restore normal biomechanics of the thoracic region, potentially lowering mechanical stress and increasing the distribution of joint forces in the cervical spine[15)]. Ad-

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ditionally, Cleland et al. also suggested that multiple thoracic mobilization Grade III could reduce pain and disability in the neck[13]. It was claimed that the T6 vertebral level was the most rigid in terms of nervous system mobility[16]. Therefore, performing single manipulation or mobilization at this level may improve symptoms in chronic neck pain patients. That is, evidence exists to support the use of thoracic manipulation for reduction of pain and for increasing cervical range of motion (CROM). However, previous studies have not provided evidence on the effects of single level thoracic manipulation and mobilization in patients with chronic neck pain. Single thoracic manipulation is less time consuming than multiple thoracic manipulations. Furthermore, it is not known whether thoracic mobilization produces similar treatment outcomes to thoracic manipulation. Finally, there is little evidence of outcomes of either treatment beyond immediate follow-up sessions; for example, 24 hours, after performing single level thoracic manipulation or mobilization.

Therefore, this study aimed to investigate and compare the immediate and extended 24 hour effects of single level thoracic manipulation and mobilization in subjects with chronic neck pain. It was hypothesized that: 1) single level thoracic manipulation would reduce pain at rest and increase CROM in mechanical neck pain patients, similar to multi-level manipulation; 2) single level thoracic mobilization would also reduce pain at rest and increase CROM but to a lesser extent than manipulation due to inhibitory mechanism activation directly associated with the latter modality; and 3) the effects of both thoracic manipulation and mobilization on pain at rest and CROM were expected to be apparent in both immediate and 24-hour follow-up. These hypotheses were tested through a randomized controlled trial pilot study.

SUBJECTS AND METHODS

A prospective, assessor-blind, pilot study was conducted at the School of Physical Therapy Laboratory, Khon Kaen University, Thailand. The research protocol was approved by the Research Ethics Committee for Human Research of Khon Kaen University.

Thirty-nine chronic mechanical neck pain subjects were recruited to participate in the current study. Subjects presented with unilateral or bilateral pain in the posterior neck and/or shoulder regions, and neck postures, neck movement, or palpation of the cervical region could provoke their symptoms. Inclusion criteria were: 1) aged 18 to 60 years; 2) a VAS pain rating of greater than or equal to 40 points; and 3) symptoms of more than 3 months in duration. Subject baseline ratings of neck pain were captured using a 100-point VAS with values ranging from 0 to 100.

Subjects were excluded if they presented with any of the following: 1) diagnosis of cervical radiculopathy or myelopathy (determined by a physiatrist); 2) previous history of cervical and thoracic spine fracture and/or dislocation; 3) previous history of surgery of the cervical and/or thoracic spine; 4) previous history of spinal osteoporosis, spinal infection or fibromyalgia syndrome; 5) previous history of underlying hypertension, heart disease or meningitis; 6) pregnancy; 7) any contraindication to manipulation; and 8) history of spinal manipulative therapy before this study.

The study sample size (n) was determined using the statistical formula: $n = 2\,(Z_{\alpha/2} + Z_{\beta})^2\,\sigma^2 / (m_2 - m_1)^2$. Where n is the resulting sample size, $Z_{\alpha/2}$ is the standard normal score associated with the acceptable Type I error probability, Z_{β} is the standard normal score associated with the acceptable Type II error probability, σ^2 is the standard deviation of the target response, and m_2 and m_1 are condition means for treatment and control groups. The investigators referred to a previous study for mean ratings of pain at rest for the thoracic manipulation and control groups using a VAS. Means were 15.5±7.7 mm and 4.2±4.6 mm, respectively[14]. For the sample size determination, we used a significance level of 0.05 (α) and the power of test was set at 90 percent (1-β). Based on these values, it was estimated that 13 subjects should be recruited for each group in the present study.

All subjects were examined by a rehabilitation medicine physician. Each subject was asked to complete a screening questionnaire in order to ensure they met the inclusion criteria. Each subject was required to sign an informed consent form before participating in the study. Each subject was randomly assigned to receive single level thoracic manipulation, or single level thoracic mobilization, or to rest in a prone position (the control group) using a block randomized allocation with a block size of three. Each subject chose an opaque, sealed envelope which contained their group information. The randomization process was undertaken by Clinician "A" who was not involved in the recruitment of the subjects, treatments or evaluation process. Subsequently, subject pain level at rest was measured using the VAS and cervical range of motion was assessed using a CROM measurement device (Fig. 1). All outcome measures were evaluated by Clinician "B", who was unaware of the subject's group assignment. Demographic information of each subject including age, sex, weight, height and BMI were also collected.

The subjects in the single level thoracic manipulation group were asked to lie in a prone position on a standard examination table and they were marked on both sides of the zygapophyseal joint (T6-T7) (Fig. 2). Subjects were then instructed to perform deep inhalation and exhalation and at the end of exhalation, a Clinician "C" performed thoracic manipulation (screw thrust technique) at both zygapophyseal joints of T6-T7[7]. If a popping sound (i.e., release of gas from joint cavities) was not heard on the first attempt, the subject was instructed to reposition and the same technique was repeated. This procedure was performed for a maximum of two attempts and was completed within 2 minutes[13]. It should be noted that Clinician C had more than 10 years of experience in manual therapy for treating neck pain patients.

The subjects in the single level thoracic mobilization group were asked to lie in a prone position on the examination table and they were marked on both sides of the zygapophyseal joint (T6-T7) (Fig. 3). Clinician C then performed Grade III unilaterally postero-anterior mobilization at the zygapophyseal joint of T6-T7 on both the left and right

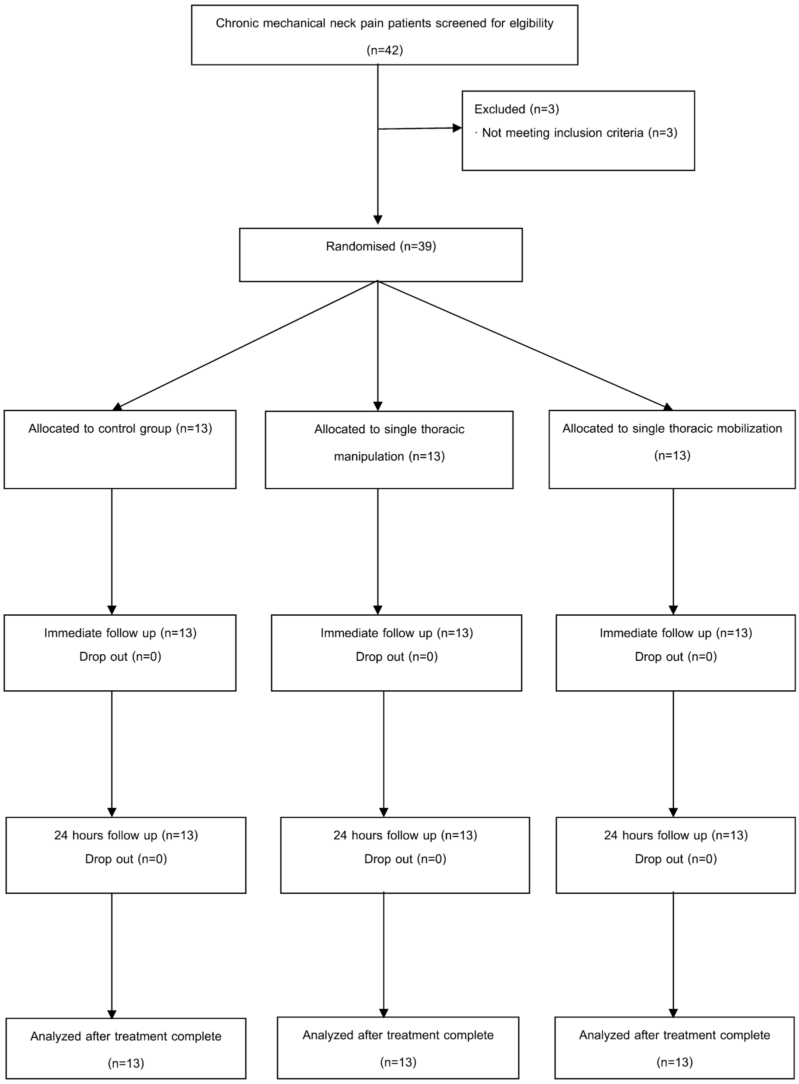

Fig.1. Participant flow diagram and follow-up evaluation

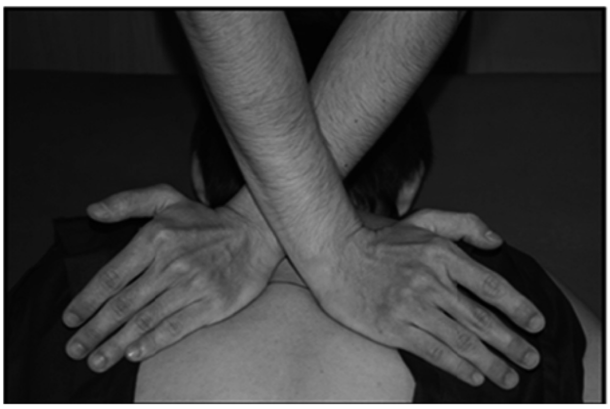

Fig.2. Single level thoracic manipulation (screw thrust technique) at both zygapophyseal joints of T6-T7

Fig.3. Single level thoracic mobilization Grade III unilateral postero-anterior mobilization at the zygapophyseal joint of T6-T7 on both the left and right sides

sides for 1 minute[7]. The Grade III mobilization involved large amplitude motion at the limit of range of motion. This technique has been used for improved range of motion. The entire process was completed within 2 minutes.

The subjects in the control group were asked to lie in a

Table 1. Characteristics data of the study subjects (n=39)

Characteristic	Con (n=13)		Man (n=13)		Mob (n=13)	
	Mean± SD	Range	Mean± SD	Range	Mean± SD	Range
Age (yrs)	35.33±10.96	22–51	37±12.49	21–52	39.91±11.52	21–56
Weight (kg)	55.50±8.05	44–70	63.62±9.83	48.5–82	57.5±8.31	47–74
Height (cm)	162.08±5.60	156–175	164.83±8.71	152–178	161.58±5.94	151–174
BMI (kg/m^2)	21.09±2.71	17.18–27.23	23.44±3.57	20.02–32.02	21.95±2.55	18.67–27.19
Sex (m/f)	3/10		4/9		4/9	

yrs = years, m/f = males/females, Con = Control group, Man = Single thoracic manipulation group, Mob = Single thoracic mobilization group

Table 2. Means (standard deviations) of each outcome measure of each group (n=39)

Variable	Con (n=13)			Man (n=13)			Mob (n=13)		
	Pre-test	immediate	24 hrs	Pre-test	immediate	24 hrs	Pre-test	immediate	24 hrs
Active cervical range of motion									
Flexion (°)	60.57 (10.77)	58.62 (10.54)	58.36 (10.68)	55.08 (8.45)	60.05 (9.07)**	60.36 (8.41)**	59.44 (7.01)	63.28 (5.74)**	61.64 (6.16)
Extension (°)	47.64 (16.45)	49.95 (16.40)	49.28 (14.11)	48.51 (14.09)	56.31 (14.52)**	54.21 (12.72)**	58.82 (7.02)	61.33 (8.71)	58.15 (8.51)
Lift lateral flexion (°)	33.03 (8.57)	34.84 (8.37)	34.10 (8.10)	32.77 (7.20)	38.41 (8.55)**	38.26 (7.01)**	36.41 (7.11)	39.90 (6.20)*	37.85 (5.39)
Right lateral flexion (°)	31.54 (8.54)	33.08 (8.26)	33.82 (6.27)	33.33 (8.71)	38.05 (7.90)**	36.82 (8.04)*	38.97 (4.48)	41.69 (4.94)*	40.31 (3.43)
Lift rotation (°)	53.79 (12.59)	55.18 (14.26)	53.90 (14>82)	53.33 (6.09)	62.62 (6.95)**	61.59 (6.52)**	57.54 (8.15)	61.69 (10.15)*	63.85 (9.31)**
Right rotation (°)	55.28 (11.48)	56.92 (12.97)	57.38 (12.76)	55.54 (6.26)	62.05 (7.06)**	60.87 (7.61)*	58.41 (7.67)	64.67 (9.37)*	65.10 (7.81)*
Neck pain at rest									
VAS (mm)	43.69 (15.60)	38 (18.12)	35.08 (14.41)**	45.08 (18.87)	37.46 (19.57)**	35.92 (19.77)*	46.62 (16.66)	38.08 (20.77)*	35.15 (18.66)*

*p<0.05, **p<0.01, Con = Control group, Man = Single thoracic manipulation group, Mob = Single thoracic mobilization group

prone position on the examination table. Clinician C placed their hands on both sides of the zygapophyseal joint at T6-T7 without compressive pressure on the joints for a total of 2 minutes. Subjects in both groups received no other treatment; for instance, massage or self-manipulation during the research period, except for any usual medicines.

The pain at rest was measured using the VAS. The rating scale was a 100-millimeter (mm) line with anchors of “no pain” associated with the value of 0 and “worst pain” associated with the value of 100. Subjects placed a mark along the line corresponding to the intensity of pain. VASs have been found to be highly reliable instruments for detecting immediate changes in pain level at rest (ICC = 0.97)[17–19].

The Cervical range of motion was measured using Cervical Range of Motion (CROM) device (Performance Attainment Associates, USA). Prior testing has shown the CROM device to be highly reliable with intra-rater reliability ranging from 0.91 to 0.95[20]. The CROM was measured three times. The mean of measurements were used for analysis purposes.

The CROM and subject’s pain level at rest (VAS ratings) were examined within each group. Additionally, comparisons were made between the thoracic manipulation, mobilization and control groups. Kolmogorov-Smirnov Goodness of fit tests were used to test the analysis of variance assumption of normality for the two response data sets. Paired t-tests were used to evaluate differences in the CROM and pain levels at rest, pre- and post-intervention within groups. An analysis of covariance (ANCOVA) was used to identify differences in CROM and pain level between groups after adjusting for differences in subject baseline values for each outcome measure. The criterion level of significance for this study was set at p<0.05.

RESULTS

Forty-two subjects were screened for the study. Of these persons, three persons did not meet the inclusion criteria. Consequently, 39 patients with chronic mechanical neck pain (10 males and 29 females) participated in the study. The mean (standard deviation) demographic data for the subjects are shown in Table 1. No differences were found for age, sex, weight, height and BMI between the study groups (p>0.05).

Table 2 presents descriptive statistics for all response measures for each subject group collected at pre-test, im-

Table 3. Results immediately after treatment

variables	Mean post adjusted			Con vs Man	Con vs Mob	Man vs Mob
	Con	Man	Mob	Mean difference (95%CI)	Mean difference (95%CI)	Mean difference (95%CI)
Active cervical range of motion						
Flexion (°)	56.57	62.87	62.51	6.30 (2.37–9.72)**	5.93 (2.15–9.72)**	−0.36 (−4.22–3.50)
Extension (°)	53.79	59.31	54.45	5.53 (1.30–9.75)*	0.70 (−3.79–5.19)	−4.83 (−9.28–0.38)*
Lift lateral flexion (°)	35.72	39.47	37.98	3.75 (0.01–7.48)*	2.26 (−1.54–6.06)	−1.49 (−5.30–2.32)
Right lateral flexion (°)	35.54	39.08	38.20	3.54 (0.33–6.74)*	2.22 (−0.80–6.12)	−0.88 (−4.23–2.47)
Lift rotation (°)	56.33	64.26	58.89	7.92 (3.68–12.17)**	2.56 (−1.74–6.86)	−5.37 (−9.68–31.05)*
Right rotation (°)	57.96	62.85	62.82	4.90 (−0.02–9.81)*	4.86 (−0.11–9.83)	−0.03 (−4.99–4.93)
Neck pain at rest						
VAS (mm)	39.37	37.51	36.66	−1.85 (−10.55–6.84)	−2.71 (−11.42–6.00)	−0.85 (−9.54–7.84)

*p<0.05, **p<0.01, Con = Control group, Man = Single thoracic manipulation group, Mob = Single thoracic mobilization group

Table 4. Results at the 24-hour follow-up

Variables	Mean post adjusted			Con vs Man	Con vs Mob	Man vs Mob
	Con	Man	Mob	Mean difference (95%CI)	Mean difference (95%CI)	Mean difference (95%CI)
Active cervical range of motion						
Flexion (°)	56.41	63.05	60.90	6.64 (2.41–10.87)**	4.49 (0.41–8.57)*	−2.15 (−6.31–2.01)
Extension (°)	52.43	56.67	52.53	4.24 (−0.75–9.22)	0.10 (−5.20–5.40)	−4.14 (−9.39–1.11)
Lift lateral flexion (°)	34.84	39.17	36.19	4.33 (0.84–7.83)*	1.35 (−2.21–4.91)	–2.98 (−6.55–0.59)
Right lateral flexion (°)	34.79	37.64	37.51	2.85 (−0.34–6.04)	2.72 (−0.72–6.17)	−0.13 (−3.36–3.21)
Lift rotation (°)	54.92	63.04	61.37	8.21 (2.98–13.27)**	6.46 (1.24–11.87)*	−1.67 (−6.90–3.57)
Right rotation (°)	58.27	61.56	63.53	3.29 (–2.22–8.79)	5.26 (−0.32–10.83)	1.57 (−3.59–7.53)
Neck pain at rest						
VAS (mm)	36.17	35.96	34.02	−0.21 (−9.99–9.57)	−2.15 (–11.94–6.65)	–1.94 (–11.72–7.84)

*p<0.05, **p<0.01, Con = Control group, Man = Single thoracic manipulation group, Mob = Single thoracic mobilization group

mediately following treatment and 24 hours after treatment. Paired t-test results revealed VAS ratings for subjects to significantly decrease for both the thoracic manipulation and mobilization groups (p<0.05). Subjects receiving thoracic manipulation significantly increased in CROM in flexion, extension, left and right lateral flexions, and left and right rotations (p<0.01) from baseline. These findings supported Hypothesis 1. In addition, subjects in the thoracic mobilization group significantly increased in CROM in flexion, left and right lateral flexions, and left and right rotations (p<0.05), but not in extension. These findings supported Hypothesis 2. There was no significant difference in CROM from baseline to post-intervention for the control group.

Comparison between groups using an analysis of covariance (ANCOVA) demonstrated no statistically significant difference in VAS ratings post-intervention. This finding was counter to our expectation. Regarding neck movement, the CROM for the thoracic manipulation group significantly increased in comparison to the control group in flexion, extension, left and right lateral flexion, and left rotation (p<0.05). The CROM for the thoracic mobilization group significantly increased in comparison to the control group in flexion only (p<0.01), but not in terms of extension and rotation. (These findings were also in-line with Hypothesis 2.). In addition, the CROM for the thoracic manipulation group significantly increased in comparison to the mobilization group in extension and left rotation (p<0.05) (Table 3).

Results at the 24-hour follow-up demonstrated VAS ratings significantly decreased for both treatment groups (p<0.05). With respect to CROM, subjects receiving thoracic manipulation significantly increased in flexion, extension, left and right lateral flexions, and left and right rotations (p<0.05). Furthermore, subjects receiving thoracic mobilization significantly increased in motion in right and left rotational directions (p<0.05). These findings were all in line with Hypothesis 3. There was no significant difference in the CROM for the control group.

Comparison between groups, using an ANCOVA demonstrated that there was no statistically significant difference in pain at rest between the three groups 24 hours after intervention. This finding was counter to our expectation. The CROM in the thoracic manipulation group significantly increased in flexion, left lateral flexion and left rotation in comparison to the control group (p<0.05). The CROM for the thoracic mobilization group significantly increased in flexion and left rotation by comparison with the control group (p<0.05). Both of these findings were in-line with

Hypothesis 3. There was no significant difference in the CROM between the thoracic manipulation and mobilization groups (Table 4).

Analyses on CROM in the extension direction revealed different effects for the treatment groups from pre-testing. The thoracic manipulation group showed a substantial increase in extension; whereas, the thoracic mobilization and the control groups showed only slight increases at immediate assessment and a decrease after 24 hours for the mobilization group.

DISCUSSION

The results of this study indicate patients with chronic neck pain immediately experienced a significant decrease in pain at rest after receiving thoracic manipulation and mobilization as well as an increase in CROM. These results supported our first and second hypotheses. In addition, observations made 24-hour after intervention indicate that patients with neck pain experienced a significant decrease in pain at rest and an increase in CROM in all directions after receiving thoracic manipulation. These results agreed with our third hypothesis. Results also indicated that patients significantly increased in CROM in left and right rotation 24 hours after receiving thoracic mobilization.

The findings of this study are in line with previous studies[14, 15]. The interventions demonstrated that thoracic manipulation and mobilization results in decreased pain and increased CROM in patients with neck pain. However, there are some limitations of the previous studies. Data was collected on patients in an acute and sub-acute stages of pain and a multiple level thoracic manipulation technique was used; whereas, in the current study, data was collected on patients in a chronic stage of pain (of 3 or more months duration) and a single level thoracic manipulation was used[14]. Prior studies employed a combination of thoracic spine thrust manipulation, electro-therapy, and thermal programs in patients with acute mechanical neck pain[15].

The neurophysiologic response of pain reduction through thoracic manipulation may be explained in terms of several mechanisms. One possible mechanism is that the manipulation induces a reflex inhibition of pain or muscle relaxation reflex by modifying the discharge of proprioceptive Group I and II afferents. This may also improve spine mobility[21]. A second mechanism is that the spinal manipulation activates descending inhibitory mechanisms resulting in pain reduction in distant areas from the manipulation. Through these mechanisms, the thoracic manipulation may induce ventral periaqueductal gray (vPAG) in the brain, which activates endogenous opioid peptides resulting in pain reduction in different areas[22–25]. Regarding the reduction in pain at rest between baseline ratings and the 24-hour follow-up for the control group, this may have been the results of overall relaxation and psychological change due to physical contact by a clinician[26, 27].

In addition, this study suggests that thoracic manipulation increases CROM. This effect may be explained by two mechanisms. Firstly, the thoracic manipulation may restore the normal biomechanics of the thoracic spine, decreasing mechanical stress and increasing the distribution of joint forces in the cervical spine[28]. Secondly, the thoracic manipulation may alter the biomechanics of the thoracic spine, which is related to the cervical spine[29, 30] and may affect the range of motion in the entire spine.

Results of this study also indicated that immediately after thoracic manipulation, the CROM significantly increased in comparison to the control group in terms of flexion, extension, left and right lateral flexion, and left rotation. Twenty-four hours after thoracic manipulation, CROM significantly increased in comparison to the control group in terms of flexion, left lateral flexion and left rotation. Furthermore, results from the current study also revealed significant increases in CROM in extension and left rotation immediately after treatment, when comparing the thoracic manipulation and thoracic mobilization groups. This finding may be due to the specific symptoms of the subjects who participated in the manipulation group. Nine of thirteen subjects (69.23%) revealed symptoms on their left side. Additionally, this may due to the CROM of the subjects at baseline in the manipulation group being less than the mobilization group. The CROM for the manipulation group in extension and left rotation was 48.51 and 53.33 degrees, respectively, while the mobilization group was 58.82 and 57.54 degrees, respectively. This may by a reason why the CROM for the manipulation group significantly improved in extension and left rotation when compared to the mobilization group.

This study demonstrated no statistically significant differences in pain at rest post-intervention (VAS ratings) among the control and the treatment groups. This finding differs from previous studies[13–15]. However, results do indicate that the level of pain at rest in patients who receive thoracic manipulation decreases more than in patients who do not. As previously mentioned, the studies involved subjects with acute to sub-acute mechanical neck pain (<3 months)[13–15]. The present investigation examined patients with chronic neck pain, who had symptoms more than 3 months in duration. Moreover, previous studies were performed with manipulation at several levels of the thoracic spine[13].

This study was limited to investigation of the immediate and short-term effects of single level thoracic manipulation on patients with chronic mechanical neck pain. Future studies should investigate the long-term effects of single level thoracic manipulation on patients with chronic mechanical neck pain. Since, the present study only investigated the effects of mobilization/manipulation at the T6-T7 vertebrae on pain at rest and CROM, future trials should also investigate the effectiveness of mobilization/manipulation at different levels of the thoracic spine in patients with chronic mechanical neck pain.

In summary, the subjects in this study reported reductions in pain at rest and increases in CROM in all movements of the cervical spine after single level thoracic manipulation at T6-T7 in patients with chronic mechanical neck pain. Single-level thoracic mobilization at T6-T7 for patients with chronic neck pain led to significantly reduced pain levels at rest and increased CROM (in some directions) by comparison with a control group. These effects were observed immediately and 24 hours after intervention. Additionally, the findings of this study demonstrated increases in CROM in extension and left rotation as immediate effects of manipulation versus mobilization treatments. However, this study did not find significant differences between the two techniques in pain level at rest immediately or 24 hours after intervention. The potential long-term effects of such interventions need to be further explored.

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