The immediate effects of thoracic transverse mobilization in patients with the primary complaint of mechanical neck pain: a pilot study

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Objective: Posterior-to-anterior (PA) vertebral mobilization to the thoracic spine has been studied as an intervention for neck pain. Our purpose was to explore effects of a different mobilization technique, transverse vertebral pressure, on cervical range of motion (ROM) and pain when applied to the thoracic spine among participants with neck pain.

Methods: A single-blinded quasi-experimental study with a one-group pretest–posttest design. A transverse group consisted of 21 participants whose neck pain increased with active movements. A non-intervention group of 20 asymptomatic participants was included simply to ensure rater blinding. The treatment group received Grades IV to IV+ transverse mobilizations at T1 through T4 bilaterally. Measurements taken immediately after intervention included pre/post cervical ROM, distant pressure pain threshold (PPT), and a numerical pain rating scale (NPRS). Analysis utilized *t*-tests and ordinal counterparts.

Results: The transverse group demonstrated significant gains in extension and bilateral rotation ($P \leq 0.005$) but not flexion or side-bend. A total of 57% of mobilized participants reported clinically meaningful decreased pain ($P < 0.001$). Seven participants exceeded the PPT MDC₉₅ of 0.36 kg/cm². The non-intervention group had no significant changes in ROM or NPRS scores.

Discussion: After 8 minutes of transverse mobilization to the upper thoracic spine, significant gains in cervical extension and bilateral rotation, and decreased pain scores were found. There were no adverse effects. Unlike other mobilization studies, PPT changes at a remote site were statistically but not clinically meaningful. Findings suggest that transverse mobilization would be a productive topic for controlled clinical trials.

Keywords: Transverse vertebral pressure, Thoracic mobilization, Neck pain

Introduction

There is increasing evidence from controlled trials that thrust techniques delivered at the thoracic spine are appropriate interventions for patients with primary complaints of neck pain. When groups receiving thoracic manipulation were compared with groups receiving alternative interventions or sham treatments, the manipulation groups had significant between-group gains in cervical range of motion (ROM),^{1–4} decreased scores on neck pain rating scales,^{1–5} and improvement in scores on neck disability questionnaires.^{1–3}

Unlike thrust techniques, few studies have explored the use of non-thrust thoracic mobilization to treat mechanical neck pain. The techniques selected for these studies have been central and unilateral posterior-to-anterior (PA) pressures. In a study by Dunning *et al.*,⁶ 51 patients with neck pain received the following protocol: one 30-second bout of Grade IV unilateral PAs to both the left and right of C1–2 motion segment and one 30-second bout of Grade IV central PAs to the T1–2 motion segment. The rationale for selecting a minimal dosage was that the study was designed to compare thrust versus non-thrust outcomes, and differences in the duration of the two approaches would avoid a confounding ‘attention effect’. From baseline to 48 hours later,

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scores on both the Neck Disability Index and the NPRS improved by 13%. Passive C1–2 rotation increased by 3.5° and 2.5°. It is not known what the outcome would have been if the mobilization durations were longer and the cervical level(s) were selected based upon examination findings, as would be more typical in clinical practice. In an earlier clinical trial by Cleland *et al.*,⁷ 30 patients with neck pain received a one-time thoracic treatment of Grade III or IV central PAs. These were delivered for 30 seconds each on the spinous processes of T1 through T6. Upon follow-up 2–4 days later, the mean decrease in the Neck Disability Index was 11% (5.5 points of 50) which did not exceed the minimally clinically important difference (MCID) of 14%; the decrease in NPRS was not clinically meaningful.

One non-thrust mobilization technique that, to our knowledge, has not been the topic of research is transverse vertebral pressure. As described by Maitland *et al.*,⁸ this technique is usually performed with the patient in the prone position, and oscillatory pressures are applied to the side of the spinous process in the frontal plane as if trying to glide the vertebra laterally. Because the spinous processes of the thoracic spine are so prominent, this technique appears to be particularly well-suited to this spinal region. Throughout this paper, we refer to this technique by the abbreviated term more commonly used in the clinic, ‘transverse mobilization’. Our primary intent was to explore the technique of transverse mobilization as a potentially useful topic for future controlled clinical trials. To that end, our specific purpose was to explore the immediate effects of thoracic transverse mobilization on cervical ROM and pain among participants with the primary complaint of neck pain.

Methods

Participants

As described in the Statistical Analyses section, sample size calculation yielded a requirement of 40 participants with neck pain. Recruitment was by convenience sampling via referrals from local physical therapists and flyers posted on a university campus. Participants qualified for either a transverse mobilization group or a non-intervention group. Inclusion criteria for the mobilization group were (1) age 18–60 years and (2) mechanical neck pain. Neck pain was defined as pain in the cervical region proper. Potential participants with suprascapular pain in addition to their neck pain were also accepted. ‘Mechanical’ neck pain was defined as neck pain exacerbated by movement. Our exclusion criteria were symptoms inferior to the suprascapular area, unexplained night pain, unexplained weight loss, numbness and tingling in the arms and/or legs,

balance or coordination problems, morning stiffness lasting greater than 1 hour, a history of whiplash injury within 6 weeks of treatment, diagnosis of osteoporosis, symptoms suggestive of nerve root compression, prior cervical or thoracic spine surgery, or a pending legal action. Inclusion criteria for the non-intervention group were (1) age 18–60 years and (2) asymptomatic neck and thoracic regions over the previous 6 years by participant report. In this pilot study, the latter group was labeled ‘non-intervention’ rather than ‘control’ because the sole purpose for inclusion was to assure blinding of the rater; it was not designed to provide a sham treatment group for comparison of therapeutic effect. The project was approved by the University of Puget Sound Institutional Review Board, and written informed consent was obtained from all the participants. The registration identifier at <http://clinicaltrials.gov> is NCT02028741.

Outcome measures

Outcomes of interest were active neck motion, pressure pain threshold (PPT), and report of pain. For active ROM, a single bubble inclinometer (MIE Inclinometer, Medical Research Ltd, London, UK) was used to measure flexion, extension, and side-flexion with the participants seated. Since measurement of rotation by inclinometer would introduce a change from the sitting position, a universal goniometer was chosen to measure rotation. de Koning *et al.*⁹ conducted a systematic review of seated cervical inclinometry. Inter-rater intraclass correlation coefficients (ICCs) varied from 0.81 to 0.94 for healthy participants and from 0.68 to 0.86 for those with neck pain. Among patients with mechanical neck pain, ICCs for cervical rotation using the universal goniometer in sitting have been reported as 0.77 to the right and 0.57 to the left.¹⁰ In order to consider a motion to have changed, we required statistical significance at ≤ 0.05 and a difference of $\geq 5^\circ$. Before commencing the study, one researcher participated in a training session followed by intra-rater reliability testing for all ROM measurements.

An 11-point numerical pain rating scale (NPRS) was used to assess pain before and after the intervention. In a cohort of 137 patients with neck pain, Cleland *et al.*¹¹ reported test–retest reliability as moderate (ICC=0.76; CI, 0.51–0.87). The MCID was a change of 1.3 points. Two studies have examined the relationship between NPRS scores and patient global impression of change (PGIC) scores in order to identify the clinically important difference.^{12,13} In a retrospective study of 2724 patients, a reduction of two points or a reduction of 30% on the NPRS was correlated with ‘much improved’ or ‘very much improved’.¹² In a prospective cohort study of 825

Figure 1 Position of researcher during transverse mobilization. Oscillation force was generated from the legs and transferred through the arms.

patients with chronic musculoskeletal pain, a reduction of one point, or a reduction of 15%, was associated with 'slightly better' and a reduction of two points, or a reduction of 33%, was associated with 'much better'.¹³ In our study, since the NPRS was scored in integers, we utilized the MCID standard of two points.

Pressure pain threshold, the minimum pressure that induces pain, was measured at the right lateral epicondyle using a hand-held digital algometer (Model FPX 25, Wagner Instruments, Greenwich, CT, USA). Good to excellent intra-rater, inter-rater, and test-retest reliabilities for PPT have been reported.^{14–18} Fernandez-de-las Penas *et al.*¹⁷ found ICC(1,3) values of 0.97 (95% CI, 0.93–0.98) and 0.94 (95% CI, 0.90–0.97), and Martinez-Segura *et al.*¹⁸ found ICC(3,1) values, which also ranged from 0.94 to 0.97. A minimal detectable change (MDC₉₅) value of 0.26 kg/cm² has been reported by Koo *et al.*¹⁹ using a manual algometer on the lumbar erector spinae muscles among healthy individuals. Prushansky *et al.*¹⁴ reported site-specific MDC₉₅ values ranging from 31.6 to 58.2 kPa (0.32–0.60 kg/cm²), which corresponded to a 17–33% change. In that study, three measurements were taken separated by 10-second intervals, and the mean of these trials was used for analysis. However, these authors noted a significant difference between raters, which prompted their recommendation that PPT measurements should be performed by the same rater when utilized as an outcome measure. We followed their

Figure 2 Overhead view of hand placement for transverse mobilization. One thumb abutted the lateral spinous process; the other thumb transferred pressure in a direction perpendicular to the midline of the spine.

measurement protocol. We also placed the algometer such that the PPT value was not visible to the participant. Regarding an MCID value, we did not find a commonly used standard value. In lieu of this, changes of 15–25% have been recommended as indicative of clinically important change.^{14,20} The finding by Sayed-Noor *et al.*²¹ of large inter-individual variability in PPT values when taken at the same anatomical site supports the use of percent change. For our study, a change in PPT value was considered to reach the MCID if it both exceeded the MDC and amounted to at least a 20% change from baseline.

Study protocol

After recruiting the two separate groups, baseline ROM and PPT scores were taken by one blinded rater, and all participants completed an NPRS. The mobilization group was treated with non-thrust transverse vertebral pressure as described by Maitland.⁸ The patient lay prone with arms to the side and head in a 'forehead rest position'.⁸ Mobilization was applied to spinal levels T1 through T4. The spinous process of T1 was identified by first locating C6 using the cervical extension method²² and then counting caudally. The researcher stood at the level of the vertebra to be mobilized on one side of the subject (Fig. 1). The pad of the researcher's non-dominant thumb was placed in contact with the lateral aspect of the spinous process of T1, whereas the dominant thumb was placed on the dorsal side of the other thumb (Fig. 2). Pressure was applied to the spinous process to produce small amplitude, low velocity oscillations into resistance to the end-range of the vertebra (Grades IV–IV+). This procedure was performed for 30 seconds, then sequentially applied to the next caudal level through T4. The same pattern of application was used on the participant's contralateral side. The entire procedure

Figure 3 Flow diagram of group recruitment and participation.

was repeated once again for a total of 8 minutes. This was followed by a repeat of the outcome measurements. The non-intervention group received no treatment. Each non-intervention participant assumed the same prone position for 8 minutes, as was used with the mobilization group, and outcome measurements were repeated. The researcher performing the outcome measurements was blinded to group assignment. All participants were clothed such that no localized residual evidence of thoracic manual contact was visible (Fig. 3).

Statistical analyses

Our sample size calculation for a single group paired *t*-test was based upon detecting a moderate effect ($d=0.50$) in parametric outcome data using a one-tailed test, an alpha level of 0.05, and a desired power

of 0.70.²³ This estimate was then adjusted for the NPRS outcome data. When an ordinal analog of the *t*-test is used for sample size estimation, it has been suggested that power is reduced to 95.5% of the *t*-test power.²⁴ This correction increased the required number of mobilization participants to 40.

Data were analyzed with SPSS, Version 14.0 (SPSS, Inc, Chicago, IL, USA). We compared pre-intervention data between the transverse mobilization group and the non-intervention group utilizing independent *t*-tests for ROM and PPT, and the Mann–Whitney test for NPRS scores. We compared pre- and post-session measurements within each group utilizing paired *t*-tests for ROM and PPT, and the Wilcoxon signed-rank test for NPRS scores. *Post hoc* power analyses were performed using G*Power 3.1.7 (Heinrich Heine University of Dusseldorf, Germany).²⁵

Table 1 Baseline data for non-intervention and mobilization groups*

Variable	Group	Mean $\pm$ SD	Test value	P-value
Age (years)	Non-intervention	25.4 $\pm$ 5.5	1.4(39) [†]	0.074
	Mobilization	29.9 $\pm$ 13.4		
Gender (female)	Non-intervention	<i>n</i> =18		
	Mobilization	<i>n</i> =14		
Flexion (°)	Non-intervention	56.7 $\pm$ 10.1	2.4(39) [†]	0.023
	Mobilization	47.8 $\pm$ 13.5		
Extension (°)	Non-intervention	73.1 $\pm$ 11.0	2.1(39) [†]	0.044
	Mobilization	64.5 $\pm$ 14.9		
R lateral flexion (°)	Non-intervention	47.0 $\pm$ 8.6	1.4(39) [†]	0.166
	Mobilization	43.1 $\pm$ 8.6		
L lateral flexion (°)	Non-intervention	46.5 $\pm$ 8.0	2.9(39) [†]	0.006
	Mobilization	29.9 $\pm$ 13.4		
R rotation (°)	Non-intervention	70.2 $\pm$ 8.3	1.9(39) [†]	0.067
	Mobilization	65.0 $\pm$ 9.3		
L rotation (°)	Non-intervention	62.7 $\pm$ 8.4	1.3(39) [†]	0.208
	Mobilization	58.7 $\pm$ 11.3		
PPT (kg/cm ²)	Non-intervention	3.66 $\pm$ 1.1	−0.9(36) [†]	0.383
	Mobilization	4.02 $\pm$ 1.52		
NPRS (out of 10)	Non-intervention	0 $\pm$ 0	<i>Z</i> = −5.86 [‡]	<0.001
	Mobilization	3.8 $\pm$		

PPT: pressure pain threshold; NPRS: numerical pain rating scale.

*Mobilization *n*=21; non-intervention *n*=20.

[†]Independent *t*-test value (degrees of freedom (df)).

[‡]Mann-Whitney test.

Emboldened data indicate significance of ≥ 0.05 .

Results

The mobilization group included 21 participants, 71% female, with a mean age of 30. The non-intervention group included 20 participants, 90% female, with a mean age of 25. Demographic data are presented in Table 1. One participant was screened and accepted for treatment but displayed extreme tenderness to superficial touch over the entire thoracic back region. She declined intervention and was analyzed by intention to treat.

Prior to data collection, high intra-rater reliability of cervical ROM measurements was demonstrated with all ICCs over 0.90. A baseline comparison of outcome measures between the two groups revealed that the neck pain group entered the study with significantly decreased cervical flexion, extension, and left side-bend, and increased NPRS as compared to the asymptomatic group (Table 1).

As presented in Table 2, the non-intervention group demonstrated no statistically significant changes in any of the outcome measures except PPT following 8 minutes of prone lying. The MDC₉₅ value for this group was 0.21 kg/cm².

For the neck pain group, a comparison of the outcome measurements before and after 8 minutes of transverse mobilizations is presented in Table 3. Statistically significant increases in ROM for cervical extension and bilateral rotation were found. Gains in left side-bend, which was the other cervical motion found to be restricted when compared to the non-intervention group, were statistically significant at *P*=0.014 but did not meet our requirement of a difference of 5° or greater. A total of 52% of mobilized participants reported clinically meaningful decreases in pain on the NPRS. All scores decreased by at least one point with the exception of one participant. That

Table 2 Non-intervention group outcome measures before and after 8 minutes positioned in prone (*n*=20)

Variable	Pre-positioning mean $\pm$ SD	Post-positioning mean $\pm$ SD	Test statistic	P-value
Flexion (°)	56.7 $\pm$ 10.1	56.9 $\pm$ 9.6	0.117 (19)*	0.908
Extension (°)	73.1 $\pm$ 11.0	74.4 $\pm$ 12.9	0.737 (19)*	0.470
R lateral flexion (°)	47.0 $\pm$ 8.6	47.5 $\pm$ 8.8	0.569 (19)*	0.576
L lateral flexion (°)	46.5 $\pm$ 8.0	47.0 $\pm$ 7.7	0.567 (19)*	0.577
R rotation (°)	70.2 $\pm$ 8.3	72.4 $\pm$ 8.7	2.02 (19)*	0.058
L rotation (°)	62.7 $\pm$ 8.4	65.4 $\pm$ 8.3	1.769 (19)*	0.093
PPT (kg/cm ²)	3.66 $\pm$ 1.1	3.58 $\pm$ 1.1	2.233 (19)*	0.038
NPRS (0–10)	0.0 [†]	0.0 [†]	<i>Z</i> = 0.000 [‡]	1.0

PPT: pressure pain threshold; NPRS: numerical pain rating scale.

*Paired *t*-test absolute value; df in parenthesis.

[†]Mean, median.

[‡]Wilcoxon signed-rank test.

Emboldened data indicate significance of ≥ 0.05 .

score changed from 3 to 4, which did not exceed the established MCID. Changes in PPT values were statistically significant. Seven of the participants had values that exceeded the 0.36 kg/cm^2 MDC₉₅ value for this group. None reached the level of the MCID.

Discussion

In the manual therapy literature, inter-regional changes resulting from mobilization have often been attributed to neurophysiologic effects. Our findings support this explanation in several ways. It is improbable that mobilization forces introduced at the thoracic spine produced simultaneous, inadvertent rotation of the cervical segments. Since all participants were positioned prone on treatment tables with openings for the face, the cervical spine was essentially stabilized in a neutral position throughout the intervention. Even without this stabilization, direct movement of the cervical segments via thoracic mobilization would surpass the force used when correctly delivering a Grade IV+ mobilization. It is also improbable that the reduction in NPRS scores after thoracic mobilization occurred because the cervical pain was thoracic in origin. Of the 21 people with neck pain, the majority did not have symptoms extending to the suprascapular region. Of those who did, no symptoms were distal to the region that is considered the provenance of the C4 and, to a lesser extent, C5 dermatomes, myotomes, and sclerotomes. Taken together, we reasoned that the improvements in cervical ROM and pain were consistent with a neurophysiological mechanism.

In terms of PPT, our MDC₉₅ value of 0.36 kg/cm^2 at the elbow was similar to other site-specific reports at the lateral epicondyle. Villafane *et al.*²⁶ reported a standard error of measurement of 0.44 kg/cm^2 at the lateral epicondyle. Following cervical manipulation among patients with lateral epicondylalgia, Fernandez-Carnero *et al.*²⁷ reported MDC values of 0.24 and 0.27 kg/cm^2 at the involved and uninvolved elbows, respectively. At pre-intervention baseline, we found no

statistical difference in PPT between participants with and without neck pain.

After an extensive search of the literature, we were unable to find a standard MCID value for PPT, either site-specific or general. We settled, instead, on a 20% change from baseline PPT. Using this criterion, our increase of 4.7% exceeded the MDC value but did not reach clinical significance. Our findings differed from some other non-thrust mobilization studies in which larger PPT changes did occur at distant sites. For instance, two reports by the team of Willett *et al.*^{28,29} involved three, 1-minute bouts of central PA mobilizations to the lumbar spines of 30 asymptomatic subjects. The ensuing PPTs were measured at four sites in the upper and lower quadrants. The average percent change ranged from 11.0 to 21.8²⁸ and from 11.6 to 16.6.²⁹ These authors concluded that non-thrust mobilization had a systemic hypoalgesic effect even among asymptomatic participants. The explanation for our contradictory findings may be as simple as a limited sample size. In reviewing studies that included both PPT and pain scales, it is interesting that the two are not necessarily correlated.²¹ Martinez-Segura *et al.*¹⁸ stated ‘... because the MCID for PPTs has not been established, it is not possible at this stage to determine the clinical relevance of changes in PPTs’.

In clinical practice, manual therapists often start with a single technique during the first few patient visits in order to assess its value with a minimum of confounders. Techniques are then modified, added, or discarded based upon individual patient responses. Transverse mobilization is a versatile technique that can be applied to any spinal region in which the spinous processes are prominent enough to allow a lateral purchase for the thumb. In view of the growing evidence in the literature on the value of thoracic manual therapy for treating neck pain, we selected the upper thoracic spine as the site of application. This region had several advantages. First, the spinous processes were markedly palpable. Second,

Table 3 Transverse group outcome measures before and after 8 minutes of transverse thoracic vertebral mobilization (n=21)

Variable	Pre-mobilization mean $\pm$ SD	Post-mobilization mean $\pm$ SD	Test statistic	P-value
Flexion (°)	47.8 $\pm$ 13.5	51.0 $\pm$ 13.0	1.853 (20)*	0.079
Extension (°)	64.5 $\pm$ 14.9	71.2 $\pm$ 15.0	4.964 (20)*	<0.001
R lateral flexion (°)	43.1 $\pm$ 8.6	44.2 $\pm$ 8.8	1.301 (20)*	0.208
L lateral flexion (°)	39.4 $\pm$ 7.4	42.1 $\pm$ 6.8	2.694 (20)*	0.014
R rotation (°)	65.0 $\pm$ 9.3	70.0 $\pm$ 9.9	3.140 (20)*	0.005
L rotation (°)	58.7 $\pm$ 11.3	63.9 $\pm$ 11.3	3.583 (20)*	0.002
PPT (kg/cm ²)	4.02 $\pm$ 1.52	4.21 $\pm$ 1.58	3.334 (20)*	0.003
NPRS (0–10)	3.81, 3 [†]	2.10, 2 [‡]	$z = -3.821$	<0.001 [§]

PPT: pressure pain threshold; NPRS: numerical pain rating scale.

*Paired *t*-test absolute value; df in parentheses.

[†]Mean, median with range 1–8.

[‡]Mean, median with range 0–5.

[§]Wilcoxon signed-rank test.

Emboldened data indicate significance of ≥ 0.05 .

this region provided a pragmatic alternative to direct contact with the cervical spine among patients whose tissues exhibited an irritability component.

Our study had a number of limitations. The most significant concern was in the limitations imposed by the design. This was a one-group pilot study. Our 'non-intervention' group had no neck pain and was only there to blind the rater. It was not a randomized trial, so we lacked the authority to make cause and effect claims about treatment effectiveness. A second prominent limitation was the small sample size. Since the conventional minimum number of participants required to apply the concept of standard deviation is 20, it may be specious to make any claim about power in our study. With this caveat, we performed a *post hoc* power calculation. For the parametric data, effect sizes varied from smallest values of 0.28 and 0.30 for right side-bend and flexion, respectively, to largest values of 0.78 and 1.05 for left rotation and extension, respectively. Pressure pain threshold values did not approach a normal distribution, thus were not included in the power calculations. Using an alpha of 0.05 and a two-tailed test in the power calculations for the paired *t*-tests, power ranged from lows of 24 and 26% for right side-bend and flexion, respectively, to highs of 92 and 99% for left rotation and extension, respectively. For the NPRS scores, calculation using the Wilcoxon signed-rank test (one sample case) rendered an effect size of 1.02 and a power of 99%. When planning for this study, our rationale for accepting an anticipated low power stemmed from the nature of pilot studies. Our intent was to explore a technique that is routinely used in patient care by physical therapists, but has been largely ignored in the manual therapy literature. Findings from our small sample draw attention to transverse mobilization as a suitable choice for further study, especially since there were no adverse effects.

In conclusion, Maitland's technique of transverse vertebral pressure has been largely overlooked as a topic for outcome studies. After performing 8 minutes of this non-thrust mobilization technique to the upper thoracic spine, a significant increase in cervical extension and bilateral rotation, and a clinically meaningful decrease in neck pain were noted. At a remote site, we found changes in PPT that exceeded the MDC benchmark but not our criteria for an MCID. There were no adverse outcomes. Transverse thoracic mobilization may be appropriate to incorporate in a treatment plan for patients with a primary complaint of neck pain, especially when there is a cervical irritability component or when thrust techniques are not indicated.

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Ethics approval The study protocol was approved by the University of Puget Sound Institutional Review Board.

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