The effect of direction specific thoracic spine manipulation on the cervical spine: a randomized controlled trial

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ABSTRACT

Objectives: To determine the difference on neck outcomes with directional manipulation to the thoracic spine. There is evidence that thoracic spine manipulation is effective in treating patients with neck pain. However, there is no research that determines if the assessment of directional hypomobility and the selection of thrust direction offer improved outcomes.

Methods: A total of 69 patients with cervical spine pain were randomly assigned to receive either a manipulation that was consistent with their thoracic spine motion loss (matched) or opposite their motion loss (unmatched). The patient was given care consistent with the orthopedic section guidelines for neck pain and the physical therapist's clinical reasoning. Baseline outcome measures (NPRS, NDI, GROC) were taken and reassessed two days and two weeks after treatment.

Results: Both groups had positive results when pain, neck disability index, and global rating of change were assessed. There was no difference between the matched and unmatched groups.

Discussion: Directional manipulation of hypomobile thoracic spine segments may not be required to improved outcomes in patients with neck pain. Future studies should assess a variety of factors when determining the best available treatment, including manual therapy procedures, exercise, and patient selection.

Level of Evidence: 1b.

KEYWORDS

Thoracic spine; thoracic spine manipulation; neck pain

Introduction

The use of thoracic spine manipulation for patients with mechanical neck pain has been well reported in the literature and is advocated by authors of current treatment guidelines.[1–4] Citing the concept of regional interdependence when treating the thoracic spine, the resulting neurophysiological and mechanical effects appear to produce positive changes in the cervical spine.[5,6] Several studies have found that thoracic spine manipulation can increase cervical spine range of motion when reassessing the patient immediately or in the short-term after treatment.[3,7–13] There is less evidence these outcomes remain significant in the medium-term, when follow-up is at least two weeks after the initial assessment.[14,15]

There is also agreement that treating the thoracic spine will have immediate and short-term positive effects on neck pain.[8,10,11,13,14,16–22] Similar to other outcomes, the longer term effects on neck pain are not well documented.[14]

There does not appear, however, to be consensus in the change in other outcome measures, as their results

have varied.[14,16,17,21–23] Measures such as neck disability index (NDI) or global rating of change scale (GROC) are often not included.

An initial review of the research in 2009, focusing on thoracic spine manipulation's overall benefits, advocated for additional research on symptomatic patients and longer term follow-up.[3] A second review in 2011, centering on patients with neck pain, concluded that optimal treatment parameters were not clear, longer term results were not certain, and there was a need for more randomized controlled trials by a variety of authors to allow for a more generalized set of findings.[2] A more recent review comparing thoracic spine mobilization to manipulation in patients with mechanical neck pain recommended longer term follow up, multicenter trials, and comparing techniques.[4]

Additional research has been completed utilizing randomized controlled trials comparing cervical manipulation and thoracic manipulation for patients with neck pain. When compared to thoracic spine manipulation in patients with a primary complaint of neck pain, Puentedura achieved positive results with cervical

manipulation based on pain localization and detection of perceived joint hypomobility.[24] The selection of the thoracic spine techniques used was consistent with the selection used in developing a clinical prediction rule.[25] Thoracic spine hypomobility was not assessed and there was no focus on a specific segment or location. Although patients showed improvement using the clinical prediction rule described in this study, the rule was later shown to be invalid.[16]

Martinez-Segura found similar changes in outcomes comparing cervical and thoracic spine manipulation in patients with bilateral chronic neck pain.[18] The cervical spine manipulation was directed based on pain location and detection of perceived joint hypomobility, whereas when the thoracic spine manipulation was performed, no specific segment was targeted. It is not apparent why these authors applied their cervical manipulation to a hypomobile segment, but did not apply the same clinical reasoning to the treated thoracic spine levels.

Few comparisons of thoracic spine manipulation techniques for neck pain have been completed, and the results have varied. In one study, no immediate differences in outcomes were noted between a prone and a supine technique targeting the fourth thoracic vertebrae.[26] With each technique, no initial assessment of hypomobility was completed. Conversely, a supine thrust targeted to the most hypomobile thoracic segment was shown to have a greater effect on decreasing immediate pain and increasing cervical range of motion than a seated distraction technique applied with no specific target.[11] Similarly, motion improvements were produced in healthy individuals when segmental thoracic spine stiffness was assessed before and after a targeted supine manipulation.[27] The treated segment had greater motion and demonstrated greater mechanical effects than the adjacent areas. The authors concluded that this change was detectable with posterior–anterior (PA) assessments immediately after the manual intervention, and suggested a positive benefit to targeting a specific thoracic spine segment.

Based on the aforementioned findings, we developed a randomized controlled trial to address some of the shortcomings found in the current body of research. Specifically, there is a lack of longer term randomized controlled trials comparing specific thoracic spine techniques and their effect on neck pain, and evidence suggests a possible benefit to targeting a specific area of the thoracic spine in patients with neck pain. The objective of our research was to determine if there were short and medium-term (two week) differences in cervical spine outcomes when a directional manipulation was performed at an identified hypomobile thoracic spine motion segment in patients with neck pain.

Methods

Subjects

Subjects were 18–60 years of age with a primary complaint of mechanical neck pain who sought outpatient physical therapy treatment between September 2013 and January 2015 at one of five physical therapy providers. Patients with ‘red flags’ for serious pathology (infection, osteoporosis, possible or confirmed fracture, etc.), as well as prior neck surgery or signs of cervical nerve root involvement (loss of two of three of: strength, sensation, and/or reflexes), were excluded.

This study was approved by Chatham University Institutional Review Board before recruitment and treatment was initiated. This study was registered with clinicaltrials.gov (NCT01917071).

Following the initial baseline examination and provided the aforementioned inclusion/exclusion criteria were met, the physical therapist (PT) asked the patient if he/she were interested in participating in a research project. If the patient was interested, he/she was given a description of the study and an informed consent to read and sign prior to the remainder of the initial PT examination.

Physical therapists

Eight PTs with a mean age of 43.3 and average patient care experience of 18.1 years collected data for this trial. Four had advanced master’s degrees, three had obtained their DPT degree, and one completed a DSc. Five of the eight PTs had advanced certifications in manual therapy beyond their obtained degree. The PTs were spread across seven independent PT treatment facilities in five states (Pennsylvania, New Jersey, New York, Indiana, and Oregon) and two countries (United States and Germany).

Examination procedures

Standard demographic and historical data were collected. Prior to group randomization, patients completed self-report measures and were evaluated by a licensed PT. Patients completed a NDI, which is scored from 0 to 50, with higher scores correlating with greater disability. This outcome measure has been shown to be valid and reliable in patients with mechanical neck pain.[28–31] The minimal detectable change (MDC), which notes the minimum amount of pain change in a patient that is not a result of measurement error, has been suggested to be five points when using a 50-point scale.[32]

A body diagram and a numeric pain rating scale (NPRS) were also completed.[33] The NPRS has good sensitivity and is scored from 0 to 10, with higher numbers indicating greater pain.[34,35] The suggested MDC is three points or a 27% decrease.[36]

Figure 1. Thoracic spine extension. (Source: Author).

Figure 2. Thoracic spine flexion. (Source: Author).

Assessment

The PTs carried out their standard clinical examination for each subject, including an assessment of thoracic spine mobility. While the subject lay prone, the PT used posterior to anterior (PA) passive accessory intervertebral

motions (PAIVM) applied with the heel of the hand to the spinous process to determine the most hypomobile vertebral motion segment.[37,38] Pain and symptom reproduction were not considered because the patients' complaints were located in the neck. Next, the PT stood at the patient's side as the patient was sitting, while palpating the hypomobile motion segment and assessed the directional mobility in both flexion and extension.[39,40] The PT determined if the hypomobility of the motion segment was more apparent in flexion or extension.

Randomization

Subjects were randomly assigned to receive manipulation in supine to the thoracic spine, that either corresponded to their motion limitation at the hypomobile segment (matched), or was opposite their movement limitation (unmatched). Group allocation was randomly completed by providing the PT with an opaque envelope denoting the assigned group, either matched or unmatched, which had been randomly assigned. Their exam and treatment was then performed.

Interventions

Patient setup

Prior to manipulations, subjects were positioned in supine, with knees flexed, hands grasped behind the neck, and elbows in front of the face. An alternate position allowing the patients to hug themselves, so that the elbows obtained the same approximate position, was permitted when required for patient comfort. The PT then rolled the patient toward them and placed his/her hand at the inferior vertebrae of the thoracic spine motion segment that was determined to be hypomobile.[41]

Flexion manipulation

After the above setup procedure, the patient was rolled into supine in slight flexion. The PT then asked the patient to partially sit up, while maintaining their flexed position (Figure 1). When the PT perceived contact on his/her hand, the patient's position was stabilized and he/she was asked to take a breath in and a long breath out. At the end of the breath, the PT applied a downward and upward force (toward the patient's glenohumeral joints) as the hand positioned on the patient's spine pulled inferiorly in an attempt to flex the targeted vertebral segment.[41]

Extension manipulation

Again after the above setup procedure, the patient was rolled into supine in a moderate amount of flexion. The PT then slowly controlled the patient back toward the table (such that the thoracic spine was moving into extension) until there was pressure on the PT's stabilizing

hand (Figure 2). At that point, the patient was asked to take a breath in and take a long breath out while the PT applied a downward and upward force (toward the patient's glenohumeral joints) as the hand positioned on the patient's spine pushed superiorly in an attempt to extend the targeted vertebral segment.[41]

Subjects were then instructed to maintain their motion with a series of home exercises. The PTs provided pragmatic therapeutic exercise, education, postural correction, and modalities based on clinical reasoning and patient presentation, as recommended in the Orthopedic Section of the American Physical Therapy guidelines for the treatment of neck pain.[1] Each patient received appropriate, individualized exercises based on these guidelines, such that not all exercise programs were identical.

Follow-up

All subjects were scheduled for follow-up two days after their initial treatment.[42] Prior to seeing the PT, they were asked to complete a NDI, NPRS, and GROC to determine the status of their neck pain. The GROC is commonly used in clinical research for patients with neck pain and allows the patient to self-select which improvements they believe are most important.[43,44] The GROC ranges from -7 (much worse) to $+7$ (much better), with a middle point of 0 , which indicates no change.[42] It has been suggested that GROC values of $4-5$ represent moderate change, while $6-7$ indicate a large change. The same manipulative procedures were then performed and appropriate treatment completed. Since the assessment was completed recently, we did not reassess the patient at this time. No immediate reassessment was completed because the positive immediate effects of manipulation are well documented.

A second follow-up was made two weeks after the initial treatment. In the same fashion, prior to seeing the PT, patients were asked to complete an NDI, NPRS, and GROC to determine the status of their neck pain. At this point the data collection was finished and the PTs continued treating the patients, as they deemed appropriate. Throughout the course of the study, we lost 12% of patients due to failure to continue with their PT appointments.

Statistical methods

Summary measures (descriptive statistics and basic hypothesis tests) across treatment groups (matched vs. unmatched) were obtained to assess any possible baseline differences in study variables. Fisher's Exact Test was used when comparing the two groups across categorical variables. For numeric outcomes, either a two-sample t -test or the Mann-Whitney U test was used, the latter when data were not normally distributed. Normality was assessed graphically and via sensitivity analyses comparing the p -values from the t - and Mann-Whitney tests.

Additionally, plots of means of each outcome (pain, neck disability and global rate of change) over time and across groups (all, matched, unmatched) were constructed to help visualize patterns in the data.

Subsequent analyses addressed the outcome variables across treatment groups (matched or unmatched) at single points in time: two days or two weeks after treatment. Two-sample t - or Mann-Whitney U tests were again used as appropriate (i.e. depending on whether or not normality could be reasonably assumed met).

Lastly, mixed-models were used to assess possible interactions between treatment group and time, as well as the main effects for treatment and time. An unstructured correlation matrix was used in all cases, as there weren't many repeated measures (thus this structure didn't require many degrees of freedom to estimate its parameters) and a sensitivity analyses gave consistent results despite the correlation structure assumed. Analyses were conducted in R version 3.1.2 and in SAS/STAT[®] software version 9.3.

Standardized effect sizes were calculated to compare the difference in change in pain (NPRS), neck disability (NDI), and GROC between the two treatment groups (matched and unmatched) over time.[45]

For NPRS and NDI, the changes in each were calculated for all combinations of follow-up time: (1) two days post-treatment – baseline, (2) two weeks post-treatment – baseline and (3) two weeks post-treatment – two days post-treatment. For GROC, which is itself a measure of change and thus only collected at two days and two weeks post-treatment, this comparison was only done for case (3) above.

Results

There were no significant differences across treatment groups (matched/unmatched) at baseline (all p -values greater than $\alpha = 0.05$) (Table 1). Therefore, it was concluded randomization was successful and there was no evidence of heterogeneity between subject groups at baseline.

Over time, the outcomes (pain, NDI, GROC) improved for the entire sample (all subjects taken together), as well as for the matched and unmatched groups separately (see mean values in Table 2 and Figure 3). Within a given outcome, the effect of time for all three groups (all subjects, matched, and unmatched) followed the same trajectory (Figure 3). Results from the mixed-model show time were indeed a significant predictor of each outcome (third column of Table 3).

Table 4 gives the effect sizes for the change in a given outcome at each relevant point of follow-up. All effect sizes were weak (approximately or less than 0.3 in magnitude).

Lastly, the study indicated none of the outcomes were affected by treatment. This is first illustrated in the

Table 1. Summary measures and tests of variables at baseline.

	All subjects	Matched	Unmatched	p-value
Sample size (<i>n</i> (100% of <i>n</i>))	69 (100%)	34 (49.27%)	35 (50.72%)	-
Age (mean years (SE))	38.72 (1.63)	39.92 (2.37)	37.57 (2.44)	0.349
Female (count (% of <i>n</i>))	54 (78.3%)	26 (37.7%)	28 (40.6%)	0.777
Physical therapist (count (% of <i>n</i>))				0.673
1	15 (21.7%)	7 (10.1%)	8 (11.6%)	
2	4 (5.8%)	3 (4.3%)	1 (1.4%)	
3	6 (8.7%)	4 (5.8%)	2 (2.9%)	
4	2 (2.9%)	1 (1.4%)	1 (1.4%)	
5	7 (10.1%)	4 (5.8%)	3 (4.3%)	
6	12 (17.4%)	3 (4.3%)	9 (13.0%)	
7	14 (20.3%)	7 (10.1%)	7 (10.1%)	
8	9 (13.0%)	5 (7.2%)	4 (5.8%)	
Pain (NPRS) (mean (SE))	4.54 (0.22)	4.50 (0.29)	4.57 (0.35)	0.937
Neck disability index (NDI) (mean (SE))	30.55 (1.35)	30.97 (2.13)	30.14 (1.71)	0.857

Table 2. Outcomes at baseline evaluation, two days post-treatment, and two weeks post-treatment.

	All subjects	Matched	Unmatched	p-value
<i>Pain (NPRS) (mean (SE))</i>				
Baseline	4.54 (0.22)	4.50 (0.29)	4.57 (0.35)	0.937
Two days post-treatment	3.17 (0.23)	3.38 (0.33)	2.97 (0.33)	0.306
Two weeks post-treatment	1.94 (0.20)	2.06 (0.28)	1.83 (0.30)	0.407
<i>Neck disability index (NDI) (mean (SE))</i>				
Baseline	30.55 (1.35)	30.97 (2.13)	30.14 (1.71)	0.857
Two days post-treatment	22.48 (1.37)	24.26 (2.03)	20.74 (1.84)	0.438
Two weeks post-treatment	15.01 (1.26)	16.38 (1.86)	13.69 (1.69)	0.304
<i>Global rating of change (GROC) (mean (SE))</i>				
Two days post-treatment	2.97 (0.30)	2.76 (0.41)	3.17 (0.43)	0.342
Two weeks post-treatment	4.36 (0.25)	4.41 (0.33)	4.31 (0.38)	0.884

basic analyses reported in Table 2: for each outcome, the *p*-values comparing the matched and unmatched groups at two days or two weeks post-treatment were always greater than $\alpha = 0.05$. Subsequently, Table 3 shows the results of the mixed-model, which takes into account treatment and time simultaneously. No time-by-treatment interactions were observed (never significant in any model), and the treatment main effect was also not significant for any outcome, whether the interaction term was in the model or not.

In conclusion, both the matched and unmatched groups improved over time, but there was no significant difference in the amount of improvement between treatment groups. Matching of directional mobilization appears to have had no effect on the outcomes tracked.

Discussion

The results of this study demonstrate that although specific manipulation of the thoracic spine had positive effects on neck outcomes, the direction of thrust applied to the identified hypomobile motion segment did not make a significant difference on the measured outcomes in our patient population. The results for NPRS as well as NDI met the proposed MDC for neck pain suggesting a positive treatment effect. The GROC values after two weeks correlated to a moderate level of change for the entire sample.

This study shows that when placing a patient into a treatment group that might, from a biomechanical construct perspective, move a specific motion segment further away from its limitation, patients still improve. While we acknowledge that finding a dysfunctional segment using PA assessment is a common technique whose validity remains unclear, thoracic spine manipulation was indicated in our subjects because they had neck pain.[46–48] However, manipulation to the vertebrae identified as most hypomobile did produce positive results. We did not compare these techniques to others within our sample, so no other conclusions can be drawn.

The treatments in this study produced positive short and medium-term (two weeks) results in outcomes in both the matched and unmatched group (i.e. regardless of the direction of thrust). Our results suggest it may be simply the movement of the hypomobile joint that has beneficial properties for the patient, possibly supporting a neurophysiological effect.[49,50] More information about a patient's history and subsequent exercise prescription would be needed to determine if a directional preference existed for therapeutic exercise. Since only the direction of the manual therapy intervention was controlled in this trial, conclusions cannot be drawn concerning other factors such as exercise.

Limitations

We acknowledge limitations in this research. We did not attempt to provide a prescriptive set of exercises or treatments for the subjects. We believed there were too many variables for each patient that would make a prescriptive treatment and exercise approach untenable. In addition, no agreement currently exists regarding the most effective exercise approach for patients with neck pain. Even though our prescription and treatment was based on the current guidelines of the orthopedic section of the APTA, we acknowledge that considerable variations between PTs may have been applied.

In addition, although there was an educational component to the intervention to help achieve consistency across treatment from each PT, we acknowledge that subtle variations in technique and personal interactions

Figure 3. (A) Mean pain, (B) mean NDI, and (C) mean global rate of change over time, by group.

Table 3. Results of mixed-models (unstructured correlation) for outcomes of interest over time and treatment assignment (matched vs. unmatched). The p-value for each term in the model is reported.

	Time*Treatment	Treatment	Time
Pain (NPRS)	0.588	0.585	<0.0001*
Neck disability index (NDI)	0.387	0.319	<0.0001*
Global rating of change (GROC)	0.347	0.751	<0.0001*

*Significant with $\alpha = 0.05$.

between PT and patient may have influenced outcomes. [51] Since five of our eight PTs had advanced training, our results may not be applicable to all PTs.

Although a randomized controlled trial was conducted, there is some chance not all variables were completely balanced across treatment groups. It is plausible symptom duration and psychological factors may have differed, for example. However, as the results in Table 1

show, none of the variables measured were significantly different at baseline. This is evidence that randomization indeed worked and thus we have no reason to believe it wasn't successful for other, unmeasured potential confounders.

We additionally note our results may only apply to patients who fall within our inclusion and exclusion criteria. We did not further define our patients by differentiating between acute and chronic pain, primary diagnosis, or whether the patient's neck pain may have been a primary injury or compensatory in nature.

Finally, this research was not double-blinded since the treating PTs were aware of their patients' group assignment (out of necessity, so they could be treated). However, patients completed the outcome measures without the PT present and returned them to the clinic staff. In this manner, we believe we eliminated any influence on our outcome measures from the treating PT.

Table 4. Effect sizes comparing treatment groups with respect to the change in a given outcome at each follow-up time, as relevant. Calculated as: [(Mean change in the outcome in the matched group) – (Mean change in the outcome in the unmatched group)]/(Pooled standard deviation of change in the outcome across all participants), where ‘the outcome’ is each of NPRS, NDI, and GROC, in turn.

	Effect size
Pain (NPRS)	
Two days post-treatment – Baseline	0.249
Two weeks post-treatment – Baseline	0.140
Two weeks post-treatment – Two days post-treatment	–0.099
Neck disability index (NDI)	
Two days post-treatment – Baseline	0.330
Two weeks post-treatment – Baseline	0.175
Two weeks post-treatment – Two days post-treatment	–0.101
Global rating of change (GROC)	
Two weeks post-treatment – Two days post-treatment	0.228

Conclusion

Future studies may allow researchers to make use of patients’ history, occupation, posture, and joint mobility in order to effectively treat the thoracic spine for patients with neck pain. While the authors do advocate for utilization of the PA to assist in assessing thoracic spine hypomobility and clinical reasoning to implement appropriate therapeutic exercise, the results given here cannot be used to draw conclusions regarding their effectiveness. While directional specific thoracic manipulation may not provide improved outcomes for patients with neck pain, we cannot apply these same conclusions to patients with a chief complaint of thoracic pain. Additional research is needed to assess the effects of specific exercise combined with manipulative techniques in patients who have neck pain associated with thoracic spine dysfunction.

Contributors

SK, BT, MT, TS, BW conceived and designed the study. SK, BW obtained funded and ethics approval. SK, MJOH, BT, MT, TS, BW collected and analysed the data. MJOH analysed the data. SK, MJOH, BT, MT, BW wrote the article in whole/part. SK, MJOH, BT, MT, TS, BW revised the article.

Ethical approval

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Disclosure statement

No potential conflict of interest was reported by the authors.

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