A randomized clinical trial to compare the immediate effects of seated thoracic manipulation and targeted supine thoracic manipulation on cervical spine flexion range of motion and pain

Steve Karas[1], Megan J. Olson Hunt[2]

[1]Physical Therapy Program, Chatham University, Pittsburgh, PA, USA, [2]Department of Biostatistics, University of Pittsburgh, PA, USA

Design: Randomized clinical trial.
Objectives: To determine the effectiveness of seated thoracic manipulation versus targeted supine thoracic manipulation on cervical spine pain and flexion range of motion (ROM). There is evidence that thoracic spine manipulation is an effective treatment for patients with cervical spine pain. This evidence includes a variety of techniques to manipulate the thoracic spine. Although each of them is effective, no research has compared techniques to determine which produces the best outcomes.
Methods: A total of 39 patients with cervical spine pain were randomly assigned to either a seated thoracic manipulation or targeted supine thoracic manipulation group. Pain and flexion ROM measures were taken before and after the intervention.
Results: Pain reduction (post-treatment–pre-treatment) was significantly greater in those patients receiving the targeted supine thoracic manipulation compared to the seated thoracic manipulation ($P<0.05$). Although not significant, we did observe greater improvement in flexion ROM in the targeted supine thoracic manipulation group. The results of this study indicate that a targeted supine thoracic manipulation may be more effective in reducing cervical spine pain and improving cervical flexion ROM than a seated thoracic manipulation. Future studies should include a variety of patients and physical therapists (PTs) to validate our findings.

Keywords: Thoracic spine, Orthopedic manipulative therapy, Cervical spine pain, Thoracic spine manipulation

Introduction

The cervical and thoracic spines, while anatomically distinct regions, are not clinically independent of each other. A full pathoanatomical examination of the thoracic spine has been suggested in all patients with cervical spine pain.[1,2] It has also been suggested that because the upper thoracic spine has similar features as the lower cervical spine, it may be treated in a similar manner.[3] Additional studies have shown that dysfunctions in the thoracic spine may result in pain and altered movement patterns in the cervical spine.[4–6] These altered patterns may inhibit the cervical spine facet joints from reaching their end-range positions.[7] Owing to these relationships and the perceived adverse effects of cervical manipulation, thoracic spine manipulation is a common intervention for the treatment of cervical spine pathology.[8–14]

Short-term benefits of thoracic spine manipulation for cervical pathology have been documented. These studies do not provide a clear rationale that would explain why a particular region was selected for manipulation. Thoracic manipulations (targeted at T1-4, then T5-8) have been shown to be superior to mobilization (grade 4 to T1-6) in the treatment of cervical spine pain when assessing cervical pain and disability immediately after treatment.[15] In addition, thoracic spine manipulation applied to hypomobile segments has been shown to be superior to a sham treatment when a visual analog scale (VAS) for cervical pain was assessed just after treatment.[16]

Improvements in pain and function have been documented between 2 and 28 days as well. A supine

Correspondence to: Steve Karas, Physical Therapy Program, Chatham University, Pittsburgh, PA, USA. Email: skaras@chatham.edu

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manipulation to the T4 segment produced decreases in cervical pain and increases in cervical range of motion (ROM) immediately and 48 hours after treatment.[17] Similar outcomes were found using a different supine thoracic manipulation (defined as translatoricspinal manipulation) between T1 and T4.[18,19] Finally, a study utilizing a seated distraction technique without an effort to target a specific region also successfully produced improvements in the patients' cervical ROM, as well as their VAS and neck disability index (NDI) scores, at 2- and 4-week follow-up.[20]

Despite these findings, there continues to be a lack of research on specific thoracic spine manual therapy techniques as compared to the cervical and lumbar spine.[21–23] In addition, a recent review article detailing the use of thoracic spine manipulation for cervical spine pain cited a lack of randomized control trials, a lack of variety of lead authors, and unclear treatment parameters as limitations in the current body of literature.[12]

A variety of techniques to manipulate the thoracic spine have been used to treat cervical spine pain.[15,19,24–26] Clinically, more time may be required to target a specific hypomobile motion segment and apply a technique directed at that segment as compared to applying a technique not focused on a particular hypomobility. Therefore, it is important to ascertain if treatment targeted at a specific segment leads to improved outcomes.

The purpose of this study was to determine if there would be immediate differences in cervical spine outcome measures between two different thoracic spine manipulation techniques. We utilized a randomized clinical trial to compare the change in cervical flexion ROM and pain before and after treatment between two high-velocity, low-amplitude manipulation techniques: a seated thoracic manipulation and a targeted supine thoracic manipulation. During the seated thoracic manipulation, no attempt was made to focus the treatment on a particular area. During the targeted supine thoracic manipulation, the therapist attempted to apply the manipulation to an identified hypomobile segment.

Methods

Patients

A total of 39 patients who presented to three different trained physical therapists (PTs) over a 22-month period participated in this study. The inclusion criteria required patients to be between 18–60 years old with a primary complaint of neck pain. Exclusion criteria were: identification of red flags suggestive of nonmusculoskeletal etiology, history of whiplash injury within six weeks of the initial visit, diagnosis of cervical spine stenosis, central nervous system involvement, or signs of nerve root compression (two of the following limited at the same level: strength, sensation, reflexes). All patients viewed and signed an informed consent form from the Chatham University Institutional Review Board. The informed consent did not suggest that one treatment was preferred over the other. This research project is registered with clinicaltrials.gov under the identifier: NCT01938209.

Physical therapists

Three PTs (average experience 13 years) at three different outpatient orthopedic facilities participated in the examination and treatment of the research patients. All PTs had post-graduate training in manual PT, which included instruction in thoracic spine manipulation. One PT was an orthopedic clinical specialist (OCS) and had an advanced certified manual physical therapist (CMPT) designation. A second PT also had an OCS and is a fellow in the American Academy of Orthopedic Manual Physical Therapists. The third PT had achieved his OCS designation. All PTs were provided with standardized written instructions for the assessment and manipulation procedures used in this project and reviewed the procedures during a hands-on educational session. The education session lasted approximately 1 hour and consisted of reviewing the literature advocating thoracic spine manipulation for patients with cervical spine pain, as well as a hands-on component to standardize the methods for applying the techniques. The PTs were also provided with written and illustrated instructions.

Allocation and treatment

After excluding patients based on the aforementioned criteria, patients were randomly divided into one of two groups for thoracic spine manipulation (seated thoracic manipulation or targeted supine thoracic manipulation) using a coin toss. The initial and follow-up evaluations included measurement of cervical flexion (in degrees) with a baseline bubble inclinometer (Fabricated Enterprises Incorporated, White Plains, NY, USA), which has been shown to be both valid and reliable, with reliability coefficients ranging from 0.81 to 0.84.[27–29] The PT measured cervical spine flexion three times with the patient in sitting position and recorded the average. Additionally, patients reported cervical flexion pain during the motion using a numeric pain scale of 0–10 before and after treatment, with 0 indicating the least amount of pain.

The seated group's treatment began with a seated thoracic manipulation as described by Gibbons and Tehan[24] (see Fig. 1). If a cavitation was heard, the intervention ended. If no cavitation was heard, the patient was set up again and the manipulation repeated. The intervention then ended even if there was no cavitation.

In the targeted supine thoracic manipulation group, the PT identified hypomobile segments via

Figure 1 Seated thoracic manipulation.

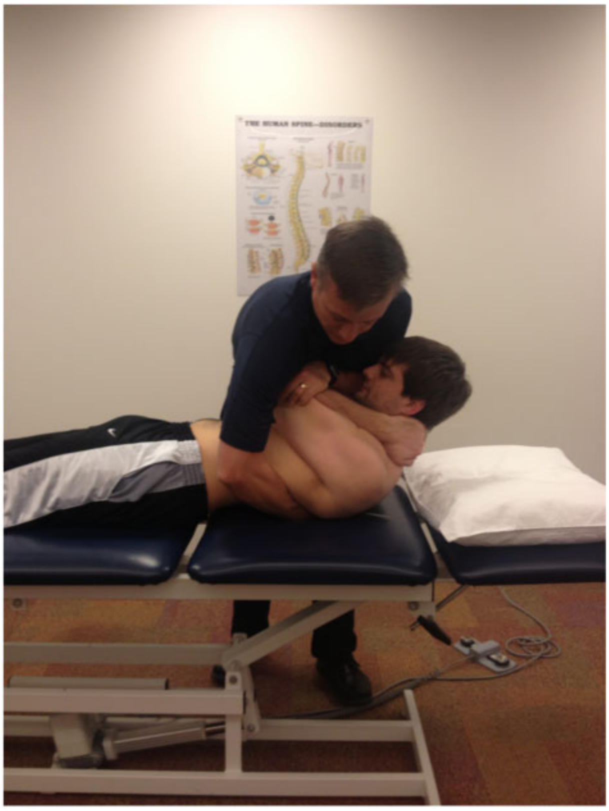

Figure 2 Targeted supine thoracic manipulation.

posterior–anterior (PA) mobilization (a maximum of two segments), and then applied a thoracic spine manipulation targeted at the identified segment or segments as described by Cleland *et al.* (see Fig. 2).[15] A modification was allowed such that patients could cross their arms over their shoulders if the PT felt it made the intervention more effective based on patient comfort and body type (see Fig. 3). The intervention ended if there was a cavitation. If no cavitation was heard, a second manipulation was carried out, and the intervention concluded even if no cavitation was heard. After each patient was treated, the PT reassessed cervical flexion ROM and pain.

Statistical methods

We assessed cervical flexion ROM and pain before and immediately after treatment and compared the change in these measures across treatment groups: seated thoracic manipulation or targeted supine thoracic manipulation. Other measured variables included gender, age, PT, baseline pain, and baseline ROM.

Initially, 13 patients were recruited, randomized, and treated. A sample size calculation was conducted on the results of those interventions for each of the outcome measures using the PASS software. The larger of the two sample size calculations (that associated with ROM) indicated that 15 patients were needed in each group (30 total) to yield a significant difference across treatments with alpha$<$0.05 and power of 80% or higher. At the conclusion of the study, a total of 39 patients (including the original 13 from the pilot data) were recruited, with 20 in the seated treatment group and 19 in the supine.

Summary measures of demographics and variables across treatment groups were obtained to check for baseline differences. For categorical variables, P-values comparing the two variables were calculated by Fisher's Exact Test. A two-sample t-test, or the Kruskal–Wallis Test, was used for numeric data depending on the normality of the data.

Linear regression models were used to explore the hypothesis of interest: whether the choice of treatment significantly predicts change in pain or ROM. In addition to the simple regression of change in pain (or change in ROM) versus treatment, models adjusted for each potential confounder (age, gender, PT, and baseline pain/ROM) were also individually considered even though the treatment groups were not statistically different at baseline with regard to these variables. This was done to quantify how much (or how little) the point estimate for treatment changed and to emphasize the strength of the treatment effect even when controlling for the covariates. When both the treatment and confounder effects were significant in a given model, a two-way interaction between these two variables was tested for significance. For all models, predictors were deemed significant if their associated P-value was less than alpha$=$0.05.

The assumptions of normality, homoscedasticity, and linearity were checked using a combination of density plots, histograms of residuals, and scatter

Figure 3 Targeted supine thoracic manipulation, alternate arm position.

plots of the residuals versus fitted values. There was no significant evidence that any assumptions were violated for the various models.

In addition to modeling the data with linear regression, standardized effect sizes were calculated to compare the magnitude of the difference in change in pain and change in ROM between the two treatment groups. Specifically, the effect size was defined as [(mean change in pain in the targeted group) −(mean change in pain in the seated group)]/(standard deviation (SD) of change in pain in the seated group), and similarly for change in ROM.[30] As a sensitivity analysis, the effect size was also calculated using the pooled SD as opposed to that based on the seated group only. The magnitudes of the effect sizes are reported.

Lastly, Pearson's product–moment correlation coefficient was calculated between the two outcomes (change in pain, change in ROM) to determine if they were significantly related to one another in this data set. All analyses were conducted in R version 2.13.1.

Results

The 39 patients in this study, including 26 females and 13 males, had a mean age of 40.2 years (SD=11.2). In the seated thoracic manipulation group, one patient did not have an audible cavitation after two manipulations. Also in this group, 14 patients received one manipulation and 6 received two. In the targeted supine thoracic manipulation group, 13 patients had a single motion segment treated and in each of these, an audible cavitation was heard on the first treatment. In the six patients who had two motion segments treated, three had two treatments and three had a second attempt at a cavitation. Table 1 shows demographic and study variable summary measures across treatment groups. Of these variables, only change in pain (an outcome of interest) was significantly different across groups (P=0.001). Change in ROM was not significant (P=0.28). Treatment groups were not significantly different with regard to any covariates.

For the analyses of interest, both unadjusted and adjusted regression models indicated that the treatment group was significantly predictive of change in pain, but not predictive of change in ROM. Table 2 summarizes these findings by providing the parameter estimates, 95% confidence intervals, and P-values associated with treatment for each model (estimates for covariates not reported). No two-way interactions

Table 1 Summary measures of variables by treatment group

	General	Targeted	P-value
Sample size (n)	20	19	–
Age (mean years (SD))	38.6 (12.2)	41.9 (10.0)	0.46
Female (count, % of n)	14 (70%)	13 (68%)	1.00
Physical therapist (PT)			
1 (count, % of n)	6 (30%)	3 (16%)	0.12
2 (count, % of n)	2 (10%)	7 (37%)	
3 (count, % of n)	12 (60%)	9 (47%)	
Pain measurements[¥]			
Baseline pain (mean (SD))	4.2 (2.1)	5.1 (1.9)	0.19
Post-treatment pain (mean (SD))	3.2 (1.9)	2.8 (1.7)	0.64
Change in pain (mean (SD))	−1.1 (.2)	−2.3 (0.9)	0.001[†]
Range of motion (ROM) measurements (°)			
Baseline ROM (mean (SD))	46.4 (10.3)	43.6 (15.7)	0.24
Post-treatment ROM (mean (SD))	59.1 (10.5)	58.4 (13.6)	0.98
Change in ROM (mean (SD))	12.7 (5.7)	14.8 (6.5)	0.28

[¥]Pain scores could range from 0 (least pain) to 10 (most pain).
[‡]Change was calculated as (measurement after treatment)−(measurement before treatment).
[†]Significant with alpha=0.05.

were significant, so results from these analyses are not included in Table 2. Note that when change in pain was the outcome, baseline pain (and not baseline ROM) was used as a predictor, whereas when change in ROM was the dependent variable, baseline ROM was a predictor (but not baseline pain).

From Table 2 we see that the targeted supine thoracic manipulation group had significantly more pain reduction than the seated thoracic manipulation group (beta=−1.21, P=0.001). Once we adjusted for age (second column), treatment remained significant (beta=−1.24, P=0.001). Similarly, when controlling for gender, PT, or baseline pain, the targeted supine thoracic manipulation treatment reduced pain significantly more than the general (beta=−1.21, P=0.001; beta=−1.32, P<0.001; and beta=−1.00, P=0.004, respectively). These results were expected because the groups did not differ significantly with regard to any of the covariates.

Table 2 also shows the results for change in ROM (second row), which, as mentioned previously, did not have a significant relationship with treatment across any model (P>0.05 for all models). However, referring back to Table 1, we note that the mean change in ROM for the seated thoracic manipulation treatment group was 12.7° (SE=1.3), whereas that for the targeted supine thoracic manipulation was 14.8 (SE=1.5), suggesting a greater increase in ROM for the targeted supine group, although the difference between groups was not statistically significant.

With regard to effect size, that for change in pain was 1.02 using the SD of the seated thoracic manipulation group, indicating a large effect size favoring the targeted supine thoracic manipulation. Using the pooled SD gave a similar but slightly larger result of 1.13. For change in ROM, the effect size using the SD of the seated thoracic manipulation group was 0.38, indicating a small to moderate effect again favoring the targeted supine thoracic manipulation. The result using the pooled SD was again similar with a value of 0.35.

Finally, there was no significant correlation between the two outcome measures in this data set. For the seated group, r=−0.17 (P=0.46), and for the targeted, r=0.07 (P=0.76).

Discussion

The results of this study indicate that the targeted supine thoracic manipulation directed to an identified hypomobile segment may be more effective than a seated thoracic manipulation in reducing cervical flexion pain. Clinicians must decide if a 1.2 point reduction in end-range cervical flexion pain is clinically relevant to a specific patient. Although our pain change was significant, it was just below the 1.3 minimal clinically important difference established in a prior cohort of patients with neck pain.[31]

Although there was greater improvement in cervical flexion ROM for the targeted supine thoracic manipulation group (average of 14.8°) over the seated thoracic manipulation group (average of 12.7°), the results were not statistically significant. Specifically, within the pilot data, the mean change in ROM for the targeted supine group was about 5.4° more than that of the seated group, but for the entire 39 patients this difference dropped to about 2.1°. Because the observed mean difference in the final set of patients was notably smaller than that in the pilot data, the power to detect a difference (keeping alpha=0.05) was reduced below the desired level of 80% that was determined by the pilot data, leaving the pilot study underpowered for this outcome measure.

Table 2 Parameter estimates, 95% confidence intervals, and *P*-values associated with targeted treatment for unadjusted and adjusted linear regression models (no values reported for covariates). The first row gives estimates with respect to change in pain, the second for change in ROM. The first column represents the unadjusted model – i.e. change in pain (or ROM) versus treatment. The remaining columns are adjusted for each of the potential confounders individually. There was significant evidence that treatment predicts change in pain across all models, but not change in ROM (alpha=0.05). No two-way interaction terms involving treatment and the covariates were significant in any of the models

	Independent variables				
	Treatment	Treatment (age)	Treatment (gender)	Treatment (physical therapist (PT))	Treatment (¥baseline pain/baseline ROM)
Change in pain					
Beta	−1.21	−1.24	−1.21	−1.32	−1.00
95% CI	(−1.91, −0.52)	(−1.96, −0.53)	(−1.92, −0.51)	(−2.07, −0.58)	(−1.65, −0.35)
P-value	0.001†	0.001†	0.001†	<0.001†	0.004†
Change in ROM					
Beta	2.14	2.37	2.15	1.97	1.64
95% CI	(−1.82, 6.10)	(−1.67, 6.41)	(−1.87, 6.17)	(−2.24, 6.17)	(−2.08, 5.35)
P-value	0.28	0.24	0.29	0.35	0.38

¥For models with change in pain as the outcome, baseline pain was used as a predictor, but not baseline ROM. Similarly, for models with change in ROM as the outcome, baseline ROM was used, but not baseline pain.
‡Change was calculated as (measurement after treatment)−(measurement before treatment).
†Significant with alpha=0.05.

Other researchers have reported a standard error of the mean for cervical flexion ROM as 4.6°.[29] Whereas our changes for each group were outside this margin of error, the mean change in difference was not.

The minimal detectable change (MDC) established in prior research for cervical ROM has been established at 13–18°.[31] This change was realized in the targeted supine thoracic manipulation group, but not in the seated thoracic manipulation group.

We acknowledge the follow-up time was limited to a single session, with assessment of cervical flexion ROM and pain occurring immediately after treatment (so that between-session changes were not documented). However, manual therapy research involving the cervical and lumbar spine has shown percentage improvement within PT sessions to be predictive of the percentage of between-session changes of pain and ROM.[32,33] However, no studies have been completed investigating within- and between-session changes when treating the thoracic spine or the thoracic spine's effect on the cervical spine. The purpose of the current study was not to determine between-session changes, and this could be better evaluated with future research.

The reliability of the administered treatments was not formally assessed in this study and we recognize there are variations in the techniques used to manipulate the thoracic spine. Because of this, we implemented two well-described techniques, included a hands-on, pre-study educational session, and fit a regression model that controlled for PT, which did not change our conclusions about treatment for either outcome.

Review articles concerning PA motion palpation have cited a lack of accepted reference standards[34] and suggested that inter-examiner motion palpation is more reliable when a segment is pre-identified and the initial step of identifying a specific segment is removed.[35] However, research has shown good intra-examiner reliability establishing hypomobility in the thoracic spine.[36] As a result, the PA assessment remains a common, albeit subjective, technique in the field of manual PT.

Regarding validity of the assessment procedures, there are, to our knowledge, no studies validating the use of thoracic spine PA tests for assessing hypomobility. However, our clinical decision to manipulate the thoracic spine was made because the patient had cervical spine pain. Additionally, we acknowledge that our results only apply to the techniques we used with our patients.

Limitations

Given the single-session follow-up, both the before and after outcome measurements were conducted by the same PT, so that the study was not blinded. Because the PT was the same person who administered treatment and took both measurements, bias could have resulted. Also, our PTs also had additional manual therapy training, so these results may not be generalized to those therapists who do not have additional training.

Another possible concern is the potential for a placebo effect affecting the outcome measures. However, prior research showed that there indeed was a clinical effect utilizing a manipulative thrust versus a sham treatment that involved only set-up.[16]

Future research should compare the long-term effects of these two techniques, their reliability, potential placebo effects, and the effect of their utilization among trained and novice PTs.

Conclusion

We found a statistically significant relationship between the type of manipulation selected and the pain outcome measure. In addition, we observed a greater, albeit not statistically significant change in cervical flexion ROM. Collectively, these suggest that the targeted supine thoracic manipulation we used was more effective than the seated thoracic manipulation.

Given the results of the present study, we advise that clinicians consider using a targeted supine thoracic manipulation applied to the identified hypomobile segments of the thoracic spine for patients with neck pain. This may more effectively decrease cervical spine pain and increase cervical spine flexion ROM.

Conflict of Interest

The authors report no conflict of interest.

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