The Immediate Effects of Upper Thoracic Translatoric Spinal Manipulation on Cervical Pain and Range of Motion: A Randomized Clinical Trial

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Painful, restricted cervical mobility is seen and treated daily in physical therapy clinics and it accounts for up to 25% of the patient population seen in outpatient orthopedic practice. According to Kelsey, 40% to 50% of the general population will experience mechanical neck pain. Injury and degenerative changes affecting the intervertebral disc may account for excessive translation between two adjacent vertebrae during active cervical motion. This excessive translation can cause considerable strain on the annulus fibrosis, increase load on the cervical facet joints, and result in pain during active cervical motion. Aprill and Bogduk reported that the occurrence of cervical facet joint pain can be as high as 64%. Provocation discography has shown a relationship between radiographic appearance of an abnormal cervical disc and the pain provocation results at that cervical spinal motion segment.

There is a clinical and biomechanical concept that suggests that a hypomobile spinal motion segment(s) may produce or perpetuate a symptomatic response from an adjacent hypermobile spinal motion segment. Cervical-thoracic and upper thoracic mobility restrictions have been associated with neck pain. According to Norlander et al, reduced mobility at the cervical-thoracic junction has been shown to be a risk factor for neck pain. This relationship was further explored by Fernandez-de-la-Peñas et al, who identified upper thoracic (UT) joint dysfunctions in patients experiencing cervical whiplash (69%) and mechanical neck pain (13%).

Upper thoracic joint dysfunction has been defined as a temporary reduction of mobility in one or more planes in the first four thoracic segments. A number of different passive intervertebral movement techniques have been developed to evaluate for excessive or limited passive segmental motion. Antero-posterior (A-P) joint play testing is an examination technique that uses linear motion to evaluate the amount of segmental translation. Other passive segmental motion tests use angular motion such as flexion...
and extension in order to determine if passive movement impairment is present at a segmental level. Studies have questioned the reliability of passive segmental mobility testing in the thoracic spine. This may in part be due to errors in nominal palpation; however, from a treatment perspective, identification of exact nominal level may not be essential as long as the segment treated is correctly identified as hypomobile.

A number of recent studies have explored the interaction between high-velocity manipulation of the thoracic spine and cervical pain. These studies have used outcome measures such as the Neck Disability Index (NDI), the Visual Analog Scale (VAS), the Numeric Pain Rating Scale (NPRS), and the Global Rating of Change (GROC) Scale. The general findings of these studies are that high-velocity manipulations applied to the UT spine reduces subjective complaints of neck pain and disability. This outcome appears to occur regardless of how many cavitations occur and how segmentally specific the cavitations are.

Another method of measuring improvement in cervical spine function following the application of high-velocity thoracic manipulation is through the use of goniometric or inclinometer measurements. Two studies have been identified that directly examine this outcome. Cleland et al. examined the relationship between the audible pop and manipulation and changes in cervical range of motion (ROM). They concluded that the number and location of cavitations did not seem to impact improvements in cervical ROM. Using a case series design, Fernandez-de-la-Penas et al. examined the effects of thoracic manipulation on cervical ROM and found a trend towards significance in ROM changes post-manipulation. No controlled randomized studies were identified that examined the effects of thoracic manipulation on cervical ROM as measured by an inclinometer.

The 9-point Faces Pain Scale (FPS) developed by Bieri et al. uses nine different faces depicting various severities of pain. This scale was first validated for use in children and adolescents and was later validated for use with mature populations (>55 years of age). In regards to patient preference, the FPS has been shown to be of greater preference than the NPRS by mature adults. In addition, there is cross-cultural evidence to the usefulness of the FPS.

Translatory Spinal Manipulation (TSM) co-developed by Evjenth and Kaltenborn is a manipulative approach that uses short straight-lined high- and low-velocity movements directed parallel to or at a right angle to the spinal joint surfaces. Techniques that are part of this manipulative approach are well described by Krauss, Evjenth, and Creighton, who theorized that short straight-lined movements are an effective method of restoring joint motion with minimal risk of symptom exacerbation. This study sought to determine if TSM would have an effect on cervical pain (measured by the FPS) and cervical ROM (measured by an inclinometer) when applied to hypomobile segments found in the upper thoracic region.

**Methods**

**Subjects**

A convenience sample of 32 patients admitted to three different outpatient physical therapy clinics with a diagnosis of cervical pain voluntarily participated in the study. Patients between 19 and 50 years old presenting with complaints of non-traumatic posterior mid-cervical pain of an insidious onset in the region of the fourth to seventh cervical vertebral levels and aggravated with active cervical rotation were invited to participate. Patients with symptoms originating from the thoracic spine, systemic disease or autoimmune disease affecting the musculoskeletal system, positive radicular signs, myelopathy, or previous surgery to the cervical spine were excluded from the study. The study was approved by the Oakland University Institutional Review and Ethics Board in Rochester, Michigan.

**Procedures**

Patient examinations were performed at three different outpatient physical therapy clinics by three orthopedic manual physical therapists (OMPTs) trained at a two-year certificate program at Oakland University (Rochester, MI). The average number of years in clinical practice for the treating therapists was 12.3. During the examinations, patients were screened for the presence of mechanical neck pain during the performance of active cervical rotation. Diagnostic criteria for mechanical neck pain have been put forth by Van Schalkwyk and Parkin-Smith. Their criteria include neck pain without neurologic or vascular deficit, unilateral or bilateral neck pain, discomfort with joint challenge/pressure, and restriction of movement of a motion segment(s) identified by static or motion palpation. Neck pain was rated at the end of active left and right rotation using a 9-point Faces Pain Scale (FPS). Stuppy reported that the FPS is reliable (r = .70, p < .001), valid (when correlated with the NPRS r = .95, p < .001) and differentiates between more and less pain. Active cervical right and left rotation were measured with a cervical range of motion inclinometer/compass system (CROM) (Performance Attainment Associates, St. Paul, MN). Youdas et al. reported intraclass correlation coefficient values (ICC) for left rotation (ICC = .90) and right rotation (ICC = .93) to be highly reliable when repeated by the same physical therapist. Between-tester reliability for active range of motion measurements of neck rotation with the CROM device ranged from good (ICC = .82) for left rotation to high for right rotation (ICC = .92).

To reduce the likelihood that patient complaints of neck pain were of thoracic origin, symptoms were localized to the mid-cervical region by performing rotational symptom localization as described by Evjenth. For example, if active rotation to the right increased the patient's cervical pain, the clinician would have the patient rotate his or her neck to the right until the pain increased. Then the patient would slowly rotate the head/neck to the left until the cervical pain slightly decreased. This cervical position was then maintained by the clinician's chest and non-testing hand. At this point the clinician would passively rotate individual cervical vertebra to the right beginning at the C7.
level. The manual contact for the examination technique was the posterior portion of the lamina on the left side and the right side of the spinous process. When similar symptoms were provoked as compared with the patient’s active cervical right rotation, the cranial vertebra of the involved symptomatic segment was considered to have been identified (Figure 1). Jull et al showed that manual diagnosis by a trained manipulative therapist can be as accurate as radiologically controlled diagnostic blocks in the diagnosis of cervical zygapophysial syndromes. The symptomatic cervical motion segment(s) found with symptom localization testing was then recorded.

A-P joint play testing was used to identify UT segmental motion restriction. This was performed with the patient seated on the treatment table with the arms folded across the chest. The clinician palpated with the index finger at the interspinous space of the segment to be tested. The remainder or proximal portion of the palpating hand provided stabilization caudal to the segment being tested. The clinician’s movement arm wrapped around the patient’s trunk and under the patient’s crossed arms allowing for contact on the anterior portion of the rib cage and opposite upper extremity. A-P translation was produced by the clinician’s arm and chest movement (Figure 2). All subjects examined presented with one or more levels of restricted A-P translation. The hypomobile UT motion segment(s) was recorded for each patient by the examining OMPT.

The patient was then informed of the study and given detailed instructions regarding the study timeline and participant responsibilities in addition to an informed consent form to review and sign prior to participating in the study. The patient was not treated on the day of the initial examination nor was he or she given a home exercise program or seen by another practitioner prior to his or her first return visit. The first return visit was scheduled one to two days after the initial examination.

When the patient returned for the second visit, he or she was randomly assigned to either the experimental group (EG) or control group (CG). Randomization was performed via the use of a numbered and sealed envelope containing a slip of paper indicating group assignment as either EG or CG. The envelope was given to the treatment OMPT upon participant arrival. Envelope numbers were recorded by the OMPT on all data collection forms and on a master sheet containing both envelope numbers and group assignment. This master sheet was then stored in a locked container maintained at each data collection site.

Three physical therapist assistants (PTAs), one at each outpatient clinic, collected the data for this study. Each PTA was trained in the use of the CROM and was blinded to group assignment. In
an enclosed treatment booth, the PTA recorded CROM measurements for active left and right rotation and pain level at end range of active cervical rotation in both directions using a FPS. This process was performed for both the EG and CG. The PTA recording the measurements then left the booth.

The OMPT then entered the booth and performed a bilateral translactoric facet joint traction manipulation to the hypomobile UT intervertebral segments (Figure 3). This TSM technique is a short, passive linear movement performed in a dorsal direction approximately perpendicular to the plane of the facet joints and approximately parallel to the plane of the UT intervertebral disc (IVD) joints at each level. The CG received no intervention to minimize non-specific effects of sham treatment and remained seated on the treatment table for approximately the amount of time it would take for the TSM to be performed. The OMPT left the booth, and the assistant who originally measured cervical rotation with the CROM and collected the pain data on the FPS returned to the booth and recorded these values in the pain data on the FPS returned to the booth and recorded these values in the same manner as above. Patient participation in this study was then concluded.

The effect of the TSM intervention on ROM and pain was analyzed using a paired t-test to analyze within-group differences and a 2-way repeated-measure analysis of variance (ANOVA) with intervention group (TSM versus control) as the between-subjects variable and the time (baseline and follow-up) as the within-subject variable. Separate ANOVAs were performed with ROM and pain (FPS) as the dependent variables. For each ANOVA, the hypothesis of interest was the 2-way interaction (group x time). Data analysis was performed using SPSS 15.0. Statistical significance was accepted at the 0.05% level of confidence. Further, analysis of the minimal detectable change at a 95% confidence interval was calculated using the formula MDC95 = 1.96 x SD x \sqrt{2} x SEM with SEM = SD x \sqrt{1-ICC}.

### Results

Thirty-two subjects participated in the study, 6 males and 26 females with 22 in the EG and 10 in the CG. Three males were distributed to each group and 7 females were distributed to the CG with the remaining 19 distributed to the EG. The mean age (SD) of participants was 34.2 years (9.56) for the CG and 35.5 years (10.51) for the EG. Descriptive statistics in terms of age, initial rotation, and initial FPS for both groups are listed in Table 1. Of the 32 participants, 10 had pain with bilateral rotation, 11 had pain with left rotation only, and 11 had pain with right rotation only. Levene's statistic revealed no violation in normality and homogeneity of variance between groups for age, gender, rotation, FPS, and direction of symptoms. No candidates refused to participate in the study.

A paired t-test analysis revealed no significant within-group change in left and right rotation in the CG (p = .62 and .90, respectively). Paired t-test analysis revealed significant within-group change in left and right rotation in the EG (p < 0.01 and < 0.01, respectively) (Table 2). The 2-way group x time interaction for the repeated-measures ANOVA was statistically significant for right rotation (p = .002) and left rotation (p = .001). Subjects in the TSM group experienced greater ROM with a mean (SD) increase in cervical right rotation of 8.23° (7.41°) and left rotation of 7.09° (5.83°). The MDC was calculated using the between-tester ICC reported by Youdas et al and was .82 for left rotation and .92 for right rotation. Based on these calculations (Table 3), the changes in motion detected within this study (7.09° for left rotation and 8.23° for right rotation) exceeded the MDC of 6.82° for left rotation and 5.79° for right rotation.

To analyze the effects of pain during left and right rotation, subjects were grouped according to which direction

### Table 1. Between-group comparisons for age and baseline ROM (in degrees) and FPS.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error</th>
<th>95% Confidence Interval for Mean</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
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<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Control</td>
<td>34.20</td>
<td>9.555</td>
<td>3.021</td>
<td>27.37</td>
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<tr>
<td>TSM Group</td>
<td>34.95</td>
<td>10.513</td>
<td>2.241</td>
<td>30.29</td>
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<tr>
<td>Initial Left Rotation</td>
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<td>54.80</td>
<td>12.656</td>
<td>4.002</td>
<td>45.75</td>
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<td>TSM Group</td>
<td>58.95</td>
<td>14.669</td>
<td>3.128</td>
<td>52.45</td>
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<td>Initial Right Rotation</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>55.80</td>
<td>11.084</td>
<td>3.505</td>
<td>47.87</td>
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<tr>
<td>TSM Group</td>
<td>60.41</td>
<td>15.271</td>
<td>3.256</td>
<td>53.64</td>
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<td>Initial Pain with</td>
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<tr>
<td>Left Rotation</td>
<td>2.50</td>
<td>2.838</td>
<td>.898</td>
<td>.47</td>
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<td>TSM Group</td>
<td>3.73</td>
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<td>Initial Pain with</td>
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<td>Right Rotation</td>
<td>2.80</td>
<td>1.889</td>
<td>.597</td>
<td>1.45</td>
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<tr>
<td>TSM Group</td>
<td>2.75</td>
<td>2.671</td>
<td>.570</td>
<td>1.57</td>
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</table>

TSM = Experimental Group.
TABLE 2. Within-group comparisons of changes in cervical rotation (in degrees).

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
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<tr>
<td>Control Group Left Rotation</td>
<td>-0.6</td>
<td>3.66</td>
<td>-2.02 - 3.22</td>
<td>0.529</td>
<td>9</td>
<td>&lt;0.01</td>
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<td>TSM Group Left Rotation</td>
<td>7.09</td>
<td>5.83</td>
<td>4.52 - 9.68</td>
<td>5.71</td>
<td>21</td>
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<tr>
<td>Control Group Right Rotation</td>
<td>-0.1</td>
<td>2.33</td>
<td>-1.57 - 1.77</td>
<td>0.136</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>TSM Group Right Rotation</td>
<td>8.23</td>
<td>7.41</td>
<td>4.94 - 11.51</td>
<td>5.21</td>
<td>21</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

* Significant at a .05 level. TSM = Experimental Group.

TABLE 3. Within-group comparisons of changes in pain reported during cervical rotation (measured using a 9-point Faces Pain Scale).

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
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<td>Pain with Right Rotation Only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Group Right Rotation</td>
<td>-1.00</td>
<td>.224</td>
<td>-.378 - .178</td>
<td>1.00</td>
<td>4</td>
<td>.37</td>
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<tr>
<td>TSM Group Right Rotation</td>
<td>1.50</td>
<td>2.88</td>
<td>-1.52 - 4.52</td>
<td>1.28</td>
<td>5</td>
<td>.26</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Group Left Rotation</td>
<td>.667</td>
<td>1.16</td>
<td>-2.20 - 3.54</td>
<td>1.00</td>
<td>2</td>
<td>.42</td>
</tr>
<tr>
<td>TSM Group Left Rotation</td>
<td>.688</td>
<td>1.03</td>
<td>-.176 - 1.55</td>
<td>1.88</td>
<td>7</td>
<td>.10</td>
</tr>
<tr>
<td>Pain during Bilateral Rotation</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Control Group Right Rotation</td>
<td>-5.00</td>
<td>.707</td>
<td>-6.85 - 5.85</td>
<td>1.00</td>
<td>1</td>
<td>.50</td>
</tr>
<tr>
<td>TSM Group Right Rotation</td>
<td>1.38</td>
<td>1.09</td>
<td>.461 - 2.29</td>
<td>3.56</td>
<td>7</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Control Group Left Rotation</td>
<td>-5.00</td>
<td>.707</td>
<td>-6.85 - 5.85</td>
<td>1.00</td>
<td>1</td>
<td>.50</td>
</tr>
<tr>
<td>TSM Group Left Rotation</td>
<td>1.63</td>
<td>1.62</td>
<td>.270 - 2.98</td>
<td>2.84</td>
<td>7</td>
<td>&lt;.03</td>
</tr>
</tbody>
</table>

* Significant at a .05 level. TSM = Experimental Group.

provoked the pain (right, left, or bilateral). Paired t-test analysis for patients experiencing pain during right rotation only (N = 5 for the CG and N = 6 for the EG) revealed no significant within-group difference for the EG or CG (p = .258 and .374, respectively) (Table 4). No significant between-group differences were noted upon repeated-measure ANOVA for patients experiencing pain with right rotation only (p = .25).

Paired t-test analysis for patients experiencing pain during left rotation only (N = 3 for the CG and N = 8 for the EG) revealed no significant within-group difference for the EG or CG (p = .10 and .42, respectively). No significant between-group differences were noted upon repeated-measure ANOVA for patients experiencing pain with left rotation only (p = .98).

Paired t-test analysis for patients experiencing pain during bilateral rotation (N = 2 for the CG and N = 8 for the
The results from this study support the hypothesis that high-velocity manipulation of the thoracic spine may increase cervical spine rotation. All subjects in the EG demonstrated an increase in post-intervention active cervical rotation that exceeded the MCD. Of the twenty-two subjects in the EG, twelve of the subjects showed a significant increase in end-range pain. The decrease in pain during right cervical rotation was 1.38 (1.1) and during left rotation it was 1.63 (1.6).

Discussion

The results from this study support the hypothesis that high-velocity manipulation of the thoracic spine may increase cervical spine rotation. All subjects in the EG demonstrated an increase in post-intervention active cervical rotation that exceeded the MCD. Twelve of the twenty-two subjects in the EG demonstrated a range of active motion improvement between 10' to 30'.

Pain levels perceived during post-intervention cervical rotation showed statistically significant improvement during right rotation for patients experiencing symptoms during bilateral rotation only. While this is in contrast to the findings of other studies that detected significant reductions in pain following thoracic manipulation, it should be noted that these studies examined pain at rest and not at end-range rotation. The only study that attempted to examine changes in end-range pain used a case series design and did not detect significant end-range pain reductions.

While there was a statistically significant decrease in pain during right rotation, there remains a question regarding the clinical significance of this finding as there is no information regarding the minimally clinically important difference (MCID) for the FPS. It should be noted that post-intervention evaluation of pain level was taken at the end of any new or additional gains in active cervical rotation. As described in the introduction, symptom localization was used to implicate the cervical spine as the source of the patients' pain. It is our belief that treatment of the thoracic spine may improve the movement available in the cervical spine during rotation; however, it may not necessarily reduce the reactivity of the cervical source of neck symptoms. Therefore, regardless of the increase in range, the painful cervical source may be provoked at end range of rotation. In our opinion, if the post-intervention pain rating had been taken at the same point in the range of movement pre-intervention instead of the end of the new ROM gained post-intervention, there would likely have been a greater decrease in pain than noted in this study.

The limitations for this study include the use of the FPS as opposed to the numeric pain rating scale (NPRS). Childs has demonstrated that clinicians could be confident that a 2-point change on the NPRS represents clinically meaningful change that exceeds the bounds of measurement error. This type of analysis has not been performed for the FPS. A second limitation relates to a sample that was limited in number, age range, and gender (consisting predominantly of females). The number of participants was particularly problematic when the groups were analyzed for changes in pain based on the direction of symptoms and resulting in small numbers of participants per group. Additional limitations of this study include the lack of baseline demographics specifically in terms of acuity or chronicity of symptoms. Lastly, we cannot rule out any placebo effect that may have occurred due to manual contact being applied to the manipulation group only.

Future research could explore the utility of the FPS for this type of research in addition to establishing an MCID for the scale. While a 9-point FPS was used in this study, a new 11-point FPS has been shown to be valid and reliable and more directly comparable to the NPRS, and it may also be a useful alternative to the NPRS when applied to populations of various educational and cultural backgrounds. Future research could incorporate a comparison between TSM versus a placebo treatment or a different form of research-based manipulation applied to hypomobile UT segments. Also, changes in rotation as a result of UT manipulation could be analyzed and compared between subjects with pain-dominant cervical motion limitation versus stiffness-dominant cervical motion limitation. Lastly, future studies should directly compare UT manipulation for cervical pain and motion impairment versus manipulation of symptomatic cervical segments.

Conclusion

There are numerous orthopedic manual physical therapy treatment strategies that can be used to assist patients in the management of painful movement impairments affecting their cervical spine. This study demonstrated that application of TSM to the UT segments may also be a useful treatment option for the management of the same. Cervical rotation range of motion improved in all subjects following the application of this form of manipulation to the UT segments. No patient reported any increase in cervical symptoms post-manipulation.

REFERENCES

2. Kelsey JL. Epidemiology of Musculoskeletal
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