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[1]. According to Kelsey[2], 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[3,4]. 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[4,5]. Aprill and Bogduk reported that the occurrence of cervical facet joint pain can be as high as 64%[3,4]. 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[6,7].

ABSTRACT: This study examined the effect of translatoric spinal manipulation (TSM) on cervical pain and cervical active motion restriction when applied to upper thoracic (T1-T4) segments. Active cervical rotation range of motion was measured re- and post-intervention with a cervical inclinometer (CROM), and cervical pain status was monitored before and after manipulation with a Faces Pain Scale. Study participants included a sample of convenience that included 32 patients referred to physical therapy with complaints of pain in the mid-cervical region and restricted active cervical rotation. Twenty-two patients were randomly assigned to the experimental group and ten were assigned to the control group. Pre- and post-intervention cervical range of motion and pain scale measurements were taken by a physical therapist assistant who was blinded to group assignment. The experimental group received TSM to hypomobile upper thoracic segments. The control group received no intervention. Paired t-tests were used to analyze within-group changes in cervical rotation and pain, and a 2-way repeated-measure ANOVA was used to analyze between-group differences in cervical rotation and pain. Significance was accepted at $p = 0.05$. Significant changes that exceeded the MDC_{95} were detected for cervical rotation both within group and between groups with the TSM group demonstrating increased mean (SD) in right rotation of 8.23° (7.41°) and left rotation of 7.09° (5.83°). Pain levels perceived during post-intervention cervical rotation showed significant improvement during right rotation for patients experiencing pain during bilateral rotation only (p=.05). This study supports the hypothesis that spinal manipulation applied to the upper thoracic spine (T1-T4 motion segments) significantly increases cervical rotation ROM and may reduce cervical pain at end range rotation for patients experiencing pain during bilateral cervical rotation.

KEYWORDS: Manipulation, Pain, Range of Motion, Thoracic Spine, Translatoric Spinal Manipulation

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[8]. 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[9,10]. This relationship was further explored by Fernandez-de-la-Peñas et al[11], 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[12]. 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[8]. Other passive segmental motion tests use angular motion such as flexion

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and extension in order to determine if passive movement impairment is present at a segment[8,13-15]. Studies have questioned the reliability of passive segmental mobility testing in the thoracic spine[16,17]. 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[18].

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[19-22]. The general findings of these studies are that high-velocity manipulation 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[23-24].

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[24] 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-Peñas et al[25] 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[26] 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)[27,28]. In regards to patient preference, the FPS has been shown to be of greater preference than the NPRS by mature adults[27]. In addition, there is cross-cultural evidence to the usefulness of the FPS[28].

Translatoric 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[29], 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[29].

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[30,31]. 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[27] 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[32] 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)[32].

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[15]. 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[13]. 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[8]. 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 clinican's arm and chest movement[8,33] (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

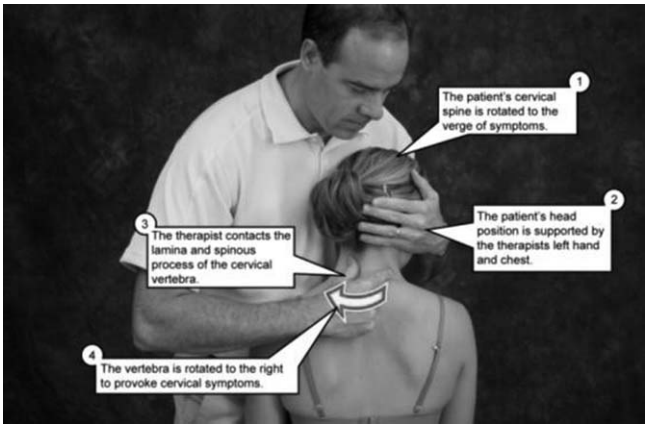

FIGURE 1. Symptom localization of the cervical spine.

FIGURE 2. AP joint play of the thoracic spine in sitting.

FIGURE 3. Translatoricspinal manipulation of the thoracic spine.

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 translatoric facet joint traction manipulation to the hypomobile UT intervertebral segments[29] (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[29]. The CG received no intervention to minimize nonspecific 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 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 $MDC95 = 1.96 \times \sqrt{2} \times SEM$[34,35] with $SEM = SD \times \sqrt{(1-ICC)}$[36].

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 (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 MCD_{95} 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_{95} 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.

					95% Confidence Interval for Mean			
		Mean	Standard Deviation	Standard Error	Lower Bound	Upper Bound	Min	Max
Age	Control	34.20	9.555	3.021	27.37	41.03	19	50
	TSM Group	34.95	10.513	2.241	30.29	39.62	16	52
Initial Left Rotation ROM	Control	54.80	12.656	4.002	45.75	63.85	30	70
	TSM Group	58.95	14.669	3.128	52.45	65.46	17	78
Initial Right Rotation ROM	Control	55.80	11.084	3.505	47.87	63.73	35	70
	TSM Group	60.41	15.271	3.256	53.64	67.18	22	85
Initial Pain with Left Rotation	Control	2.50	2.838	.898	.47	4.53	0	7
	TSM Group	3.73	2.707	.577	2.53	4.93	0	9
Initial Pain with Right Rotation	Control	2.80	1.889	.597	1.45	4.15	0	5
	TSM Group	2.75	2.671	.570	1.57	3.93	0	8

TSM = Experimental Group.

TABLE 2. Within-group comparisons of changes in cervical rotation (in degrees).

	Mean	Standard Deviation	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
			Lower	Upper			
Control Group Left Rotation	−0.6	3.66	−2.02	3.22	.529	9	.626
TSM Group Left Rotation	7.09	5.83	4.52	9.68	5.71	21	*< 0.01
Control Group Right Rotation	−0.1	2.33	−1.57	1.77	.136	9	.895
TSM Group Right Rotation	8.23	7.41	4.94	11.51	5.21	21	*< 0.01

* 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).

	Mean	Standard Deviation	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
			Lower	Upper			
Pain with Right Rotation Only							
Control Group Right Rotation	−.100	.224	−.378	.178	−1.00	4	.37
TSM Group Right Rotation	1.50	2.88	−1.52	4.52	1.28	5	.26
Pain with Left Rotation Only							
Control Group Left Rotation	.667	1.16	−2.20	3.54	1.00	2	.42
TSM Group Left Rotation	.688	1.03	−.176	1.55	1.88	7	.10
Pain during Bilateral Rotation							
Control Group Right Rotation	−.500	.707	−6.85	5.85	−1	1	.50
TSM Group Right Rotation	1.38	1.09	.461	2.29	3.56	7	*.01
Control Group Left Rotation	−.500	.707	−6.85	5.85	−1	1	.50
TSM Group Left Rotation	1.63	1.62	.270	2.98	2.84	7	*.03

* 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

TABLE 4. Reliability and responsiveness of inclinometer measurement of cervical active range of motion in rotation.

	ICC	SD	SEM	MDC95
Right rotation	.92	7.41	2.09	5.79
Left rotation	.82	5.83	2.47	6.82

ICC=Intraclass correlation coefficient; SD=Standard deviation; SEM=Standard error of measurement; MDC95 =minimal detectable change at 95% confidence.

EG) revealed significant within-group difference for the EG during right and left rotation (p = .01 and .03, respectively). No significant within-group difference was revealed during paired *t*-test analysis for the CG during right and left rotation (p = .50 and .50, respectively). For this subgroup, a repeated-measure ANOVA revealed significant between-group differences in pain during right rotation (p = .05) but not during left rotation (p = .25). The EG's mean (SD) 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_{95}. 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[25].

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 testing 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[37] 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 occured 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[28]. 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 stratagies 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 managment 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

1. Jette AM, Smith K, Haley SM, Davis KD. Physical therapy episodes of care for patients with low back pain. *Phys Ther* 1994;74:101–110.
2. Kelsey JL. *Epidemiology of Musculoskeletal*

Disorders. New York: Oxford University Press, 1982.

3. Aprill C, Bogduk N. The prevalence of cervical zygapophyseal joint pain: The first approximation. *Spine* 1992;17:744–747.
4. Kirkaldy-Willis WH, Burton CV. *Managing Low Back Pain.* 3rd ed. New York: Churchill Livingstone, 1992.
5. Bogduk N, Twomey LT. *Clinical Anatomy of the Lumbar Spine*. 2nd ed. Edinburgh, UK: Churchill Livingstone, 1991.
6. Ohnmeiss DD, Guyer RD, Mason SL. The relation between cervical discographic pain responses and radiographic images. *Clin J Pain* 2000;16:1–5.
7. Amevo B, Aprill C, Bogduk N. Abnormal instantaneous axes of rotation in patients with neck pain. *Spine* 1992;17:748–756.
8. Kaltenborn F. *The Spine: Basic Evaluation and Mobilization Techniques.* 2nd ed. Oslo, Norway: Olaf Norlis Bokhandel, 1993.
9. Norlander S, Gustavsson BA, Lindell J, Nordgren B. Reduced mobility in the cervicothoracic motion segment: A risk factor for musculoskeletal neck-shoulder pain. A two-year prospective follow-up study. *Scand J Rehabil Med* 1997;29:167–174.
10. Norlander S, Aste-Norlander U, Nordgren B, Sahlstedt B. Mobility in the cervico-thoracic motion segment: An indicative factor of musculo-skeletal neck-shoulder pain. *Scand J Rehabil Med* 1996;28:183–192.
11. Fernandez-de-la-Peñas C, Fernandez-Carnero J, Fernandez AP, Lomas-Vega R, Miangolarra-Page JC. Dorsal manipulation in whiplash injury treatment: A randomized controlled trial. *J Whiplash Related Disorders* 2004;3:55–72.
12. Triano JJ. Biomechanics of spinal manipulative therapy. *Spine* 2001;1:121–130.
13. Jull G, Bogduk N, Marsland A. The accuracy of manual diagnosis for cervical zygapophysial joint pain syndromes. *Med J Aust* 1988; 148:233–236.
14. Jull G, Zito G, Trott P, Potter H, Shirley D. Inter-examiner reliability to detect painful upper cervical joint dysfunction. *Aust J Physiother* 1997;43:125–129.
15. Evjenth O, Gloeck C. *The Symptom Localization in the Spine and Extremity Joints*. Seehausen, Germany: 1997.
16. Christensen HW, Vach W, Manniche C, Hagfelt T, Hartvisger L, Hoilund-Carlsen PF. Palpation of the upper thoracic spine: An observer reliability study. *J Manipulative Physiol Ther* 2002;25:285–292.
17. Bertilson BC, Grunnesjo M, Strender LE. Reliability of clinical tests in the assessment of patients with neck/shoulder problems: Impact of history. *Spine* 2003;28:2222–2231.
18. Breen A. The reliability of palpation and other diagnostic methods. *J Manipulative Physiol Ther* 1992;15:54–56.
19. Schiller L. Effectiveness of spinal manipulative therapy in the treatment of mechanical thoracic spine pain: A pilot randomized clinical trial. *J Manipulative Physiol Ther* 2001;24:394–401.
20. Cleland JA, Childs JD, McRea M, Palmer JA, Stowell T. Immediate effects of thoracic manipulation in patients with neck pain: A randomized clinical trial. *Man Ther* 2005; 10:127–135.
21. Cleland JA, Glynn P, Whitman JM, Eberhart SL, Macdonald C, Childs JD. Short-term effects of thrust vs. nonthrust mobilization/manipulation directed at the thoracic spine in patients with neck pain: A randomized clinical trial. *Phys Ther* 2007;87:431–440.
22. Cleland JA, Childs JD, Fritz JM, Whitman JM, Eberhart SL. Development of a clinical prediction rule in guiding treatment of a subgroup of patients with neck pain: Use of thoracic spine manipulation, exercise, and patient education. *Phys Ther* 2007;87:9–23.
23. Ross JK, Bereznick DE, McGill SM. Determining cavitation location during lumbar and thoracic spinal manipulation: Is spinal manipulation accurate and specific? *Spine* 2004;29:1452–1457.
24. Cleland JA, Flynn TW, Child JD, Eberhart S. The audible pop from thoracic spine manipulation and its relationship to short-term outcomes in patients with neck pain. *J Man Manip Ther* 2007;15:143–154.
25. Fernandez-del-la-Peñas C, Palomeque-del-Cerro L, Rodriguez-Blanco C, Gomez-Conesa A, Miangolarra-Page JC. Changes in neck pain and active range of motion after a single thoracic spine manipulation in subjects presenting with mechanical neck pain: A case series. *J Manipulative Physiol Ther* 2007;30:312–320.
26. Bieri D, Reeve R, Champion GD, Addicoat L, Ziegler JB. The Faces Pain Scale for the self-assessment of severity of pain experienced by children: Development, initial validation, and preliminary investigation for ratio scale properties. *Pain* 1990;41:139–150.
27. Stuppy, D. The Faces Pain Scale: Reliability and validity with mature adults. *Appl Nurs Res* 1998;11:84–89.
28. Kim EJ, Buschmann MT. Reliability and validity of the Faces Pain Scale with older adults. *Int J Nurs Stud* 2006;43:447–456.
29. Krauss J, Evjenth O, Creighton D. *TSM: Translatoric Spinal Manipulation for Physical Therapists.* Minneapolis, MN: Lakeview Media, 2006.
30. Van Schalkwyk R, Parkin-Smith GF. A clinical trial investigating the possible effect of the supine cervical rotatory manipulation and the supine lateral break manipulation in the treatment of mechanical neck pain: A pilot study. *J Manipulative Physiol Ther* 2000;23:324–331.
31. Parkin-Smith GF, Penter C. A clinical trial investigating the significance in two manipulative approaches in the treatment of mechanical neck pain: A pilot study. *J Neuromusc System* 1998;6:6–16.
32. Youdas JW, Carey JR, Garrett TR. Reliability of measurements of cervical spine range of motion: Comparison of three methods. *Phys Ther* 1991;71:98–104; discussion 105–106.
33. Creighton D, Viti J, Krauss J. Use of translatoric mobilization in a patient with cervical spondylotic degeneration: A case report. *J Man Manip Ther* 2005;13:12–26.
34. Stratford P. Getting more from the literature: Estimating the standard error of measurement from reliability studies. *Physiother Can* 2004;56:27–30.
35. Eliasziw M, Young S, Woodbury M, Fryday-Field K. Statistical methodology for the concurrent assessment of interrater and intrarater reliability: Using goniometric measurements as an example. *Phys Ther* 1994;74: 777–788.
36. Weir JP. Quantifying test-retest reliability using the interclass correlation coefficient and the SEM. *J Strength Cond Res* 2005; 19:231–240.
37. Childs J, Piva S, Fritz J. Responsiveness of the numeric pain rating scale in patients with low back pain. *Spine* 2005;30:1331–1334.