Available online at www.sciencedirect.com
SCIENCE DIRECT
ELSEVIER
Manual Therapy 10 (2005) 127–135
MANUAL THERAPY
www.elsevier.com/locate/math

Original article

Immediate effects of thoracic manipulation in patients with neck pain: a randomized clinical trial ☆

Joshua A. Cleland[a,b,*], Maj. John D. Childs[c], Meghann McRae[d], Jessica A. Palmer[a], Thomas Stowell[a]

[a]Physical Therapy Program, Franklin Pierce College, 5 Chenell Drive, Concord, NH 03301, USA
[b]Rehabilitation Services of Concord Hospital, Concord, NH, USA
[c]Department of Physical Therapy, Wilford Hall Medical Center, San Antonio, TX, USA
[d]Monadnock Community Hospital, Peterborough, NH, USA

Received 23 December 2003; received in revised form 14 July 2004; accepted 18 August 2004

Abstract

Mechanical neck pain is a common occurrence in the general population resulting in a considerable economic burden. Often physical therapists will incorporate manual therapies directed at the cervical spine including joint mobilization and manipulation into the management of patients with cervical pain. Although the effectiveness of mobilization and manipulation of the cervical spine has been well documented, the small inherent risks associated with these techniques has led clinicians to frequently utilize manipulation directed at the thoracic spine in this patient population. It is hypothesized that thoracic spine manipulation may elicit similar therapeutic benefits as cervical spine manipulation while minimizing the magnitude of risk associated with the cervical technique. The purpose of this randomized clinical trial was to investigate the immediate effects of thoracic spine manipulation on perceived pain levels in patients presenting with neck pain. The results suggest that thoracic spine manipulation results in immediate analgesic effects in patients with mechanical neck pain. Further studies are needed to determine the effects of thoracic spine manipulation in patients with neck pain on long-term outcomes including function and disability.

Keywords: Cervical pain; Thoracic spine manipulation; Manual therapy; Mechanical neck pain

1. Introduction

Approximately 54% of individuals have experienced neck pain within the last six months (Cote et al., 1998, 2000), and the incidence appears to be rising (Nygren et al., 1995). The economic burden due to neck disorders is high, second only to low back pain in annual workers' compensation costs in the United States (Wright et al., 1999). Patients with neck pain are frequently encountered in outpatient physical therapy practice, consisting of approximately 25% of all patients (Jette et al., 1994). Manual therapy interventions are one treatment strategy appropriate for patients with neck pain (American Physical Therapy Association, 2001). The *Guide to Physical Therapist Practice* (American Physical Therapy Association, 2001) uses the term ''mobilization/manipulation'' to refer to a ''manual therapy technique comprising a continuum of skilled passive movements to the joints and/or related soft tissues that are applied at varying speeds and amplitudes, including a small-amplitude/high-velocity therapeutic movement.'' To be more specific, the term ''manipulation'' in this paper refers specifically to techniques involving a high-velocity low-amplitude thrust, whereas mobilization refers to techniques performed as lower velocity, passive movements of a joint. Approximately 37% of therapists who

☆Work should be attributed to the Physical Therapy Program, Franklin Pierce College, Concord, NH.

*Corresponding author. Franklin Pierce College, 5 Chenell Drive, Concord, NH 03301, USA. Fax: +1 603 785 5576.
E-mail address: clelandj@fpc.edu (J.A. Cleland).

1356-689X/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.math.2004.08.005

routinely perform manual therapy interventions for patients with spinal disorders in their clinical practice perform manipulation and/or mobilization to the cervical spine in patients with neck pain (Hurley et al., 2002). The effectiveness of these interventions in patients with neck pain and cervicogenic headaches has been recently supported by an increasing number of high quality randomized clinical trials (RCT) (Bronfort et al., 2001b; Evans et al., 2002; Hoving et al., 2002; Jull et al., 2002), and systematic reviews (Bronfort et al., 2001a; Gross et al., 2002) suggesting both forms of manual therapy are effective.

The benefits of manual therapy interventions directed to the cervical spine must be considered in the context of the potential risks. The risk of serious complications such as vertebrobaslilar insufficiency (VBI) has been estimated to be extremely low (approximately six in 10 million; 0.00006%) (Hurwitz et al., 1996). However, studies to date have largely failed to substantiate the ability of currently available screening procedures to identify at-risk patients prior to treatment (DiFabio, 1999). Therefore, it has been suggested that cervical manipulation interventions be abandoned altogether (Bolton et al., 1989; Cote et al., 1996; DiFabio, 1999; Haldeman et al., 1999, 2002a,b). In one survey of physical therapists in Canada, 88% of respondents strongly agreed that all available screening tests should be performed prior to cervical manipulation (Hurley et al., 2002), suggesting that therapists are indeed concerned about the risks. Therefore, some therapists may conclude the benefits achieved from manual therapy interventions directed to the cervical spine are not worth even the small risks associated with these interventions.

Clinical experts have suggested that a thorough examination of the thoracic spine be included in the evaluation of patients with primary complaints of neck pain (Porterfield and DeRosa, 1995; Greenman, 1996). Due to the biomechanical relationship between the cervical and thoracic spine, perhaps disturbances in joint mobility in the thoracic spine serve as an underlying contributor to the development of neck disorders. It has also been demonstrated that mobilization/manipulation of joints remote to the patient's pain results in an immediate hypoalgesic effect (Vicenzino et al., 1996, 1998, 2001; Paungmali et al., 2003). This is speculated to occur through the stimulation of descending inhibitory mechanisms (Vicenzino et al., 1998; Skyba et al., 2003). For these reasons it has been suggested that perhaps the incorporation of thoracic spine manipulation interventions in lieu of manipulation or mobilization interventions directed to the cervical spine may avoid even the small inherent risks associated with manual therapy interventions directed to the cervical spine, while achieving similar therapeutic benefits (Erhard and Piva, 2000).

Only scant evidence exists regarding the use of thoracic spine manipulation in patients with neck pain. Flynn and colleagues have reported preliminary data suggesting that thoracic spine manipulation results in an immediate reduction in pain and increases in cervical range of motion in individuals presenting with primary neck dysfunction (Flynn et al., 2004). However, the lack of a comparison group in this study precludes establishing that a cause-and-effect relationship exists. In addition, Parkin-Smith (Parkin-Smith and Penter, 1998) and colleagues demonstrated that thoracic manipulation in addition to cervical manipulation in patients with neck pain was no more advantageous than cervical manipulation alone. Therefore, the purpose of this study was to further investigate the immediate effects of thoracic manipulation on neck pain in a randomized clinical trial.

2. Methods

Potential participants were patients between 18 and 60 years of age with a primary complaint of mechanical neck pain referred by their primary care physician to an outpatient orthopaedic physical therapy clinic. Mechanical neck pain was defined as nonspecific pain in the area of the cervicothoracic junction that is exacerbated by neck movements (Bogduk, 1984; Childs et al., 2003). The study was approved by the Institutional Review Board at Franklin Pierce College (Rindge, NH) before recruitment and data collection began. All patients provided informed consent.

Patients with "red flags" for a serious spinal condition (e.g., infection, tumors, osteoporosis, spinal fracture, etc.) were excluded, as were individuals who were pregnant, exhibited positive neurologic signs or symptoms suggestive of nerve root involvement (eg., symptoms distal to the acromion, or diminished upper extremity reflexes, sensation, or strength), had a history of cervical or thoracic surgery, exhibited hypermobility of the thoracic spine, or those who had prior experience with spinal manipulative techniques.

Prior to randomization, patients completed several self-report measures and then received a standardized history and physical examination by a licensed physical therapist. Demographic information including age, gender, past medical history, location and nature of symptoms was collected. Self-report measures included a body diagram to assess the distribution of symptoms (Mann et al., 1993). Subjects also completed the Neck Disability Index (NDI) to measure perceived disability. The NDI was collected only at baseline to assess for differences in disability between groups. The NDI is scored from 0 to 50, with higher scores corresponding to greater disability. The score is then multiplied by two and expressed as a percentage. The NDI has been demonstrated to be a reliable and valid assessment of disability in patients with neck pain (Vernon and Mior, 1991). A Visual Analog Scale (VAS) was used to record the patient's level of resting pain at baseline and immediately after treatment. The VAS is a 100 mm line anchored with a "0" at one end representing "no pain" and "100" at the other end representing "the worst pain imaginable". Patients placed a mark along the line corresponding to the intensity of their symptoms, which was scored to the nearest millimeter. The VAS is a reliable and valid instrument to assess pain intensity (Price et al., 1983; Bijur et al., 2001) and was selected as the outcome measure based on its ability to detect immediate changes in pain (Bijur et al., 2001; Bird and Dickson, 2001; Gallagher et al., 2001).

Following the baseline examination, the examining therapist left the treatment room and notified a second licensed physical therapist blinded to the patient's demographic information and baseline levels of pain and disability that the subject was ready for thoracic spine segmental mobility examination and associated treatment based on group assignment. Segmental mobility testing was performed in the positions of thoracic spine flexion and extension according to the procedures described by Bookhout (1994). The specific level(s) and position of restriction was recorded. The intrarater reliability of accurately identifying the specific level of segmental mobility restriction in the thoracic spine is poor (Kappa = .33) (Christensen et al., 2002).

Following the segmental mobility examination, patients were randomly assigned to receive either thoracic spine manipulation or placebo manipulation. A computer-generated randomized table of numbers created prior to the beginning of the study was utilized to determine group assignment. The patient's group assignment was sealed in a sequentially numbered opaque envelope and was opened after the treating therapist completed the segmental mobility examination. Treatment was then administered according to the patient's group assignment. The treating therapist was therefore unaware of the patient's group assignment during the segmental mobility examination.

2.1. Manipulation group

Patients randomized to the manipulation group received thoracic manipulation interventions directed to the previously identified segmental mobility restrictions. To perform the manipulation, the stabilizing hand was placed at the level immediately caudal to the restricted segment using a "pistol grip" (Fig. 1). Once the premanipulative position was achieved the patient was instructed to take a deep inhalation and exhale. During the exhalation the treating clinician performed a high velocity, small amplitude thrust in a direction to facilitate relative closing or opening of the respective facet joint as indicated by the segmental examination (Fig. 2) (Flynn, 1994). If an audible cavitation was heard during the first manipulation attempt, the treating clinician proceeded to the next segment. If no audible cavitation was heard, the patient was repositioned, and the manipulation intervention was repeated at the same segment. If no audible cavitation was noted after two attempts, the physical therapist manipulated the next segmental restriction. This procedure was repeated for each segmental mobility restriction identified, progressing sequentially from cephalad to caudad. The level at which treatment was directed and whether an audible cavitation was achieved was recorded.

There is little evidence to suggest that the thoracic spine manipulation interventions used in this study are specific for an individual level (Isaacs and Bookhout, 2002). Even presuming they are, it is possible that the lack of reliability to accurately identify individual

Fig. 1. Hand positioning utilized during manipulation techniques (actual technique performed with skin to skin contact).

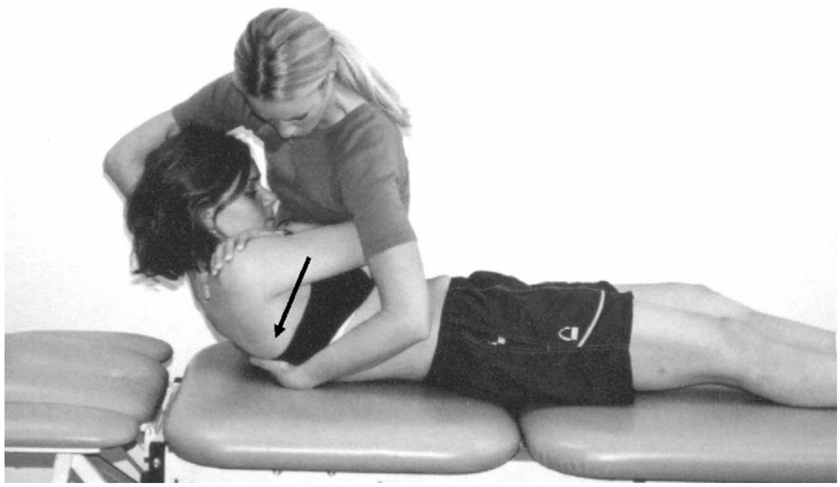

Fig. 2. Manipulation technique for a flexion restriction. High velocity, small amplitude thrust performed in the direction of the arrow.

segmental motion restrictions (Christensen et al., 2002), means that the segment presumed to be restricted may not be the same segment at which the thoracic spine manipulation intervention was directed. However, this procedure is consistent with standard of care practice during thoracic spine manipulation in patients with neck pain at our facility, and we are unaware of another decision-making scheme preferable to this one.

2.2. Placebo manipulation group

Patients randomized to receive placebo thoracic spine manipulation were placed in the identical set up position as patients in the manipulation group with the exception of hand positioning. An ''open hand'' was placed over the inferior vertebrae of the pre-determined segmental restriction. Once the ''premanipulative position'' was achieved, the patient was instructed to take a deep inhalation and then exhale. No high-velocity thrust maneuver was performed during the exhalation. The level at which the placebo or manipulation intervention was directed and whether an audible cavitation was achieved were both recorded. Given that patients with previous exposure to spinal manipulation were excluded from the study, it is unlikely that patients were aware that a high-velocity thrust maneuver is usually performed during this manipulation intervention.

The therapist who performed the baseline examination then re-entered the room, remaining blinded to the patient's group assignment. The patient was asked to report their perceived level of pain intensity on the VAS after treatment. This assessment was always performed within 5 min after completing treatment. All subjects were instructed to contact the principal investigator if they experienced any side effect (soreness lasting greater than 3 h).

2.3. Data analysis

Baseline demographic and self-report measures of pain and disability were compared between groups using independent *t*-tests or Mann–Whitney *U* tests for continuous data, and χ^2 tests of independence for categorical data (Table 1). A two-way repeated measures analysis of variance (ANOVA) was used to assess the change in pain intensity immediately after treatment. Intervention (thoracic spine manipulation or placebo manipulation) served as the between-subjects independent variable and Time (baseline and immediately after treatment) served as the repeated measures factor. The hypothesis of interest was the two-way Intervention*Time interaction based on an a priori determined alpha-level equal to .05. We hypothesized that patients who received thoracic spine manipulation would experience greater immediate improvements in pain than patients who received placebo manipulation. All data analysis was performed using the SPSS Version 10.1 statistical software package (SPSS Inc, Chicago, IL).

3. Results

Sixty-eight patients were screened for eligibility during a six-month period from January 2003 to June 2003. Sixteen patients (24%) did not satisfy the inclusion and exclusion criteria for the study. Sixteen eligible patients (31%) elected not to participate because of preferring not to receive manipulation interventions ($n = 11$) or specifically requesting manipulation ($n = 5$). The remaining 36 patients, mean age equal to 36 (SD = 9.8) (27 female), were randomized to receive thoracic spine manipulation ($n = 19$) or placebo manipulation ($n = 17$) (Fig. 3).

Table 1
The results of statistical analysis between manipulation and placebo manipulation groups for demographics and pretreatment visual analog score data

	Manipulation group ($n=19$)	Placebo manipulation group ($n=17$)	P
Age mean (SD);	36 (8.5)	35 (11.3)	.742
Gender mean (SD);	14 females	13 females	.849
Symptom Duration (in weeks) mean (SD);	12.2 (3.5)	13.2 (4.2)	.460
VAS pretreatment mean (SD);	41.6 (17.8)	47.7 (18.4)	.323
VAS post treatment means (SD);	26.1 (17.2)	43.5 (19.5)	$<.01$
VAS change score mean (SD);	15.5 (7.7)	4.2 (4.6)	$<.001$
Number of manipulations or placebo manipulations mean (SD);	3.7 (.83)	3.0 (.89)	.291
NDI mean (SD)	28.4 (11.9)	33.6 (14.2)	.237

VAS = Visual analog scale.
NDI = Neck disability index.

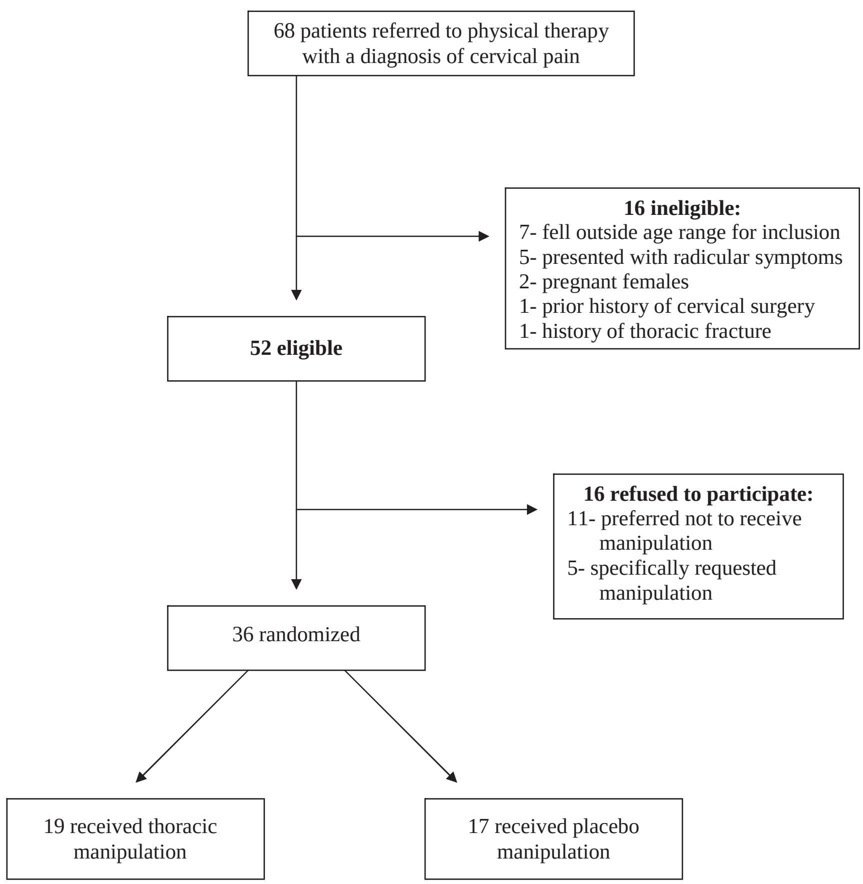

Fig. 3. Flow chart depicting subject selection and randomization.

No differences in key demographic variables or baseline levels of pain and disability were detected between the groups at baseline ($P>.05$) (Table 1). The repeated measures ANOVA demonstrated a significant Intervention∗Time interaction ($P<.001$) (Fig. 4), suggesting that patients receiving thoracic spine manipulation experienced immediate improvements in pain compared to patients in the placebo group. The change in pain in the group receiving thoracic spine manipulation was 15.5 mm (SD 7.7) mm (95% CI: 11.8, 19.2), compared to a change in the group receiving placebo manipulation of 4.2 mm (SD 4.6) (95% CI: 1.9, 6.6). The number of thoracic spine manipulations and placebo manipulations in each group was 3.7 and 3.0,

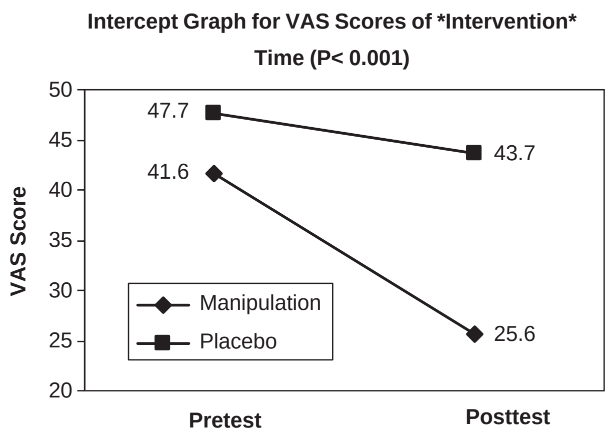

Fig. 4. Intercept graph for visual analog scores of *Intervention* Time ($P<.001$).

respectively ($P=.29$). No subjects in either group contacted the principal investigator after the completion of the study to report any side effects. Considering this we expect that no one experienced any sensation more than mild soreness following treatment or placebo.

4. Discussion

The results of this study suggest that thoracic spine manipulation in patients with a primary complaint of neck pain results in immediate improvements in their neck pain. Patients receiving thoracic spine manipulation demonstrated a mean change of 15.5 mm (95% CI: 11.8–19.2) on the VAS, compared to only a 4.2 mm (95% CI: 1.9–6.6) change among patients in the placebo group. Even if one presumes the lower bound of the 95% CI of 11.8 to be the point estimate for patients receiving thoracic spine manipulation, this magnitude of change still represents a clinically meaningful level of improvement (Kelly, 1998; Bird and Dickson, 2001; Kelly, 2001; Gallagher et al., 2001). In contrast, even if one conservatively presumes the upper bound of the 95% CI of 6.6 to be the point estimate for patients in the placebo group, this magnitude of change falls below the necessary level of change to substantiate that a clinically meaningful change has occurred (Kelly, 1998; Bird and Dickson, 2001; Kelly, 2001; Gallagher et al., 2001).

Despite evidence for its effectiveness, considerable attention has been given to the risk of serious complications such as vertebrobasilar insufficiency (VBI) from manual therapy interventions directed to the cervical spine (Hurwitz et al., 1996; DiFabio, 1999; Haldeman et al., 1999, 2002a,b). However, recent evidence suggests that cervical spine manipulation is beneficial for some patients (Cassidy et al., 1992; Hurwitz, 1996; Nilsson et al., 1997). Moreover, using techniques that place the patient's neck in a more neutral position (i.e. avoiding the terminal range of extension and rotation) appears to be a prudent strategy to minimize these risks and may be a more important consideration than the amount of force used (Mann and Refshauge, 2001; Symons et al., 2002). Therefore, we are not suggesting that cervical spine manipulation be avoided. However, the results of this study suggest that thoracic spine manipulation may be a reasonable alternative, or perhaps supplement to manual therapy interventions directed to the cervical spine. Parkin-Smith and Penter (1998) demonstrated that manipulating both the cervical and upper thoracic spine did not result in any significant benefits over patients receiving cervical manipulation, for neck pain. However, it was reported that some of the patients also received soft tissue massage yet the number of individuals or their group assignment was not reported. Therefore it is unknown if this added variable could have affected patient outcomes.

Despite the limited evidence for thoracic spine manipulation, many clinicians have intuitively adopted this same practice presumably because of less concern about risks with thoracic spine manipulation (Adams and Sim, 1998). A recent survey among clinicians that practice manual therapy reported that the thoracic spine is the region of the spine most often manipulated, despite the fact that more patients complain of neck pain (Adams and Sim 1998).

The precise mechanism by which thoracic spine manipulation improves neck pain remains elusive. It has been suggested that reductions in neck pain from thoracic spine manipulation interventions may be attributable to a restoration of more normal biomechanics to this region, potentially lowering mechanical stresses and improving the distribution of joint forces in the cervical spine. The theory that a biomechanical link between the thoracic and cervical spine may lead to abnormal distribution of forces in the cervical spine has only recently been investigated. Norlander et al. (1996, 1997), Norlander and Nordgren (1998) investigated whether mobility in the cervico-thoracic motion segment is associated with musculoskeletal neck-shoulder pain. They reported a significant relationship between decreased mobility in the thoracic spine and the presence of subjective complaints associated with neck pain (Norlander et al. 1996, 1997; Norlander and Nordgren, 1998). This hypothesis would have been further supported if we had collected measures related to musculoskeletal impairments such as cervical range of motion.

Several recent studies (Vicenzino et al., 1996, 2001; McLean et al., 2002; Coppieters et al., 2003) have demonstrated that manual therapy interventions directed at the spine can result in improvements in pain in regions distant to the area in which the treatment is directed. In addition, recent studies (Chiradejnant et al., 2003; Haas et al., 2003) have demonstrated that mobilization/manipulation techniques directed at impaired motion segments were no more beneficial than the treatment of randomly selected segments. It has been speculated that the immediate hypoalgesia following manual techniques directed at the spine may be related to stimulation of descending inhibitory mechanisms. (Vicenzino et al., 1998; Skyba et al., 2003).

We acknowledge several limitations. First, we limited this study to a short-term follow-up based on this study serving as a preliminary step in the investigation of the effects of thoracic spine manipulation in patients with neck pain. However, the fact that statistically significant and clinically meaningful change occurred over such a short time frame among patients who received thoracic spine manipulation bolsters the argument that these changes are likely relevant for patients with neck pain, providing impetus for future research in this area. Additionally, examining changes in cervical range of motion could have provided further insight as to the biomechanical implications associated with thoracic spine manipulation in patients with neck pain. Although we did not measure cervical spine ROM in this study, preliminary evidence (Flynn et al., 2004) suggests that thoracic spine manipulation is associated with immediate improvements in cervical spine ROM, providing a theoretical construct by which thoracic spine manipulation may act to improve pain in patients with a primary neck complaint.

Future research in this area should examine the long-term effects of thoracic spine manipulation in patients with neck pain on outcomes of care, patient satisfaction, and costs. Head-to-head clinical trials are also needed to determine if thoracic spine manipulation is most beneficial in isolation, or if it should in some combination as a supplement to manual therapy interventions directed to the cervical spine. Given the recent development and validation of a clinical prediction rule to identify patients with low back pain likely to experience a successful outcome from spinal manipulation (Flynn et al., 2002), perhaps the development of a clinical prediction rule would be advantageous to identify whether a subgroup of patients with a primary complaint of neck pain exists that may benefit from a manual therapy treatment approach directed primarily to the thoracic spine.

5. Conclusion

Thoracic spine manipulation results in immediate improvements in perceived levels of cervical pain in patients with mechanical neck pain. Given the concern regarding the risks of cervical spine manipulation, perhaps thoracic spine manipulation is a reasonable alternative, or supplement to, cervical manipulation and mobilization to maximize the patient's outcome at a reasonably low level of risk. This study was limited to an immediate follow-up and the patient's perceived levels of pain, thus further research is needed to examine the longer-term effects of thoracic spine manipulation on patient-centered outcomes and determine if relevant subgroups of patients with neck pain exist who may particularly benefit from thoracic spine manipulation interventions.

Disclaimer

The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the U.S. Air Force or Department of Defense.

References

Adams G, Sim J. A survey of UK manual therapists' practice of and attitudes towards manipulation and its complications. Physiotherapy Research International 1998;3(3):206–27.

American Physical Therapy Association (APTA). Guide to physical therapist practice, 2nd ed. Alexandria, VA: APTA; 2001.

Bijur PE, Silver W, Gallagher JE. Reliability of the visual analog scale for measurement of acute pain. Academic Emergency Medicine 2001;8(12):1153–7.

Bird SB, Dickson EW. Clinically significant changes in pain along the visual analog scale. Annals of Emergency Medicine 2001;36(6):639–43.

Bogduk N. Neck pain. Australian Family Physician 1984;13:26–30.

Bolton PS, Stick PE, Lord RS. Failure of clinical tests to predict cerebral ischemia before neck manipulation. Journal of Manipulative and Physiological Therapeutics 1989;12(4):304–7.

Bookhout MR. Evaluation of the Thoracic Spine and Rib Cage. In: Flynn TW, editor. The thoracic spine and rib cage; musculoskeletal evaluation and treatment. Boston: Butterworth-Heinemann; 1994. p. 147–70 (chapter 8).

Bronfort G, Assendelft WJ, Evans R, Haas M, Bouter L. Efficacy of spinal manipulation for chronic headache: a systematic review. Journal of Manipulative and Physiological Therapeutics 2001a;24(7):457–66.

Bronfort G, Evans R, Nelson B, Aker PD, Goldsmith CH, Vernon H. A randomized clinical trail of exercise and spinal manipulation for patients with chronic neck pain. Spine 2001b;26(7):788–99.

Cassidy JD, Lopes AA, Yong-Hing K. The immediate effect of manipulation versus mobilization on pain and range of motion in the cervical spine: a randomized controlled trial. Journal of Manipulative and Physiological Therapeutics 1992;15(9):570–5.

Childs JD, Whitman JM, Fritz JM, Piva SR, Young B. Physical therapy of the cervical spine and temporomandibular joint. Lacrosse, WI: Orthopaedic Section, American Physical Therapy Association, Inc; 2003.

Chiradejnant A, Maher CG, Latimer J, Stepkovitch N. Efficacy of "therapist selected" versus "randomly selected" mobilization techniques for the treatment of low back pain: a randomized controlled trial. Australian Journal of Physiotherapy 2003;49:233–41.

Christensen HW, Vach W, Vach K, Manniche C, Haghfelt T, Hartvisger L, Hoilund-Carlsen PF. Palpation of the upper thoracic spine: an observer reliability study. Journal of Manipulative and Physiological Therapeutics 2002;25(5):285–92.

Coppieters MW, Stappaerts KH, Wouters LL, Janssens K. The immediate effects of a cervical lateral glide treatment technique in patients with neurogenic cervicobrachial pain. Journal of Orthopaedic and Sports Physical Therapy 2003;33(7):369–78.

Cote P, Kreitz BG, Cassidy JD, Thiel H. The validity of the extension-rotation test as a clinical screening procedure before neck manipulation: a secondary analysis. Journal of Manipulative and Physiological Therapeutics 1996;19(3):159–64.

Cote P, Cassidy JD, Carroll L. The Saskatchewan Health and Back Pain Survey: the prevalence of neck pain and related disability in Saskatchewan. Spine 1998;23(15):689–98.

Cote P, Cassidy JD, Carroll L. The factors associated with neck pain and its related disability in the Saskatchewan population. Spine 2000;25(9):1109–17.

DiFabio RP. Manipulation of the cervical spine: risks and benefits. Physical Therapy 1999;79(1):50–65.

Erhard RE, Piva SR. Manipulation therapy. In: Placzek JD, Boyce DA, editors. Orthopaedic physical therapy secrets. Philadelphia: Hanley and Belfus; 2000. p. 83–91.

Evans R, Bronfort G, Nelson B, Goldsmith CH. Two-year follow-up of a randomized clinical trial of spinal manipulation and two types of exercise for patients with chronic neck pain. Spine 2002;27(21):2383–9.

Flynn TW. Direct treatment techniques for the thoracic spine and rib cage: muscle energy, mobilization, high-velocity thrust, and combined techniques. In: Flynn TW, editor. The thoracic spine and rib cage; musculoskeletal evaluation and treatment. Boston: Butterworth-Heinemann; 1994. p. 171–210 (chapter 9).

Flynn T, Fritz JM, Whitman J, Wainner R, Magel J, Butler B, Garber M, Allison S. A clinical prediction rule for classifying patients with low back pain who demonstrate short-term improvement with spinal manipulation. Spine 2002;27(24):2835–43.

Flynn T, Wainner R, Whitman J, Childs JD. The immediate effect of thoracic spine manipulation on cervical range of motion and pain in patients with a primary complaint of neck pain—a technical note. Journal of Orthopaedic and Sports Physical Therapy, 2004, in Review.

Gallagher EJ, Liebman M, Bijur PE. Prospective validation of clinically important changes in pain severity measured on a visual analog sale. Annals of Emergency Medicine 2001;38(6): 633–8.

Greenman PE. Principles of Manual Medicine, 2nd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 1996.

Gross AR, Kay TM, Kennedy C, Gasner D, Hurley L, Yardley K, Hendry L, McLaughlin L. Clinical practice guidelines on the use of manipulation or mobilization in the treatment of adults with mechanical neck disorders. Manual Therapy 2002;7(4):193–205.

Haldeman S, Kohlbeck FJ, McGregor M. Risk factors and precipitating neck movements causing vertebrobasilar artery dissection after cervical trauma and spinal manipulation. Spine 1999;24(8):785–94.

Haldeman S, Kohlbeck FJ, McGregor M. Stroke, cerebral artery dissection, and cervical spine manipulation therapy. Journal of Neurology 2002a;249(8):1098–104.

Haldeman S, Kohlbeck FJ, McGregor M. Unpredictability of cerebrovascular ischemia associated with cervical spine manipulation therapy: a review of sixty-four cases after cervical spine manipulation. Spine 2002b;27(1):49–55.

Haas M, Groupp E, Panzner D, Partna L, Lumsden S. Efficacy of cervical endplay assessment as an indicator for spinal manipulation. Spine 2003;28(11):1091–6.

Hoving JL, Koes BW, de Vet CW, van der Windt DAWM, Assendelt WJJ, Mameren Hv, Deville WLJM, Pool JJM, Scholten RJPM, Scholten JPM, Bouter LM. Manual therapy, physical therapy, or continued care by a general practitioner for patients with neck pain. Annals of Internal Medicine 2002;136(10):713–22.

Hurley L, Yardley K, Gross AR, Hendry L, McLaughlin L. A survey to examine attitudes and patterns of practice of physiotherapists who perform cervical spine manipulation. Manual Therapy 2002;7(1):10–8.

Hurwitz EL, Aker PD, Adams AH, Meeker WC, Shekelle PG. Manipulation and mobilization of the cervical spine. A systematic review of the literature. Spine 1996;21(15):1746–59.

Isaac ER, Bookhout MR. Treatment of the Thoracic Spine. In: Isaacs ER, Bookhout MR, editors. Bourdillon's spinal manipulation. 6th ed. Woburn, MA: Butterworth-Heinemann; 2002. p. 185–206 (chapter 9).

Jette AM, Smith K, Haley SM, Davis KD. Physical therapy episodes of care for patients with low back pain. Physical Therapy 1994;74(2):101–10.

Jull G, Trott P, Potter H, Zito G, Niere K, Shirley D, Emberson J, Marscher I, Richardson C. A randomized controlled trial of exercise and manipulative therapy for cervicogenic headache. Spine 2002;27(17):1835–43.

Kelly AM. Does the clinically significant difference in visual analog scale pain scores vary with gender, age, or cause of pain? Academic Emergency Medicine 1998;5(11):1086–90.

Kelly AM. The minimum clinically significant difference in visual analogue scale pain score does not differ with the severity of pain. Emergency Medicine Journal 2001;18(3):205–7.

Mann T, Refshauge KM. Causes of complications from cervical spine manipulation. Australian Journal of Physiotherapy 2001;47(4):255–66.

Mann NH, Brown MD, Hertz DB, Enger I, Tompkins J. Initial-impression diagnosis using low-back pain patient pain drawings. Spine 1993;18(1):41–53.

McLean S, Naish R, Reed L, Urry S, Vicenzino B. A pilot study of the manual force levels required to produce manipulation induced hypoalgesia. Clinical Biomechanics 2002;17(4):304–8.

Nilsson N, Christensen HW, Hartvigsen J. The effect of spinal manipulation in the treatment of cervicogenic headache. Journal of Manipulative and Physiological Therapeutics 1997;20(5):326–30.

Norlander S, Nordgren B. Clinical symptoms related to musculoskeletal neck-shoulder pain and mobility in the cervico-thoracic spine. Scandinavian Journal of Rehabilitation Medicine 1998;30:243–51.

Norlander S, Aste-Norlander U, Nordgram B, Sahlstedt B. Mobility in the cervico-thoracic motion segment: an indicative factor of musculoskeletal neck-shoulder pain. Scandinavian Journal of Rehabilitation Medicine 1996;28:183–92.

Norlander S, Gustavsson BG, Lindell J, Nordgren B. Reduced mobility in the cervico-thoracic motion segment—a risk factor for musculoskeletal neck-shoulder pain: a two-year prospective follow-up study. Scandinavian Journal of Rehabilitation Medicine 1997;29:167–74.

Nygren A, Berglund A, von Koch M. Neck-and-shoulder pain, an increasing problem. Strategies for using insurance material to follow trends. Scandinavian Journal of Rehabilitation Medicine 1995;32:107–12.

Parkin-Smith GF, Penter CS. A clinical trial investigating the effect of two manipulative approaches in the treatment of mechanical neck pain: a pilot study. Journal of Neuromusculoskeletal System 1998;6(1):6–16.

Paungmali A, O'Leary S, Souvlis T, Vicenzino B. Hypoalgesic and sympathoexcitatory effects of mobilization with movement for lateral epicondylalgia. Physical Therapy 2003;83(4):374–83.

Porterfield JA, DeRosa C. Mechanical neck pain: perspectives in functional anatomy. Philadelphia, PA: W.B. Saunders; 1995.

Price DD, McGrath PA, Raffi A, Buckingham B. The validation of visual analogue scales as a ratio scale measure for chronic and experimental pain. Pain 1983;17(1):45–56.

Skyba DA, Radhakrishnan R, Rohlwing JJ, Wright A, Sluka KA. Joint manipulation reduces hyperalgesia by activation of monoamine receptors but not opiod or GABA receptors in the spinal cord. Pain 2003;106:159–68.

Symons BP, Leonard T, Herzog W. Internal forces sustained by the vertebral artery during spinal manipulative therapy. Journal of Manipulative and Physiological Therapeutics 2002;25(8): 504–10.

Vernon H, Mior S. The neck disability index: a study of reliability and validity. Journal of Manipulative and Physiological Therapeutics 1991;14(7):409–15.

Vicenzino B, Collins D, Wright A. The initial effects of a cervical spine manipulative physiotherapy treatment on the pain and dysfunction of lateral epicondylalagia. Pain 1996;68(1):69–74.

Vicenzino B, Collins D, Benson H, Wright A. An investigation of the interrelationship between manipulative therapy-induced hypoalgesia and sympathoexcitation. Journal of Manipulative and Physiological Therapeutics 1998;21(7):448–53.

Vicenzino B, Paungmali A, Buratowski S, Wright A. Specific manipulative therapy treatment for chronic lateral epicondylalgia produces uniquely characteristic hypoalgesia. Manual Therapy 2001;6(4):205–12.

Wright A, Mayer TG, Gatchel RJ. Outcomes of disabling cervical spine disorders in compensation injuries. A prospective comparison to tertiary rehabilitation response for chronic lumbar spinal disorders. Spine 1999;24(2):178–83.