Journal of Back and Musculoskeletal Rehabilitation 21 (2008) 143–152
IOS Press

Review Article

Manual therapy for non-specific thoracic pain in adults: Review of the literature

Carla Vanti[a], Silvano Ferrari[b], Filomena Morsillo[c], Daniele Tosarelli[d] and Paolo Pillastrini[e,*]
[a]*Manual Therapy Sciences, University of Bologna, Bologna, Italy*
[b]*Manual Therapy Sciences, University of Padova, Padova, Italy*
[c]*Occupational Medicine Unit, S. Orsola-Malpighi Hospital, University of Bologna, Bologna, Italy*
[d]*Health Care Service, Istituti Ortopedici Rizzoli, Bologna, Italy*
[e]*Department of Neurological Sciences, University of Bologna, Bologna, Italy*

Abstract. *Objective:* The aims of this work are to evaluate the validity and reliability of manual assessment and treatment, and the effectiveness of manual therapy for non-specific adult thoracic pain.
Data sources: Review of the literature. Databases consulted: PubMed, Embase, CINAHL, PEDro, and the Cochrane Library.
Study selection: Articles were selected if they concerned the thoracic spine and rib cage, and outcome measures were within the scope of manual therapy practice.
Data extraction: Studies about diagnostic tests were excluded if the study population was less than 10 subjects, and Cohen's Kappa scores or Pearson's Correlation Coefficients or Intraclass Correlation Coefficients were not calculated. Studies about treatment were excluded if the PEDro score was less than 4/10.
Data synthesis: Studies concerning physical examination procedures have shown a good intrarater, but poor interrater reliability. Studies of the mechanical effects of manipulation have given discordant results, while those on the clinical effects of manipulation have given positive results.
Conclusions: Procedures of physical examination did not show sufficient interexaminer reliability. Manipulative treatment seems to be clinically effective, but whether manual treatment is more effective than non-treatment, other treatments or placebo, cannot be established.

Keywords: Back pain, spinal manipulation, manual therapy, physical examination

1. Background

The prevalence of spinal pain in the general population was estimated at 66%, with 44% of patients reporting pain in the cervical region, 56% in the lumbar region, and only 15% in the thoracic region. Non-specific adult thoracic pain of unknown or uncertain cause is not as common as neck and low back pain (respectively 2:5:20) [57] and as a consequence it is much less studied. In addition, there are no published studies on the evolution and progression of thoracic pain when treated or untreated. For reasons such as these, it is not known whether or not thoracic pain may share a similar evolution with low back and neck pain [45]. The assessment and treatment of the thoracic segment is not simple.

The complexity of the thoracic segment is due to the co-presence of numerous joints, the thoracic cage, the autonomic ganglia, and the passage of the neurovascular bundle from the cervical district to the upper limbs in the thoracic outlet. Therefore, there are many possible pain-generating locations and many segments which may cause the patient pain (thorax, chest, lumbar area, upper limbs and cervical area, etc.) [16,21,37,58]. Finally, often a pain of cervical origin is referred to the

*Corresponding author. E-mail: paolo.pillastrini@unibo.it.

ISSN 1053-8127/08/$17.00

thoracic paravertebral area [1,18,23] and the trunk is the most involved district for visceral pain [51].

There is neither a universally accepted method for collecting anamnesis, nor research investigating the validity and reliability of the elements of clinical history in relation to thoracic pain [13,34]. A physical exam may include inspection, palpation and observation of movements. Unfortunately, the available data concerning validity and reliability of these physical signs in the assessment of the thoracic spine are also very poor.

There are several procedures of manual therapy treatment for thoracic pain. The main procedures of passive manual therapy include Osteopathy [26], Chiropractics [3], Maitland's concept [44], Kaltenborn-Evjenth's Orthopaedic Manual Therapy [33], Cyriax's Orthopaedic Medicine [14], and Butler's Mobilization of the Nervous System [5]. Other procedures combine passive and active techniques, such as Mulligan's Mobilization with Movement [47] and Muscle Energy Techniques [6]. The McKenzie approach [46] emphasizes the importance of self-treatment. Other techniques focus on postural re-education or the treatment of muscular dysfunctions [12,53].

The role of manual therapy is not yet clear (resolution of joint dysfunctions, regaining a correct alignment, reduction of nuclear protrusion, reduction of meniscoid entrapment, joint decompression, etc.) [52] and there is not a single rationale for manipulation [2]. It is also not clear whether any clinical studies have demonstrated the reliability and effectiveness of manual therapy procedures or whether some procedures have proved to be better than others or than a placebo.

The aims of this review are to evaluate: (1) the validity and reliability of manual assessment and (2) the effectiveness of manual therapy for non-specific adult thoracic pain.

Therefore, this review concerns both the reliability of physical examination procedures, and the effects of treatment procedures. In Manual Therapy practice there is a link between assessment and treatment procedures: actually in the clinical setting some assessment procedures are used for evaluating the outcome of the manual treatment too. For this reason, high reliability of assessment procedures increases the quality of the clinical practice. Sometimes in the research setting different outcome measures were used: the outcome studies employ both manual procedures and other tools. Generally, it is better to choose, both for the clinical and the research setting, procedures as valid and reliable as possible.

2. Methods

We reviewed the international literature concerning validity, reliability and effectiveness of manual procedures of assessment and treatment of non-specific adult thoracic pain.

2.1. Literature search

The following medical databases were consulted: PubMed, Embase, CINAHL, PEDro, and the Cochrane Library. References of relevant articles were also screened. Two independent reviewers (CV, SF) conducted the searches. The searches were carried out in May 2007 with no date limitation.

The key words and free text words used to identify the study population were Thoracic spine – Rib cage – Thoracic pain – Thoracic dysfunction – Thoracic impairment – Rib cage pain – Chest pain – Complex regional pain syndrome.

The key words and free text words used to identify the validity and reliability of diagnostic tests were Measurement – Assessment – Palpation – Reliability – Validity – Responsiveness.

The key words and free text words used to identify the intervention were Manual therapy – Manipulation – Mobilization – Massage – Exercise – Physiotherapy – Bed rest – Back school – Conservative treatment.

2.2. Selection of studies

Articles were considered relevant and selected if (1) they concerned the thoracic spine and rib cage; (2) assessment and treatment procedures were within the field of physiotherapy or manual therapy practice; and (3) the language of publication was English, German, French, Spanish, Portuguese, or Italian.

Clinical studies about diagnostic tests were excluded if (1) the study population was less than 10 subjects; (2) Cohen's Kappa scores or Pearson's Correlation Coefficients or Intraclass Correlation Coefficients were not calculated. Clinical studies about treatment were excluded if (1) they were non-controlled studies, observational studies, case series, case reports, anecdotic or tutorial works; (2) the PEDro score [43] was less than 4/10; (3) they concerned physical modalities, such as ultrasound, magnetotherapy, electrotherapy, cryo-therapy and warm-therapy, manipulation under anaesthesia, acupuncture and other complementary therapies, back belts, pharmacological therapy and pain therapy.

3. Results

From the research in medical databases and libraries, 138 articles were examined of which 35 were considered relevant, and therefore were selected. According to exclusion criteria, 2 clinical studies about diagnostic tests and 13 clinical studies about treatment were excluded. Thus, this review includes 19 works, of which 2 are guidelines: Evidence-based Management of Acute Musculoskeletal Pain – Cap. 5 – Australian Acute Musculoskeletal Pain Guidelines Group [45] and Low Back – lumbar and thoracic (acute and chronic) – Guideline [59], 8 articles concern assessment [8,25, 27,29,32,42,50], and 9 treatment, of which 8 are randomized controlled trials [9–11,24,28,35,54,60] and 1 a controlled trial [39]. The majority of the articles about treatment concern chiropractic-type manipulative therapy (mobilization with impulse), while there is a lack of scientific literature concerning the various procedures of mobilization and the other active and passive techniques. Because of the lack of homogeneous and high level studies, we could not pool data for adequate meta-analysis. The results of the selected studies were divided by topics.

3.1. Validity and reliability of assessment procedures

The outcome in terms of intraexaminer reliability for cervico-thoracic and shoulder posture was positive; conversely, interexaminer reliability was found to be poor [27]. Most thoracic spine palpatory tests were poor in quantitative accuracy. In fact, studies indicated a limited or poor reliability. No study supported the effectiveness of palpatory tests with regards to standard criteria. Johnston [32] reported a high interexaminer reliability for the assessment of the presence or absence of deep muscle tension in marked spinal segments. Such interexaminer reliability, however, proved to be insufficient in unmarked spinal segments. Moderate interexaminer and intraexaminer reliability was found in paraspinal palpation for tenderness [8]. However, poor interexaminer and intraexaminer reliability was noticed in palpation for intercostal tenderness or tenderness in the minor and major pectoral muscles [7], and low reliability was found for the paraspinal percussion palpatory exam of the thoracic spine used to identify segmental tissue tension [25]. There were no studies on the reliability of tests for assessment of global movement restriction of the thoracic spine. Studies on segmental palpatory assessment of movement showed good repetitivity but low reproducibility [8,29,42]. The intraexaminer reliability in identifying a joint with signs of segmental dysfunction of the thoracic spine was also low [50] (Table 1).

3.2. Effectiveness of treatment procedures

Concerning the studies on the mechanical effects of manipulation, results were discordant. Thoracic spine manipulation seemed to be effective at restoring the normal joint mechanics and the recovery of thoracic ROM immediately after treatment, as emerged from Haas's randomized controlled trial (RCT) [28] and Gavin's RCT [24]. Postero-anterior manipulation however, did not seem to modify joint stiffness in the same direction in asymptomatic subjects, as indicated by Lee's CT [39] and manipulation without thrust did not appear to modify thoracic spine mobility, compared with non-treatment [35] (Table 2).

Regarding the effects on symptoms, some studies with positive results were found. Schiller [54] conducted an RCT on manipulation outcomes with a one-month follow-up, concluding that manipulation was more effective than placebo. Cleland [10] demonstrated that mobilization/manipulation with thrust was more effective in the short-term than non-thrust mobilization/manipulation. Manipulation seemed to be useful in the treatment of referred pain. Manipulation of thoracic spine seemed, in fact, to be effective in the reduction of mechanical cervical pain, as demonstrated in Cleland's RCT [9]. Manipulation of the upper thoracic spine seemed to reduce arterial pressure, as shown in Yates's RCT [60].

Lower thoracic spine manipulation appeared to improve muscle-strength and more specifically, it reduced the inhibition of the lower trapezius, as demonstrated in Cleland's RCT [11] (Table 3).

Clinical studies on effectiveness of education, active and home exercises, bed rest, work hardening, back school, were not found.

4. Discussion

The results of this review, though based on few papers, confirm most data from systematic reviews published on manual therapy of cervical and lumbar spine. First of all, concerning physical examination procedures, in line with our review, Najm [48] highlighted serious gaps in our knowledge about the accuracy of spinal palpatory procedures. Hestboek and Leboeuf-Yde [30] concluded that none of the chiropractic tests

Table 1
Studies concerning validity and reliability of assessment procedures

First author (Year)	Study type	Examiner	Study subject	Main results	Conclusions
Johnston (1983)	Interrater reliability	1 osteopathic faculty physician specializing in manipulation and 5 osteopathic medical students	31 volunteer patients	Intertester agreement: 79–86% distinguishing between the presence and absence of deep muscular tension of marked thoracic spinal segments. Slight level of intertester agreement (Kappa = 0.31) concerning the presence or absence of dysfunction in 10 unmarked thoracic spinal segments	Positive for interrater reliability of marked spinal segments Negative for interrater reliability of unmarked spinal segments
Love (1987)	Intrarater and interrater reliability	8 senior chiropractic students	32 volunteers student	Reliability for the most hypomobile motor unit of the spine: interrater reliability (Index of Association Statistic) not statistically significant; intrarater reliability (Pearson Product Moment Correlation Coefficient) statistically significant levels of agreement for each of the examiners (r = 0.300)	Positive for intrarater reliability Negative for interrater reliability
Griegel-Morris (1992)	Intrarater and interrater reliability	3 examiners	5 healthy subjects in the interrater component of the study. 10 healthy subjects in the intrarater component of the study	Reliability (Kappa coefficients) for postural assessment: interrater reliability 0.611; intrarater reliability: 0.825	Positive for intrarater reliability Negative for interrater reliability
Haas (1995)	Intrarater and interrater reliability	2 experienced chiropractors	73 asymptomatic and symptomatic volunteers	Reliability (Kappa coefficients) for end-play palpation on the thoracic spine: inter-examiner reliability 0.14–0.19 (poor); intra-examiner reliability 0.55 and 0.43 for the respective examiners (moderate)	Positive for intrarater reliability Negative for interrater reliability
Ghoukassian (2001)	Interrater reliability	10 senior postgraduate experienced osteopathic students	19 asymptomatic volunteers	Reliability (Kappa scores) for paraspinal percussion palpatory exam of the thoracic spine: inter-examiner reliability 0.07 (poor)	Negative for interrater reliability
Christensen (2002)	Intrarater and interrater reliability	2 chiropractors in the interobserver component of the study 1 chiropractor in the intraobserver component of the study	29 patients and 27 subjects in the interobserver component of the study. 14 patients and 15 subjects in the intraobserver component of the study	Reliability (Kappa coefficients) with paraspinal palpation for tenderness of T1–8: interrater reliability 0.67–0.70, intrarater reliability: 0.63–0.77. Reliability (Kappa coefficients) with prone and sitting motion palpation: interrater reliability 0.24 and 0.22. Expanded agreement accepting small inaccuracies with all 3 palpation procedures: intrarater reliability: 0.59-0.77	Positive for intrarater reliability with 3 palpation procedures Positive for interrater reliability with paraspinal tenderness Negative for interrater reliability with motion palpation
Christensen (2003)	Intrarater and interrater reliability	2 chiropractors in the interobserver component of the study 1 chiropractor in the intraobserver component of the study	29 patients and 27 subjects in the interobserver component of the study. 14 patients and 15 subjects in the intraobserver component of the study	Reliability (Kappa coefficients) with palpation for tenderness in the anterior chest wall: interrater reliability 0.22-0.31; intrarater reliability: 0.21-0.28 for the day-to-day reliability and 0.44 to 0.49 for the hour-to-hour reliability	Negative for intrarater reliability Negative for interrater reliability
Potter (2006)	Intrarater reliability	1 experienced osteopath	12 asymptomatic subjects	Intratester reliability (Intraclass correlation coefficients) for the thoracic spine 0.70 Reliability: poor	Negative for intrarater reliability

Table 2
Studies concerning mechanical effects of manipulation

First author (Year)	Study type	PEDro score	Participants	Interventions	Outcome measures	Main results	Effect size***	Conclusions
Haas (1995)	Randomized controlled trial	7/10*	60 asymptomatic subjects	E: manual high-velocity, low-amplitude rotatory manipulation C: no intervention	End-play response (the change from restricted to normal end play) immediately after intervention	End-play response 60% in the treatment group, in contrast to the 37% response in the control group. Moderate short-term responsiveness of rotatory thoracic end-play restriction to spinal manipulation	0.23 (0.11)	Positive
Gavin (1999)	Randomized controlled trial	6/10**	78 asymptomatic subjects	E1: mobility testing only E2: mobility testing and joint manipulation to a restricted segment C: no intervention	Thoracic active range of motion (forward bending and side bending right and left)	A significant difference was seen in side bending to the left only	E1 vs E2: −0.7 (0.71) E1 vs C: −2.2 (0.64) E2 vs C: −1.5 (0.83)	Positive
Kessler (2005)	Randomized controlled trial	5/10**	36 volunteers	E: posterior-anterior manipulations without thrust, two times a week for three weeks C: no intervention	Thoracic spine mobility objective evaluation, by using Medimouse. F: Thoracic spine Flexion E: Thoracic spine Extension GM: Thoracic spine General Mobility	No significant difference in the mobility of the thoracic spine within the intervention group and in comparison with the control group	F: 1.04 (3.18) E: 0.8 (3.26) GM: −0.42 (4.18)	Negative
Lee (1993)	Controlled trial	4/10**	30 asymptomatic subjects	E: posteroanterior thrust applied to the T4-5 spinal level C: supine lying	Postero-anterior stiffness at the T4 and T5 levels	No significant difference between interventions	T4: 0.35 (0.87) T5: 0.58 (0.96)	Negative

*PEDro score attributed by PEDro.
**PEDro score attributed by authors.
***Outcome measures differences between groups (standard error).

Table 3
Studies concerning clinical effects of manipulation

First author (Year)	Study type	PEDro score	Participants	Interventions	Outcome measures	Main results	Effect size***	Conclusions
Cleland (2007)	Randomized controlled trial	10/10**	60 patients with primary complaint of neck pain	E: upper and middle thoracic spine thrust mobilization/manipulation C: T1-T6 non-thrust mobilization/manipulation	NDI: Neck Disability Index NPRS: Numeric Pain Rating Scale	Thoracic spine thrust mobilization/manipulation results in significantly greater short-term reduction in pain and disability	NDI: 10 (2.34) NPRS: 2 (0.34)	Positive
Cleland (2004)	Randomized controlled trial	8/10**	40 asymptomatic subjects	E: thoracic manipulation of the lower thoracic spine (T6-T12) C: placebo technique	Measurements of isometric lower trapezius muscle strength using a Nicholas Manual Muscle Tester	Significantly greater percentage increase in lower trapezius strength in the manipulation group as compared to the controls. Lower thoracic manipulation techniques may be beneficial in reducing the lower trapezius muscle inhibition	Increase in Peak strength: 1.24 (0.20) Percentage strength increase: 10.6 (2.04)	Positive
Cleland (2005)	Randomized controlled trial	8/10*	36 patients with a primary complaint of mechanical neck pain	E: thoracic spine manipulation directed to the segmental mobility restrictions. C: placebo manipulation	Neck Disability Index, VAS	Thoracic spine manipulation results in immediate analgesic effects in patients with non-specific pain in the area of the cervicothoracic junction that is exacerbated by neck movements	11.3 (2.09)	Positive
Yates (1988)	Randomized controlled trial	6/10*	21 patients with elevated blood pressure	E1: active treatment: chiropractic adjustments of the thoracic spine (T1-T5) E2: placebo treatment C: no treatment	Systolic and diastolic blood pressure, and State-Trait Anxiety Inventory	Systolic and diastolic blood pressure decreased significantly in the active treatment condition, whereas no significant changes occurred in the placebo and control conditions. State anxiety significantly decreased in the active and control conditions	Systolic blood pressure: E1 vs E2: −16.14 (2.69) E1 vs C: −16.14 (3.14) Diastolic blood pressure: E1 vs E2: −11.57 (1.56) E1 vs C: −13.71 (1.35) State of anxiety: E1 vs E2: −7.58 (2.22) E1 vs C: −3.86 (1.28)	Positive

Table 3, continued

First author (Year)	Study type	PEDro score	Participants	Interventions	Outcome measures	Main results	Effect size***	Conclusions
Schiller (2001)	Randomized controlled trial	4/10*	30 subjects with mechanical thoracic spine pain	E: thoracic spinal manipulation C: non functional ultrasound application only. Both groups received 6 treatments over a period of 2 to 3 weeks	Objective measurements: thoracic spine ranges of motion with the BROM II goniometer and pain threshold with an algometer. Subjective information: Oswestry Back Pain Disability Index, McGill Pain Questionnaire, Numerical Pain Rating Scale-101 Questionnaire	E group: significant improvements in both subjective and objective measurements between the first to final treatment and the first treatment to the 1-month follow-up consultation. C group: statistically significant improvement in sensory pain only (subjective measurement) between the first treatment and the final treatment. Spinal manipulative therapy has greater benefits than placebo treatment	Numerical Pain Rating Scale – Final treatment −13.7 (4.70) McGill Pain Questionnaire – 1 month follow-up −0.05 (0.54)	Positive

*PEDro score attributed by PEDro.
**PEDro score attributed by authors.
***Outcome measures differences between groups (standard error).

for lumbo-pelvic spine had been sufficiently evaluated in relation to reliability and validity. Only tests for palpation for pain had consistently acceptable results. Motion palpation of the lumbar spine might be valid, but showed poor reliability. Palpation for muscle tension, palpation for misalignment and visual inspection were undocumented, unreliable, or not valid.

Seffinger [55] concluded that the majority of spinal palpatory diagnostic procedures were unreliable, pain provocation tests were most reliable, and soft tissue tests were not reliable. Regional range of motion was more reliable than segmental range of motion, and intraexaminer reliability was better than interexaminer reliability.

Moreover, many abnormalities were found by palpation in asymptomatic subjects. Anatomic variations developed frequently among bones and joints in the thoracic spine: for example, at the thoraco-lumbar junction, in more than 30% of subjects, an asymmetry of over 20° of the Z-joints was found [19]. There may also be an asymmetric orientation of the joint that is not reflected in a malalignment of the spinal process, and on the other hand, there may be other cases where there is a co-presence of symmetrically oriented joints and an asymmetric spinal process.

Our review also showed good intrarater reliability and a poor interrater reliability for palpatory tests.

We did not find articles on pain provocation tests, but our review highlighted moderate reliability for paravertebral palpation for tenderness and poor reliability for palpation for intercostal tenderness or tenderness in the minor and major pectoral muscles.

Although the thoracic spine is the most often manipulated region of the spine, recent literature showed that little evidence of effectiveness could be found for manual therapy treatments for non-specific thoracic pain and often these studies mentioned back pain, without distinguishing thoracic pain from low back pain. Di Fabio showed that there was a lack of specific publications [17] and the same judgment was expressed by March [45] and Sran [56].

Our review highlighted that there were no sufficient elements to recommend for or against any specific type of techniques, but there was an appreciable effectiveness of manipulative treatments.

However, some studies recommended careful consideration of contraindications, such as structural lesions and neurological disturbances [20], and advised pre-manipulative assessment tests and an inclination towards preferring non-traumatic manipulations [36]. In fact, techniques that include forced extensions and rotations may result in pain, damage of the joint surfaces or a painful block of the *joint menisci* [19]. An additional element supporting a cautious approach was presented in the Leboeuf-Yde and Borchgrevink study [38], showing how most side effects (local or radiating discomfort, headache, tension, dizziness, nausea, hot skin, etc.), appeared in the first session, when the treatment was extended to several levels and when the treatment was applied to the thoracic spine alone.

Bronfort et al. [4] suggested that recommendations can be made with some confidence regarding the use of spinal manipulative therapy and/or mobilization as a viable option for the treatment of both low back and neck pain. Atchison [2] underlined that the number of studies published for the upper body was small compared to the lumbar spine and the lack of uniformity of the information still leaves the individual practitioner to decide if and when manipulation fits into his or her treatment algorithms for this region of the body. Considering the adverse effects, Ernst and Canter [20] did not suggest that spinal manipulation was a recommendable treatment. Sran [56] concluded that the use of a variety of manual therapy techniques, rather than joint manipulation alone, appeared to yield better results. Fernández-de-las-Peñas et al. [22] underline that "more than one mechanism likely explains the effects of thoracic spinal manipulation. Future controlled studies comparing spinal manipulation vs spinal mobilization of the thoracic spine are required".

The integration of passive and active treatments was suggested by the Work Loss Data Institute's Guideline [59]; also Liebenson [40,41] and O'Malley [49] suggested completing manipulative treatments with postural correction, muscle strengthening and soft tissue relaxation, to prevent recurrences. A correct distribution of tasks between the physical therapist (who corrects dysfunctions and educates) and the patient (who maintains regained mobility and tissue elasticity, and avoids constant or repetitive postural stress), could be the best strategy. However, we could not find any clinical study demonstrating the effectiveness of this approach.

Some authors stressed the importance of reassuring and educating the patient [31,59]. An indication along these lines was given by De Jong [15] in a work showing how the application of graded exposure *in vivo* in chronic patients with pain-related fear in Complex Regional Pain Syndrome type I was successful at decreasing levels of self-reported pain-related fear, pain intensity, disability, and physiological signs and symptoms.

5. Conclusions

From a review of the available literature on the assessment and treatment of non-specific thoracic pain by manual therapy procedures, no firm conclusions can be drawn. In general, few studies on these topics were found and among these even fewer were of high quality. Studies concerning some procedures of physical examination, such as identification of vertebral levels, assessment of segmental movement restriction and assessment of segmental dysfunctions, showed good intrarater reliability, but poor interrater reliability. Only the palpation for paravertebral tenderness showed moderate reliability. However, no study evaluated the validity of these assessment procedures.

Studies on mechanical effects of manipulation gave discordant results. Studies on clinical effects of manipulation reported positive results in reducing symptoms, increasing muscle activation, and improving ROM. However, no study distinguished acute from chronic patients and most studies had a short-term follow-up. Whether manual therapy treatment is more effective than non-treatment, other treatments, or placebo, and what treatment might be the most effective cannot be established.

More studies in this specific field are required, particularly high quality studies that may discern between acute, sub-acute and chronic patients, including subgroups of clearly defined patients, and clearly defining the type of treatment applied (manipulation, mobilization) and consequent results. Such studies should allow: (1) investigation of the validity and reliability of assessment procedures; (2) investigation of the effectiveness of manual therapy techniques; (3) comparison of the outcomes of different treatments and comparison of the outcome of treatment versus no-treatment or versus placebo.

References

[1] C. Aprill, A. Dwyer and N. Bogduk, Cervical zygapophyseal joint pain patterns II: a clinical evaluation, *Spine* **15** (1990), 458–461.

[2] J.W. Atchison, Manipulation efficacy: Upper body, *Journal of Back and Musculoskeletal Rehabilitation*, **15** (2000), 3–15.

[3] T.F. Bergmann, D.H. Peterson and D.J. Lawrence, eds, *Chiropractic Technique: Principles and Procedures*, Churchill Livingstone, New York, 1993.

[4] G. Bronfort, M. Haas, R.L. Evans and L.M. Bouter, Efficacy of spinal manipulation and mobilization for low back pain and neck pain: a systematic review and best evidence synthesis, *Spine J* **4** (2004), 335–356.

[5] D. Butler, ed., *Mobilisation of the Nervous System*, Churchill Livingstone, New York, 1991.

[6] L. Chaitow, ed., *Muscle Energy Techniques*, Churchill Livingstone, Edinburgh, 1996.

[7] H.W. Christensen, W. Vach, C. Manniche, T. Haghfelt, L. Hartvigsen and P.F. Hoilund-Carlsen, Palpation for muscular tenderness in the anterior chest wall: an observer reliability study, *J Manipulative Physiol Ther* **26** (2003), 469–475.

[8] H.W. Christensen, W. Vach, K. Vach, C. Manniche, T. Haghfelt, L. Hartvigsen and P.F. Hoilund-Carlsen, Palpation of the upper thoracic spine: an observer reliability study, *J Manipulative Physiol Ther* **25** (2002), 285–292.

[9] J.A. Cleland, J.D. Childs, M. McRae, J.A. Palmer and T. Stowell, Immediate effects of thoracic manipulation in patients with neck pain: A randomized clinical trial, *Manual Therapy* **10** (2005), 127–135.

[10] J.A. Cleland, P. Glynn, J.M. Whitman, S.L. Eberhart, C. MacDonald and J.D. Childs, Short-term effects of thrust versus nonthrust mobilization/manipulation directed at the thoracic spine in patients with neck pain: a randomized controlled trial, *Physical Therapy* **4** (2007), 431–440.

[11] J. Cleland, Short-term effects of thoracic manipulation on lower trapezius muscle strength. *J Manual Manipulative Ther* **12** (2004), 82–90.

[12] M.J. Comerford, Functional stability re-training: principles and strategies for managing mechanical dysfunction, *Manual Therapy* **6** (2001), 15–26.

[13] B. Corrigan and G.D. Maitland, eds, *Practical Orthopaedic Medicine*, Butterworths, Sydney, 1988.

[14] J. Cyriax, ed., *Cyriax's Illustrated Manual of Orthopaedic Medicine*, Butterworth-Heinemann, London, 1993.

[15] J.R. De Jong, J.W. Vlaeyen, P. Onghena, C. Cuypers, M. Den Hollander and J. Ruijgrok, Reduction of pain-related fear in complex regional pain syndrome type I: the application of graded exposure *in vivo*, *Pain* **116** (2005), 264–275.

[16] G.G. DeFranca and L.J. Levine, The T4 syndrome, *J Manipulative Physiol Ther* **18**(1), (1995), 34–37.

[17] R.P. Di Fabio, Efficacy of manual therapy, *Physical Therapy* **72** (1992), 853–864.

[18] A. Dwyer, C. Aprill and N. Bogduk, Cervical zygapophyseal joint pain patterns: a study in normal volunteers, *Spine* **15** (1990), 453–457.

[19] S.J. Edmondston and K.P. Singer, Thoracic spine: Anatomical and biomechanical considerations for manual therapy, *Manual Therapy* **2** (1997), 132–143.

[20] E. Ernst and P.H. Canter, A systematic review of systematic reviews of spinal manipulation, *Journal of the Royal Society of Medicine* **99** (2006), 189–193.

[21] M.W. Erwin, P.C. Jackson and D.A. Homonko, Innervation of the human costovertebral joint: implications for clinical back pain syndromes, *J Manipulative Physiol Ther* **23** (2000), 395–403.

[22] C. Fernández-de-las-Peñas, L. Palomeque-del-Cerro, C. Rodríguez-Blanco, A. Gómez-Conesa, JC Miangolarra-Page, 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* **4** (2007), 312–320.

[23] S. Fukui, K. Ohsero, M. Shioriani, K. Ohno, H. Karasawa, Y. Naganuma and Y. Yuda, Referred pain distribution of the cervical zigapophyseal joints and cervical dorsal rami, *Pain* (1996), 79–83.

[24] D. Gavin, The effect of joint manipulation techniques on active range of motion in the mid-thoracic spine of asymptomatic subjects, *J Manual Manipulative Ther* **7** (1999), 114–122.
[25] M. Ghoukassian, B. Nicholls and P. McGlaughlin, Inter-examiner reliability of the Johnson and Friedman percussion scan of the thoracic spine, *J Osteo Med* **1** (2001), 15–20.
[26] P. Gibbons and P. Tehan, eds, *Manipulation of the Spine, Thorax, and Pelvis. An Ostheopatic Perspective,* Churchill Livingstone, London, 2000.
[27] P. Griegel-Morris, K. Larson, K. Mueller-Klaus and C.A. Oatis, Incidence of common postural abnormalities in the cervical, shoulder and thoracic regions and their association with pain in two age groups of healthy subjects, *Physical Therapy* **72** (1992), 425–430.
[28] M. Haas, D. Panzer, D.C. Peterson and R. Raphael, Short-term responsiveness of manual thoracic end-play assessment to spinal manipulation: A randomized controlled trial of construct validity, *J Manipulative Physiol Ther* **18** (1995), 582–589.
[29] M. Haas, R. Raphael, D. Panzer and D. Peterson, Reliability of manual end-play palpation of the thoracic spine, *Chiropractic Tech* **7** (1995), 120–124.
[30] L. Hestboek and Ch. Leboeuf-Yde, Are Chiropractic Tests for the Lumbo-Pelvic Spine Reliable and Valid? A Systematic Critical Literature Review, *J Manipulative Physiol Ther* **23** (2000), 258–275.
[31] S. Jensen, Musculoskeletal causes of chest pain, *Aust Fam Physician* **30** (2001), 834–839.
[32] W.L. Johnston, B.R. Allan, J.L. Hendra, D.R. Neff, M.E. Rosen and S.C. Thomas, Interexaminer study of palpation in detecting location of spinal segmental dysfunction. *Journal of the American Osteopathic Association* **82** (1983), 839–845.
[33] F.M. Kaltenborn, ed., *The Spine: Basic Evaluation and Mobilisation Techniques*, Olaf Norlis Bokhandel, Oslo, 1993.
[34] C. Kenna and J. Murragh, eds, *Back Pain and Spinal Manipulation*, Butterworths, Sydney, 1989.
[35] T.J. Kessler, F. Brunner, S. Kunzer, M. Crippa and R. Kissling, Effects of Maitland's manual mobilization on the thoracic spine, *Rehabilitation* (*Stuttg*) **44** (2005), 361–366.
[36] R. Kestlmeier, Thoracic disc herniation: A rare differential diagnosis of segmental irritation. Guidelines for chiropractic manipulations, *Zentralblatt fur Neurochirurgie* **60** (1999), 121–124.
[37] K. Lamb, Thoracic disk herniation: A case report, *J Manipulative Physiol Ther* **24** (2001), 58–62.
[38] C. Leboeuf-Yde and C. Borchgrevink, Predictors of side effects to spinal manipulative therapy, *J Manipulative Physiol Ther* **19** (1996), 441–445.
[39] M. Lee, Manipulation: Investigation of a proposed mechanism, *Clinical Biomechanics* **8** (1993), 302–306.
[40] C. Liebenson, Self-treatment of mid-thoracic dysfunction: A key link in the body axis – Part One, *Journal of Bodywork and Movement Therapies* **5** (2001), 90–98.
[41] C. Liebenson, Self-treatment of mid-thoracic dysfunction: A key link in the body axis – Part Two: Treatment, *Journal of Bodywork and Movement Therapies* **5** (2001), 191–195.
[42] R.M. Love and R.R. Brodeur, Inter- and intra-examiner reliability of motion palpation for the thoracolumbar spine, *J Manipulative Physiol Ther* **10** (1987), 1–4.
[43] C.G. Maher, C. Sherrington, R.D. Herbert, A.M. Moseley and M. Elkins, Reliability of the PEDro scale for rating quality of randomized controlled trials. *Physical Therapy* **8** (2003), 713–721.
[44] G.D. Maitland, ed., *Vertebral Manipulation*, Butterworth-Heinemann, London, 1986.
[45] L. March (National Health and Medical Research Council (NHMRC) and the Australian Acute Musculoskeletal Pain Guidelines Group), GUIDELINE TITLE: Evidence-based management of acute musculoskeletal pain. *Australian Acute Musculoskeletal Pain Guidelines Group*. Guideline 2003.
[46] R.A. McKenzie, ed., *The Cervical and Thoracic Spine: Mechanical Diagnosis and Therapy,* Spinal Publications, Wellington – New Zealand, 1990.
[47] B. Mulligan, Manual Therapy: "NAGS", "SNAGS", "MWMS" etc, ed. Plane View Services, Wellington – New Zealand, 1999.
[48] W.I. Najm, M.A. Seffinger, S.I. Mishra, V.M. Dickerson, A. Adams, S. Reinsch, L.S. Murphy and A.F. Goodman, Content validity of manual spinal palpatory exams – A systematic review, *BMC Complementary and Alternative Medicine* **3** (2003), 1.
[49] T.P. O'Malley, Manual examination and treatment of the cervicothoracic region, *Orthopaedic Physical Therapy Clinics of North America* **7** (1998), 499–523.
[50] L. Potter, C. McCarthy and J. Oldham, Intraexaminer reliability of identifying a dysfunctional segment in the thoracic and lumbar spine, *J Manipulative Physiol Ther* **29** (2006), 203–207.
[51] V. Rucco, ed., *Il Dolore Vertebrale. Cervicalgie, Dorsalgie, Lombalgie e Sindromi Correlate,* Verduci, Rome, 1996.
[52] V. Rucco, Regression of enlarged lumbar zygapophyseal inclusions after manipulative therapy: A case report, *Rivista di Neuroradiologia* **11** (1998), 113–116.
[53] S. Sahrmann, ed., *Diagnosis and Treatment of Movement Impairment Syndromes*, Mosby, St. Louis, 2002.
[54] L. Schiller, Effectiveness of spinal manipulative therapy in the treatment of mechanical thoracic spine pain: A pilot randomized clinical trial, *J Manipulative Physiol Ther* **24** (2001), 394–401.
[55] M.A. Seffinger, W.I. Najm, S.I. Mishra, A. Adams, V.M. Dickerson, L.S. Murphy and S. Reinsch, Reliability of Spinal Palpation for Diagnosis of Back and Neck Pain. A Systematic Review of the Literature, *Spine* **29** (2004), E413–E425.
[56] M.M. Sran, To treat or not to treat: New evidence for the effectiveness of manual therapy *British Journal of Sport Medicine* **38** (2004), 521–525.
[57] R.J. Stolker, A.C. Vervest and G.J. Groen, Percutaneous facet denervation in chronic thoracic spinal pain, *Acta Neurochirurgica* **122** (1993), 82–90.
[58] A. Wilke, Thoracic disc herniation: A diagnostic challenge, *Manual Therapy* **5**(**3**) (2000), 181–184.
[59] Work Loss Data Institute, Corpus Christi (TX): GUIDELINE TITLE: Low back – lumbar & thoracic (acute & chronic). Guideline 2006.
[60] R.G. Yates, D.L. Lamping, N.L. Abram and C. Wright, Effects of chiropractic treatment on blood pressure and anxiety: a randomized, controlled trial, *J Manipulative Physiol Ther* **11** (1988), 484–488.