Thoracic manual therapy in the management of non-specific shoulder pain: a systematic review

Aimie L. Peek¹, Caroline Miller², Nicola R. Heneghan³

¹Musgrove Park Hospital, Taunton, UK, ²University Hospitals Birmingham NHS Foundation Trust, UK,

³University of Birmingham, UK

Objectives: Non-specific shoulder pain (NSSP) is often persistent and disabling leading to high socioeconomic costs. Cervical manipulation has demonstrated improvements in patients with NSSP, although risks associated with thrust techniques are documented. Thoracic manual therapy (TMT) may utilise similar neurophysiological effects with less risk. The current evidence for TMT in treating NSSP is limited to systematic reviews of manual therapy (MT) applied to the upper quadrant. These reviews included trials that used shoulder girdle manual therapy (SG-MT) in the TMT group. This limits the scope of their conclusions with regard to the exclusive effectiveness of TMT for NSSP.

Methods: This review used a steering group for subject and methodological expertise and was reported in line with Preferred Reporting items for Systematic Reviews and Meta-analysis (PRISMA) guidelines. Key databases were searched (1990–2014) using relevant search terms and medical subject headings (MeSH); eligibility was evaluated independently by two reviewers based on pre-defined criteria. Study participants had NSSP including impingement syndrome and excluding cervical pain. Interventions included cervicothoracic junction and TMT with or without supplementary exercises. Studies that included MT applied to the shoulder girdle including the glenohumeral joint, acromioclavicular joint or sternoclavicular joint in the TMT group, without a control, were excluded. Included studies utilised outcome measures that monitored pain and disability scores. Randomized controlled trials (RCTs) and clinical studies were eligible. Using a standardised form, each reviewer independently extracted data. Risk of bias was assessed using GRADE and PEDro scale. Results were tabulated for semi-quantitative comparison.

Results: Over 912 articles were retrieved: three RCTs, one single-arm trial and three pre–post test studies were eligible. Studies varied from poor to high quality. Three RCTs demonstrated that TMT reduced pain and disability at 6, 26 and 52 weeks compared with usual care. Two pre–post test studies found between 76% and 100% of patients experienced significant pain reduction immediately post-TMT. An additional pre–post test study and a single-arm trial showed reductions in pain and disability scores 48 hours post-TMT.

Discussion: Thoracic manual therapy accelerated recovery and reduced pain and disability immediately and for up to 52 weeks compared with usual care for NSSP. Further, high-quality RCTs investigating the effect of TMT in isolation for the treatment of patients with NSSP are now required.

Keywords: Shoulder pain, Thoracic spine, Manipulation, Manual therapy

Introduction

One in three people are expected to experience shoulder pain within their lifetime¹ with 40–50% remaining functionally impaired at 1–2 years.^{2,3} Research into optimal management is, therefore, a priority.

Difficulties surrounding the diagnosis of shoulder pain include poor agreement in diagnostic criteria, lack of specificity of commonly used clinical tests, the co-existence of multiple shoulder pathologies and the lack of any diagnostic test that is considered a gold

standard.^{4–7} As a consequence, clinical trials tend to use the term, ‘non-specific shoulder pain’ (NSSP), rather than a specific diagnosis.

The use of cervical manipulation has demonstrated a positive influence on pain and disability scores in patients with NSSP,⁸ although the risks associated with thrust techniques are a concern.^{9,10} However, it is also hypothesised that thoracic manual therapy (TMT) may achieve a similar neurophysiological effect while avoiding the risks of cervical manipulation.¹¹ Wainner *et al.*¹² coined the term, ‘regional interdependence’, to describe how impairment in one region, such as the cervical or thoracic spine, can result in dysfunction elsewhere, such as the glenohumeral joint. Failure to address the original

Correspondence to: Aimie L. Peek, Physiotherapy Department, Musgrove Park Hospital, Taunton, Somerset, TA1 5DA, United Kingdom. Email: aimie.furlong@yahoo.co.uk

impairment may, therefore, be responsible for the persistence of pain.¹³ A study of 139 laundry workers demonstrated that hypomobility of the cervicothoracic junction could increase the probability of developing shoulder-neck pain in the following 12 months by 3-fold.¹⁴ In addition, pain and dysfunction of the second rib and cervicothoracic junction were identified in 40% of 101 individuals with NSSP, which was not present in age-matched asymptomatic individuals.¹⁵

Theoretically, treatment to the thoracic spine may biomechanically restore the 15° of thoracic extension required to achieve full shoulder elevation,¹⁶ improve the recruitment of muscles in the shoulder girdle^{17,18} or have a neurophysiological effect on pain and dysfunction.¹⁹

The current evidence for TMT in treating shoulder pain includes a narrative review,²⁰ which was updated in 2013.¹³ An additional two large systematic reviews investigated the effects of manual therapy (MT) to the upper quadrant including the glenohumeral joint, shoulder girdle, cervical and thoracic spine in patients with shoulder pain.^{21,22} Another systematic review investigated the role of TMT in treating a variety of musculoskeletal conditions, including three trials associated with the shoulder.²³ These reviews were all inclusive of trials, such as Winters *et al.*²⁴ and Bang and Deyle,²⁵ who did not control or separate TMT from other shoulder girdle manual therapy (SG-MT). For the purpose of this review, the shoulder girdle was defined as any joint within the shoulder complex including the glenohumeral joint, acromioclavicular joint and sternoclavicular joint.

These previous reviews concur that MT applied to the upper quadrant, including the thoracic spine, may accelerate recovery in patients with NSSP. However, the specific role of TMT cannot be established from these studies. Consequently, these reviews could only provide evidence for MT to the upper quadrant and recommended that future research investigates a particular modality, such as TMT, under controlled conditions.^{21,22}

Therefore, this is the first review, to the authors' knowledge, to focus on TMT, with or without supplementary exercises, and excluding or controlling for SG-MT, in order to establish whether or not TMT is an active component in accelerating recovery in patients with NSSP.

The purpose was to conduct a rigorous systematic review investigating the use of TMT, with or without supplementary exercise, in the management of patients with NSSP and to produce a concise, critical, synthesis of evidence from the most current literature.

Methodology

Design

A systematic literature review was used to investigate the use of TMT with or without supplementary exercise in the management of NSSP. A research

proposal was developed based on principles outlined by the Centre of Research and Dissemination (CRD)²⁶ and Cochrane.²⁷ The review is reported in line with PRISMA guidelines.²⁸ Pilot database searches were undertaken to refine the search strategy and terms to ensure adequate precision.

Two of the authors are clinical specialists in the upper quadrant (ALP, CM) and a third is a physiotherapy lecturer and researcher in a similar field (NRH).

Study eligibility criteria

Studies were included based on the following criteria:

Participants

Patients with NSSP or impingement syndrome, a term used to describe a plethora of non-specific shoulder conditions including, but not limited to, bursal irritation, tendinopathies and acromial variances. Specific diagnoses, such as adhesive capsulitis or traumatic dislocations, were excluded, as were papers investigating pain radiating from the cervical spine. There were no age restrictions.

Interventions

Included techniques were either manipulations or mobilisations applied to the thoracic spine or cervicothoracic junction. Studies were excluded if they used MT applied to the shoulder girdle, as part of the TMT group, without a control. Trials that used exercise in all treatment arms were included. Trials supplementing the TMT group with exercise focussed on restoring spinal range of movement were also included.

Comparator

Sham techniques, usual care by the general practitioner, exercise or physiotherapy were included.

Outcome measures: any clinical outcome measure of pain and/or disability

Study design

Non-randomised and randomized controlled trials (RCTs), as well as pre- post test studies, were included. Case studies and series were excluded.

Search strategy

A search strategy displayed in Fig. 1 designed with guidance from the CRD²⁶ and PRISMA guidelines²⁸ was used to search five electronic databases (Ovid Medline, Embase, AMED, CINAHL and Cochrane) on 13 January 2013 and updated in March 2014. The index to chiropractic literature was hand searched, as were citation lists from appropriate trials and literature reviews. Key MT journals were also hand searched. In addition, studies presented at relevant conferences were identified through the database search. The included studies were published in English after 1990, a date reflective of an increased interest into the investigation of neurophysiological effects of spinal manipulation for peripheral

Figure 1 Search terms used.

conditions as demonstrated through publication of research.^{29,30}

Study selection

The primary reviewer (ALP) screened titles and abstracts against the pre-determined inclusion and exclusion criteria. Duplicates were removed and the full text versions ordered. Authors of conference proceedings were contacted. Full texts were independently screened by two reviewers (ALP, CM) to generate the final articles. Disagreements were resolved through discussion with a third reviewer (NRH).

Data extraction

Data were extracted into Table 1, under the headings: study participants, interventions, comparisons, outcomes and study design (PICOS). Each reviewer independently extracted data before discussion and compilation of a final version of Table 1.

Risk of bias assessment and strength of recommendation

The grading of recommendations assessment development and evaluation (GRADE)³¹ was employed in order to allow the inclusion of non-RCTs without threatening the rigour of the review. The GRADE assesses quality of evidence using five domains including risk of bias (determined by study design), inconsistency, indirectness, impression and publication bias. Studies were consequently upgraded or downgraded as appropriate. Evidence was graded as very low, low, moderate or high quality. The PEDro was used to assess RCT's risk of bias. Trials were regarded as high quality if they scored over 7/10, moderate quality if 5–6/10, or poor

quality if scored <4.^{32,33} Results of each study were grouped for analysis with studies of a similar design, thus separating the RCTs from the non-RCTs. The heterogeneity of study design, outcome measures and the variability of follow-up time rendered them unsuitable for meta-analysis; therefore, results were tabulated for qualitative analysis.

Results

Study selection

The flowchart in Fig. 2 displays the results of the literature search. Seven trials satisfied the eligibility criteria.

Study characteristics

The characteristics of the included studies are displayed in Table 1. Data extracted included participants, outcome, intervention, control, follow-up and results.

Design

Of the seven trials selected for analysis, five papers originated from the United States^{18,34–37} and two papers were from the Netherlands and written by the same author group.^{38,39} Three papers were RCTs,^{37–39} although one was a pilot study with just nine participants.³⁷ The remaining four non-RCTs were pre-post test studies^{18,34,35} and a single-arm trial.³⁶ A total of 496 participants were included in the review; however, Bergman *et al.*³⁹ reported different outcomes generated from the same 150 participants from their previous 2004 study.³⁸

Participants

Participants had NSSP in four studies,^{35,36,38,39} clinically diagnosed impingement syndrome^{34,37} or

Table 1 Data extracted from the included studies.

Study	Participants	Outcome	Intervention	Control	Follow-up	Results
Bergman <i>et al.</i> , ³⁸ the Netherlands, Physio RCT	Non-specific GHJ pain. Variable duration. Control <i>n</i> =71 Int. <i>n</i> =79	Patient perceived recovery, severity of three GHJ complaints, GHJ pain (4 pt scale), SDQ, general health	As control plus CTJ, TSp or rib manips, pt specific, six treatments in 12 weeks	Usual medical care – info, analgesics, Non-steroidal anti-inflammatory drugs (NSAIDs), >2 CSI, ± physio at 6/52 seconds	6, 12, 26, 52 weeks	6 weeks favour int. not statistically significant, 12 weeks more recovered than control, accelerated recovery and reduced severity in int. group
Bergman <i>et al.</i> , ³⁹ the Netherlands, Physio RCT Boyles <i>et al.</i> , ³⁴ USA, Physio Pre-post test study	Non-specific GHJ pain, variable duration. Control <i>n</i> =71 Int. <i>n</i> =79 SIS duration of symptoms not stated <i>n</i> =56	Factor analysis of GHJ pain and ROM, neck pain and ROM NPRS during impingement and resisted tests and abd, SPADI and GROC	As control plus CTJ, TSp or rib manips, pt specific, six treatments in 12 weeks Protocol TSp & CTJ manips, ± Rib if tender. Two attempts at each. TSp ROM Exs As control plus protocol TSp manips <6 sessions	Usual medical care- Info, Analgesics, NSAIDs, >2 CSI, ± physio at 6/52 seconds N/A	6, 12, 26 weeks 48 hours	6 weeks favour int. not statistically significant, 12 and 26 weeks statistically favoured int. Statistical improvement at all outcomes, but none reaching MCID
Janse & Atkins, ³⁷ UK, Physio Pilot RCT	SIS for over 1 week Control <i>n</i> =3 Int <i>n</i> =6	ROM flex and abd, DASH	Tsp ROM Exs As control plus protocol TSp manips <6 sessions	Usual care- advice, Cuff exs, GHJ mobs, frictions, advice <6 sessions	6 weeks or earlier if recovered	Both groups improved but very small sample inadequate for stats
Mintken <i>et al.</i> , ³⁶ USA, Physio students Single-arm trial- CPR	NSSP, <i>n</i> =80	NPRS, SPADI, FABQ, TSK, ROM, GROC	Protocol 1 non-thrust lower CSsp, 5 TSp and CTJ manips. CSsp and TSP ROM exs	N/A	2-4 days, 6-12 days if required second treatment	Success in 49/80 pts. Five predictors identified
Muth <i>et al.</i> , ¹⁸ USA, Physio Pre-post test lab study	Rot cuff tendinopathy + ve impingement tests. Mean duration 4-2 months, <i>n</i> =30	SPAM-DASH, PSS NPRS, Break test, EMG data from two maximum resistance tests, scap angles	Protocol TSp and CTJ manips. No exs	N/A	Immediate and quest 7-10 days	No change in scap kinematics except small decrease in upward scap rot. Muscle activity small increase in mid trapez. Immed. 23/30 reached MCID NPRS on special tests. 7-10 days 23/30 exceeded MCID for PSS Manips Improved shoulder ROM and decreased VAS beyond MCID in all patients
Strunce <i>et al.</i> , ³⁵ USA, Physio Pre-post test study	NSSP, <i>n</i> =21	GHJ ROM-bubble inclinometer, VAS, GROC	Individual TSp, CTJ or rib manip. No exs	N/A	Immediate	

abd: abduction; CSsp: cervical spine; CSI: corticosteroid injection, CTJ: cervicothoracic junction; DASH: disabilities of arm, shoulder, hand; EMG: electromyography; Exs: exercise; FABQ: fear, avoidance and beliefs questionnaire; GHJ: Glenohumeral joint; GROC: global rating of change; Int.: intervention; manips: manipulation; MCID: minimal clinically important difference; NPRS: numeric pain rating scale; NSAIDs: anti-inflammatory; NSSP: non-specific shoulder pain; PSS: Penn shoulder score; RCT: randomized control trial; rot: rotation; rot cuff: rotator cuff; ROM: range of movement; scap: scapula; SDQ: shoulder disability questionnaire; SIS: sub-acromial impingement; SPADI: shoulder pain and disability questionnaire; SPAM-DASH: sports and performing arts module of DASH; trapez: trapezius; TSK: Tampa scale for Kinesiophobia; TSp: thoracic spine; VAS: visual analogue scale.

Figure 2 Flow chart of search results.

rotator cuff tendinopathy.¹⁸ Duration of symptoms was not specified.

Intervention

The specific treatment technique varied widely between studies ranging from one high velocity, low amplitude thoracic manipulation³⁸ to a series of 10 mobilisations and manipulations to the cervicothoracic junction and thoracic spine.³⁶ All studies only included joint-based treatments, rather than soft-tissue techniques directed at the thoracic spine. Three studies matched the treatment to the patient^{35,38,39} while four used a protocol of manipulations.^{18,34,36,37} Treatment varied from a single application^{18,34,35} to six sessions over 12 weeks.^{38,39} Five of the seven trials supplemented the TMT with exercise.^{34,36–39}

Comparator

All three of the RCTs used usual care as a comparison; however, this ranged from general practitioner's advice, steroid injections or physiotherapy^{38,39} to physiotherapy including SG-MT and shoulder exercises.³⁷

Outcome measures

Pain outcome measures included the visual analogue scale (VAS) and the numerical pain rating scale (NPRS). Disability outcomes were measured by the shoulder pain and disability index (SPADI), sports and performing arts module-disabilities of arm, shoulder and hand (SPAM-DASH) and the shoulder disability questionnaire; however, no two studies

used them to capture comparable data. Follow-up times varied from immediately post-intervention,^{18,35} 2–4 days,^{34,36} 6 weeks³⁷ and up to 52 weeks.^{38,39}

Methodological quality

The results of the quality assessments are displayed in Table 2. The GRADE is presented in five components reporting the rationale where downgrading occurred. The PEDro is presented as a score out of 7.

GRADE – strength of recommendation

The GRADE initially considers non-RCTs^{18,34–36} as low quality. These were further downgraded to very low quality largely because of issues of 'imprecision', which was attributed to the small sample sizes and failure to include power calculations (Table 2). Randomized control trials are initially considered as high quality; however, Bergman *et al.*^{38,39} were downgraded to low quality because of 'inconsistency' and 'imprecision'. Despite Janse van Rensburg and Atkins³⁷ being treated as an RCT, it could only be considered as very low quality because of the limitations of being a pilot study with a very small sample size, high attrition rate and large between-group differences at baseline. The GRADE criteria, therefore, make a weak recommendation for the addition of TMT to usual care for NSSP since the available research largely consists of non-RCTs of very low methodological quality and a small number of poor quality RCTs.

Table 2 GRADE and PEDro results.

Study		GRADE	Risk of bias	Incon	Indirect	Impres	Pub bias	PEDro
Bergman <i>et al.</i> ³⁸	RCT	⊙⊙⊙⊙ Low	–	↓	–	↓	–	7/10
Bergman <i>et al.</i> ³⁹	RCT	⊙⊙⊙⊙ Low	–	↓	–	↓	–	7/10
Boyles <i>et al.</i> ³⁴	Pre–post test	⊙⊙⊙⊙ Very low	–	–	↓	–	–	N/A
Janse & Atkins ³⁷	RCT – Pilot	⊙⊙⊙⊙ Very low	↓	↓	↓	↓	–	7/10
Mintken <i>et al.</i> ³⁶	Single-arm trial CPR	⊙⊙⊙⊙ Very low	–	–	↓	–	–	N/A
Muth <i>et al.</i> ¹⁸	Pre–post test, Lab study	⊙⊙⊙⊙ Very low	–	–	↓	↓	–	N/A
Strunce <i>et al.</i> ³⁵	Pre–Post test	⊙⊙⊙⊙ Very low	–	↓	–	↓	–	N/A

Note on GRADE: non-RCTs start as low quality, RCTs start as low quality.

CPR: clinical prediction rule; incon: inconsistency; GRADE: indirect: Indirectness; impres: impression; PEDro: Pub bias: publication bias; RCT: randomized control trial; N/A: PEDro can only be applied to RCTs.

PEDro – risk of bias

All three RCTs scored over 7/10 on the PEDro scale. This means that all of them are considered high quality, demonstrating good internal validity and a low risk of bias.

Summary of study results

RCTs

The results of the RCTs are displayed in Table 3. Each of them concluded that the addition of TMT could accelerate recovery in patients with NSSP, in terms of both pain and disability, when compared with usual medical care, with or without physiotherapy including exercise, or corticosteroid injection.^{37–39} These changes were apparent but not statistically significant at 6 weeks.^{37–39} In addition, owing to significant methodological flaws, conclusions drawn from the pilot study³⁷ could not be dissociated from results of chance. Accelerated recovery in the TMT groups, in terms of pain and disability, became statistically significant at 24 and 52 weeks; however, the treatment was only delivered for 12 weeks.^{38,39} These results need to be interpreted with caution as they are based on results from a single population generating two data sets.

Non-randomized controlled trials

The results of the non-RCTs are displayed in Table 4. The lack of a control group means that inferences from these studies cannot be made with regard to cause and effect. However, Muth *et al.*¹⁸ and Strunce *et al.*³⁵ assessed and treated patients over a treatment application, with no additional exercises and found an immediate improvement in VAS and NPRS exceeding the minimal clinically important difference (MCID) in 21/21 and 23/30 patients, respectively. In comparison, after a session of TMT and spinal range of motion exercises, Mintken *et al.*³⁶ found 31/80 patients achieved a successful outcome as defined by an improvement of 4+ on the global rating of change scale (GROC) at 2–4 days post-TMT. An additional 18 patients were

considered a success following the second treatment. The remaining 31 patients failed to reach the required 4-point improvement. Boyles *et al.*³⁴ used the NPRS and SPADI 48 hours post-TMT and thoracic spine range of motion exercise. They reported 33% of patients reached a 4+ improvement on the GROC. Outcomes were consistently better 48 hours post-TMT for the NPRS of all provocative shoulder tests, resisted tests and the SPADI. However, the changes observed were not large enough to reach MCID for either the pain or the disability outcome measure.

Discussion

Principle findings

The aim of this systematic review was to investigate the effect of TMT, with or without supplementary exercise, in the treatment of NSSP. Previous reviews^{20–23} have not been able to evaluate this due to the inclusion of studies that used SG-MT in the TMT group without a control.

The principle finding of the review was that all three RCTs demonstrated statistically significant acceleration of recovery and reduction of pain and disability in the TMT group compared to controls from 12 to 52 weeks. In addition, two pre–post test studies demonstrated immediate changes in pain scores beyond MCID in 76% and 100% of patients.^{18,35} The other pre–post test study and the single-arm trial showed a 4-point difference in GROC in 33%³⁴ and 63%³⁶ of patients after a treatment session.

Despite the RCTs^{37–39} demonstrating a trend in favour of recovery in the TMT group at 6 weeks, the differences did not reach statistical significance at this stage. This may reflect the variation in response within the group commonly seen when treating a heterogeneous population, potentially resulting in the under-reporting of the effectiveness of MT.^{40–42} To reduce the impact of this factor, clinical prediction rules have been used to sub-group patients who are likely to respond to an

Table 3 Results of RCTs.

Study	Intervention	Control	Baseline	Reassessment	Between-group difference
Bergman <i>et al.</i> ³⁸	<i>N</i> =79 As control plus CTJ, TSp or rib manips, pt specific, six treatments in 12 weeks	<i>n</i> =71 Usual medical care – Info, analgesics, NSAIDs, > 2CSIs, ± physio at 6/52 seconds	Shoulder disability mean improvement 7 best 28 worst Int. 17.8 (± 4.7) Control 17.9 (± 4.4)	Mean improvement (± SD) Int. 6 weeks 3.6 (± 4.5) 12 weeks 5.7 (± 5.1) 26 weeks 5.9 (± 5.3) 52 weeks 6.7 (± 5.4) Control 6 weeks 2.8 (± 4.4) 12 weeks 3.7 (± 5.2) 26 weeks 5.2 (± 5.5) 52 weeks 5.5 (± 5.5) Mean improvement (± SD) Int.	(95% CI) 6 weeks 0.8 (–0.6 to 2.3) 12 weeks 2.0 (0.3 to 3.7) 26 weeks 0.7 (–1.0 to 2.5) 52 weeks 1.2 (–0.5 to 3.0)
Bergman <i>et al.</i> ³⁹	<i>n</i> =79 As control plus CTJ, TSp or rib manips, pt specific, 6 treatments in 12 weeks	<i>n</i> =71 Usual medical care- Info, Analgesics, NSAIDs, > 2 CSI, ± physio at 6/52 seconds	Factor analysis GHJ pain Range 0–21; Lower: Better Int. 5.4 (± 4.5) Control 5.7 (± 5.6)	6 weeks 1.8 (± 2.7) 12 weeks 2.9 (± 3.3) 26 weeks 3.5 (± 4.0) Control 6 weeks 1.8 (± 3.1) 12 weeks 2.0 (± 3.7) 26 weeks 2.2 (± 4.0) Reassessment	(95% CI) 6 weeks 0.07 (–0.67 to 0.81) 12 weeks 1.06 (0.21 to 1.90) 26 weeks 1.44 (0.47 to 2.41) <i>P</i> <0.5 stat significant
Study	Int.	Control	Baseline	Reassessment	Between-group difference
Janse <i>et al.</i> ³⁷	<i>n</i> =6 As control plus a standardised thoracic manips up to six sessions	<i>n</i> =3 Usual care – advice, cuff exercises, SG-MT: shoulder girdle manual therapy, frictions, advice up to six sessions	DASH Lower: better Int. 31 (± 13.75) Control 41.75 (± 10.39)	DASH (<6 weeks) Int. 11.92 (± 6.48) Control 20.35 (± 12.37)	Mean change (SD) Within group Int. 22.49 (± 5.52) Control 21.4 (± 1.98) No between-group change reported

CI: confidence interval; CSI: corticosteroid injection, CTJ: cervicothoracic junction; DASH: disabilities of arm, shoulder, hand; GHJ: Glenohumeral joint; SG-MT: shoulder girdle manual therapy; Int.: intervention; manips: manipulation; NSAIDs: anti-inflammatory; RCT: randomized control trial; SD: standard deviation; TSp: thoracic spine.

Table 4 Results of non-RCTs.

Study	Int.	Baseline	Reassessment	Within group difference	P-value
Strunce et al. ³⁵	n=21 individual TMT No exs	VAS mean (SD) 63.1 (22.8)	Immediate VAS mean (SD) 31.2 (24.4) 48 hours PSS	VAS mean (SD) 31.9	<0.01
Muth et al. ¹⁸	n=30 Protocol TMT no exs	PSS 79.8 ± 11.4 SPAM-DASH 37.1 ± 23.1	87.4 ± 10.9 SPAM-DASH 20.3 ± 23.1	PSS 7.6 ± 9.3 (4.1, 11.1)* SPAM-DASH - 16.1 ± 16.4 (-22.5, -10.2)*	<0.001 <0.001
Mintken et al. ³⁶	n=80 Protocol TMT and ROM exs	SPADI Success: 38.1 (13.9) Non-success: 37.9 (13.1) NPRS Success: 4.0 (1.7) Non-success: 4.3 (1.8)	Within 2-12 days SPADI Success: 18.4 (12) Non-success: 30.4 (13.7) NPRS Success: 1.8 (1.1) Non-success: 3.9 (1.5)	SPADI 19.7 (15.5, 20) 6.9 (4.6, 9.1) NPRS 2.2 (1.9, 2.6) 0.5 (-0.08, 0.90)	Between-group change SPADI 12.9 (7.3, 18.5) P-value <0.001 NPRS 1.7 (1.1, 2.3) P-value <0.001 P-value <0.001
Boyles et al. ³⁴	n=56 Protocol TMT and ROM exs	SPADI 34.7 ± 17.4	48 hours SPADI 27.9 ± 21.4	SPADI 6.8	

* Values are mean ± standard deviation (95% confidence interval).

Exs: exercise; NPRS: numeric pain rating scale; non-RCTs: non-randomized control trials; PSS: Penn shoulder score; ROM: range of movement; SPADI: shoulder pain and disability scale; SPAM-DASH: sports and performing arts module-disabilities of arm, shoulder and hand; TMT: thoracic manual therapy; VAS: visual analogue scale.

intervention. Satisfaction of three out of five variables (Appendix 1) increased the success rate from 61% to 89% in an NSSP population.³⁶ This clinically relevant finding may assist clinicians' decision making; however, further validation is required to ensure that the variables were not just predictors of a favourable prognosis.⁴³

TMT intervention and dosages varied between studies. Four studies used a pre-determined protocol of MT^{18,34,36,37} while three matched the intervention to the patient presentation in an individualised approach.^{35,38,39} The variation in follow-up times and outcome measures used inhibit direct comparison of approaches. However, the two most comparable studies^{18,35} both used an outcome measure of pain (VAS, NPRS), which was measured immediately post-TMT, with no supplementary exercises. Strunce *et al.*³⁵ used an individualised approach and Muth *et al.*¹⁸ used a protocol of TMT. Strunce *et al.*³⁵ found all patients reached MCID using the VAS while Muth *et al.*¹⁸ found 24/30 patients reached MCID using the NPRS. Therefore, from these two pre-post test studies, an individualised approach appears to achieve marginally better response rates compared with using a protocol of TMT for all patients presenting with NSSP.

Five of seven studies supplemented TMT with exercises. Boyles *et al.*³⁴ and Mintken *et al.*³⁶ used thoracic range of motion exercises while the three RCTs^{37–39} used specific shoulder exercises, such as cuff strengthening and lower trapezius exercises, which were also used in the control group. Muth *et al.*¹⁸ and Strunce *et al.*³⁵ used TMT with no additional exercises. The literature suggests that adding cervical exercises to MT in treating neck pain results in a better outcome than either intervention alone, which suggests an interaction effect.^{44,45} It is not possible to establish if this is the case for TMT and exercise because of the variation in outcome measures, interventions and different follow-up times within the included studies.

Strengths of the review

The PRISMA guidelines²⁸ were closely followed in order to minimise bias and to produce an up-to-date synthesis of the evidence. The review followed the recommendation of previous reviews by investigating MT directed at one region, the thoracic spine.^{21,22} To inform policy makers, clinicians and patients of the effect of TMT with or without exercise on patients with NSSP and disability, studies including SG-MT in the intervention group without a control were excluded even though they were previously representative of the evidence for TMT.^{3,24,25,46} This allowed for conclusions to be drawn with regard to the effectiveness of TMT for NSSP which could not be established from preceding reviews.^{20–23,47}

The results from this review concur with previous reviews that investigated MT to the upper quadrant.^{20–23,47}

This review offers three additional studies,^{18,36,37} not considered in previous reviews, thus updating the existing evidence base for TMT in the treatment of NSSP. Case series and case studies that were included in other reviews^{21,22} were deemed inappropriate for this review because of their limited generalisability and the increased risk of bias associated with their subjective nature.

Previous reviews have only assessed quality using the PEDro scale. The PEDro investigates the risk of bias and the internal validity of a trial. In addition, it can only be used on RCTs. This review also used GRADE, which addresses the trial's ability to answer the research question. In addition, it allows direct comparison between non-RCTs and RCTs. Therefore, single-arm trials and pre-post test studies could be included without threatening the rigour of the review.

The results of the quality assessments displayed in Table 2 demonstrate a disparity between GRADE and PEDro scores (see Bergman *et al.*³⁸); GRADE deemed this trial to be of low methodological quality; however, PEDro considered it high, as supported by independent assessments conducted in other reviews.^{22,23,47} The reason for this is likely to be reflected in the content of the tools. The PEDro assesses the internal validity of an RCT, GRADE considers this, in part, and concurs that Bergman *et al.*³⁸ has high internal validity; however, GRADE's main focus is the trial's ability to answer the research question.⁴⁸ Therefore, it must be emphasised that reviews using GRADE as a quality assessment tool are not comparable to those using PEDro or other tools that focus on a trial's internal validity.

Possible theories behind the effect of TMT

Three trials saw immediate changes in pain following TMT^{18,34,35}; however, the underlying mechanism is not fully understood. Muth *et al.*¹⁸ used surface electromyography and scapular kinematics to detect some small but statistically significant changes in scapular position ($P=0.05$) and increase in middle trapezius activity ($P=0.03$); however, they concluded that the changes were too small to fully explain the significant reduction in pain post-TMT observed in their study, as well as others.

Wainner's term, 'regional interdependence', describes how dysfunction in a part of the body can disrupt another region.¹² The relationship between the thoracic spine and shoulder are commonly discussed in the literature.^{49–52} An increased incidence of rib joint and cervicothoracic junction stiffness has been identified in patients with shoulder pain compared with controls.¹⁵

In addition, it has been reported that stiffness of the cervicothoracic junction could increase the likelihood of developing shoulder-neck pain 3-fold over a 2-year period.¹⁴ Lewis *et al.*⁵² and Crawford and Jull¹⁶ have identified that a reduction in thoracic extension over 15° can restrict shoulder movement. The trials included in this review did not reassess spinal motion post-TMT and, therefore, we are unable to ascertain whether restoration of thoracic motion is responsible for the improvements noted.

A study by Winters *et al.*²⁴ was excluded from this review for including SG-MT in the TMT group. However, their results can be used to support the findings of this review. Winters *et al.*²⁴ sub-grouped patients with NSSP into synovial complaints (defined as pain on shoulder movements) and shoulder girdle dysfunction (defined as pain or limited movement of the cervical spine, thoracic spine, or adjoining ribs with no synovial impairments or a combination thereof).²⁴ A quarter of patients with NSSP were considered to have shoulder girdle dysfunction and this group responded best to SG-MT, which also included TMT, when compared with steroid injection or physiotherapy. Mintken *et al.*³⁶ found that one-third of patients with NSSP responded well to TMT. It was shown, using logistic regression, that these patients were most likely to have a negative Neer's test for synovial complaints.⁵³ Therefore, it could be hypothesised that these patients presented with a shoulder girdle dysfunction, as defined by Winters *et al.*²⁴ rather than a synovial complaint. In that case, a negative Neer's test might, in the future, be able to assist in the identification of patients with NSSP likely to respond to TMT.³⁶

Clinical implications

The clinical implications of the review are that it is likely that clinicians can use thoracic manipulation to accelerate recovery, in terms of pain reduction and reduced disability, in an NSSP population. The use of the clinical prediction rule may help identify patients likely to respond to treatment (Appendix 1). Previous reviews have supported the use of a multimodal approach for NSSP; however, this review demonstrates that pain relief and accelerated recovery can be achieved without directly treating the glenohumeral joint, which may be preferential in treating patients with a highly irritable presentation. It is currently unclear as to whether a protocol of treatment is as effective as an individualised treatment; however, a protocol of MT is more reproducible in a research forum. The GRADE made a weak recommendation for the use of TMT in NSSP. The significance of this to clinicians is that 'you should recognise that different choices will be appropriate for different patients and that you must help each patient arrive at a management decision consistent with her or his values and preferences'.⁵⁴

Limitations of the review

Inclusion of two non-RCTs^{34,36} that supplemented the TMT with exercise to maintain range of motion at the thoracic spine could be seen as a limitation. However, owing to the small evidence base on this topic, exclusion of these studies would lead to a limited review of the current literature. It is not possible to say for certain whether or not the changes to pain and disability seen in these studies are because of the TMT or the exercise component. However, the significant improvement seen in the two other pre-post test studies^{18,35} that did not use supplementary exercise provides evidence to support that TMT is likely to contribute to the improvement seen in the treatment of patients with NSSP.

The decision to focus on NSSP and impingement syndrome could be seen as a further limitation; however, inclusion of distinct pathologies, such as adhesive capsulitis, was deemed inappropriate since it is not considered a pain syndrome.⁷ The inclusion of the search term, 'shoulder tendinopathy', may have been beneficial; however, retrospective searches failed to generate any additional papers.

One limitation is the possibility of English language bias. Inability to obtain conference proceedings, despite contacting authors, reflects publication bias; however, their suitability for the review remains uncertain.

The heterogeneity of study population, outcome measures, follow-up and intervention made meta-analysis impossible consequently limiting statistical analysis of the results. Calculation of effect size would lead to misrepresentation due to the small sample size.

Unanswered questions and future research

This review highlights the distinct lack of RCTs that evaluate the influence of TMT in managing patients with NSSP. Further RCTs are now required where SG-MT is either controlled or excluded from the intervention group.

Disclaimer Statements

Contributors ALP is the lead author and is responsible for protocol development, searches, study selection, data extraction, quality assessment and analysis. CM, as a subject specific expert is responsible for protocol development, study selection, independent data extraction and independent quality assessment. NRH is responsible for providing subject and methodological expertise and support in analysis. All authors contributed to the development of the manuscript.

Funding No funding was received.

Conflicts of interest The authors declare no conflicts of interest.

Ethics approval No ethical approval was required for this literature review.

References

- 1 Van der Heijden GJ. Shoulder disorders: a state of the art review. *Best Pract Res Clin Rheumatol*. 1999;13(2):287–309.
- 2 Croft P, Pope D, Silman A. The clinical course of shoulder pain; a prospective cohort study in primary care. *BMJ*. 1996;313:601–2.
- 3 Winters J, Sobel J, Groenier K, Arendzen J, de Jong B. The long term course of shoulder complaints: a prospective study in general practice. *Rheumatology (Oxford)*. 1999;38:160–3.
- 4 Dickens V, Williams J, Bhamra M. Role of physiotherapy in the treatment of subacromial impingement syndrome: a prospective study. *Physiotherapy*. 2005;91:159–64.
- 5 Hegadus E, Good A, Campbell S. Physical examination tests of the shoulder: a systematic review with meta-analysis of individual tests. *Br J Sports Med*. 2008;42:80–92.
- 6 Schellingerhout J, Verhagen A, Thomas S, Koes B. Lack of uniformity in diagnostic labelling of shoulder pain: time for a different approach. *Man Ther*. 2008;13(6):478–83.
- 7 Lewis J. Rotator cuff tendinopathy/subacromial impingement syndrome: is it time for a new method of assessment? *Br J Sports Med*. 2009;43:259–64.
- 8 McClatchie L, Laprade J, Martin S, Jaglal S, Richardson D, Agur A. Mobilisations of the asymptomatic cervical spine can reduce signs of shoulder dysfunction in adults. *Man Ther*. 2009;14(4):369–74.
- 9 Ernst E. Deaths after chiropractic: a review of published cases. *Int J Clin Pract*. 2010;64:1162–5.
- 10 Gross A, Miller J, D'Sylvia J, Burnie S, Goldsmith C, Graham N, et al. Manipulation or mobilisation for neck pain. *Cochrane Database Syst Rev*. 2010;1:CD004249.
- 11 Erhard RE, Piva SR. Manipulative therapy. In: Placzek JD, Boyce DA, editors. *Orthopaedic physical therapy secrets*. Philadelphia: Hanley and Belfus; 2000. p. 635–79.
- 12 Wainner R, Whitman J, Cleland J, Flynn T. Regional interdependence: a musculoskeletal examination model whose time has come. *J Orthop Sports Phys Ther*. 2007;37(11):658–60.
- 13 Sueki D, Cleland J, Wainner R. A regional interdependence model of musculoskeletal dysfunction: research, mechanisms, and clinical implications. *J Man Manip Ther*. 2013;2(2):90–103.
- 14 Norlander S, Asto-Norlander U, Nordgron B, Sahlstedt B. Mobility in the cervico-thoracic motion segment: an indicative factor of musculoskeletal neck-shoulder pain. *Scand J Rehabil Med*. 1996;28:183–92.
- 15 Sobel JS, Kremer I, Winters JC, Arendzen J, de Jong B. Reviews of the literature. The influence of the mobility in the cervico-thoracic spine and the upper ribs (shoulder girdle) on the mobility of the scapulohumeral joint. *J Manipulative Physiol Ther*. 1996;19(7):469–74.
- 16 Crawford H, Jull G. The influence of thoracic posture and movement on range of arm elevation. *Physiother Theory Pract*. 1993;9: 143–8.
- 17 Cleland J, Selleck B, Stowell T, Browne L, Alberini S, St Cyr H, et al. Short-term effects of thoracic manipulation on lower trapezius muscle strength. *J Man Manip Ther*. 2004;12:8290.
- 18 Muth S, Barbe M, Lauer R, McClure P. The effect of thoracic spine manipulation in subjects with signs of rotator cuff tendinopathy. *J Orthop Sports Phys Ther*. 2012;14(12):1005–16.
- 19 Bialosky J, Bishop M, Price D, Robinson M, George S. The mechanism of manual therapy in the treatment of musculoskeletal pain: a comprehensive model. *Man Ther*. 2009;14(5):531–8.
- 20 Sueki D, Chaconas E. Narrative review: the effect of thoracic manipulation on shoulder pain: a regional interdependence model. *Phys Ther Rev*. 2011;16(5):399–408.
- 21 Pribicevic M, Pollard H, Bonello R, de Luca K. A systematic review of manipulative therapy for the treatment of shoulder pain. *J Manipulative Physiol Ther*. 2010;33(9):679–89.
- 22 Brantingham J, Cassa T, Bonnefin D, Jensen M, Globe G, Hicks M, et al. Manipulative therapy for shoulder pain and disorders: expansion of a systematic review. *J Manipulative Physiol Ther*. 2011;34(5):314–46.
- 23 Walser R, Meserve B, Boucher T. The effectiveness of thoracic spine manipulation for the management of musculoskeletal conditions: a systematic review and meta-analysis of randomized clinical trials. *J Man Manip Ther*. 2009;17(4):237–46.
- 24 Winters J, Sobel J, Groenier K, Arendzen H, de-Jong B. Comparison of physiotherapy manipulation and corticosteroid injection for treating shoulder complaints in general practice: randomised single blind study. *BMJ*. 1997;31(7090):1320–5.
- 25 Bang M, Deyle G. Comparison of supervised exercise with and without manual physical therapy for patients with shoulder impingement syndrome. *J Orthop Sports Phys Ther*. 2000;30(3):126–37.
- 26 CRD: Centre of Reviews and Dissemination. *Systematic reviews – CRD's guidance for undertaking reviews in health care*. York: CRD York University; 2009.
- 27 Higgins J, Green S [Internet]. *Cochrane handbook for systematic reviews of interventions*, Version 5.1.0. [cited 2013 Nov 3]. Available from: www.cochrane-handbook.org 2011.
- 28 Liberati A, Altman D, Tetzlaff J, Mulrow C, Gøtzsche P, Vonnid J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *BMJ*. 2009; 339:b2700.
- 29 Vicenzino B, Collins D, Wright A. The initial effects of a cervical spine manipulative physiotherapy treatment on the pain and dysfunction of lateral epicondylalgia. *Pain*. 1996;68(1):69–74.
- 30 Vicenzino B, Collins D, Benson H, Wright A. An investigation of the interrelationship between manipulative therapy-induced hypoalgesia and sympathoexcitation. *J Man Physiol Ther*. 1998;21(7):448–53.
- 31 Grade Working Group [Internet]. 2004. Grade Working Group; [cited 2013 Nov 12]. Available from: http://www.grade-workinggroup.org/about_us.htm
- 32 Kinnear B. Physical therapies as an adjunct to botulinum toxin-A injection of the upper and lower limb in adults following neurological impairment. *Syst Rev*. 2012;1:29.
- 33 Harvey L, Herbert R, Crosbie J. Does stretching induce lasting increases in joint ROM? A systematic review. *Physiother Res Int*. 2002;7:1–13.
- 34 Boyles R, Ritland B, Miracle B, Barclay D, Faul M, Moore J, et al. The short-term effects of thoracic spine thrust manipulation on patients with shoulder impingement syndrome. *Man Ther*. 2009;14(4):375–80.
- 35 Strunce JB, Walker MJ, Boyles RE, Young B. The immediate effects of thoracic spine and rib manipulation on subjects with primary complaints of shoulder pain. *J Man Manip Ther*. 2009;17(4):230–6.
- 36 Mintken PE, Cleland JA, Carpenter K, Bienick M, Keirns M, Whitman J. Some factors predict successful short term outcomes in individuals with shoulder pain receiving cervico-thoracic manipulation: a single-arm trial. *Phys Ther*. 2010;90(1):26–42.
- 37 Janse van Rensburg K, Atkins E. Does thoracic manipulation increase shoulder range of movement in patients with subacromial impingement syndrome? A pilot study. *Int Musculoskelet Med*. 2012;34(3):101–7.
- 38 Bergman G, Winters J, Groenier K, de-Jong B, Potemia K, van der Heijden G. Manipulative therapy in addition to usual medical care for patients with shoulder dysfunction and pain: a randomized controlled trial. *Ann Int Med*. 2004;141(6):432–9.
- 39 Bergman G, Winters J, Groenier K, Pool J, de Jong B, Potemia K, et al. Manipulative therapy in addition to usual care for patients with shoulder complaints: results of physical examination outcomes in a randomized controlled trial. *J Manipulative Physiol Ther*. 2010;33(2):96–101.
- 40 Flynn T, Fritz J, Whitman J, Wainner R, Magel J, Rendeiro D, et al. A clinical prediction rule for classifying patients with low back pain who demonstrate short-term improvement with spinal manipulation. *Spine (Phila Pa 1976)*. 2002;27(24): 2835–43.
- 41 Beattie P, Nelson R. Clinical prediction rules: what are they and what do they tell us? *Aust J Physiother*. 2006;52:157–63.
- 42 Fritz JM, Cleland JA, Childs JD. Subgrouping patients with low back pain: evolution of a classification approach to physical therapy. *J Orthop Sports Phys Ther*. 2007;37(6):290–302.
- 43 Hancock M, Herbert RD, Maher CG. A guide to interpretation of studies investigating subgroups of responders to physical therapy interventions. *Phys Ther*. 2009;89(7):698–704.
- 44 Bronfort G, Evans R, Nelson B, Aker P, Goldsmith C, Vernon H. A randomized clinical trial of exercise and spinal manipulation for patients with chronic neck pain. *Spine (Phila Pa 1976)*. 2001;26:788–97.
- 45 Jull G, Trott P, Potter H, Zito G, Niere K, Shirley D, et al. A randomized controlled trial of exercise and manipulative therapy for cervicogenic headache. *Spine (Phila Pa 1976)*. 2002;27:1835–943.
- 46 Bennell K, Wee E, Coburn S, Green S, Harris A, Staples M, et al. Efficacy of standardized manual therapy and home exercise programme for chronic rotator cuff disease: randomised placebo controlled trial. *BMJ*. 2010;340:c2756.
- 47 Ho C, Sole G, Munn J. The effectiveness of manual therapy in the management of musculoskeletal disorders of the shoulder: a systematic review. *Man Ther*. 2009;14:463–74.

- 48 Guyatt G, Oxman A, Sultan S, Glasziou P, Akl E, Alonso-Coello P, *et al.* GRADE guidelines: 9. Rating up the quality of evidence. *J Clin Epidemiol.* 2011;64:1311–6.
- 49 Poppen NK, Walker P. Normal and abnormal motion of the shoulder. *J Bone Joint Surg Am.* 1976;58:195–201.
- 50 Theodoris D, Ruston S. The effect of shoulder movements on thoracic spine 3D. *Clin Biomech.* 2002;17:418–21.
- 51 Bullock M, Foster N, Wright C. Shoulder impingement: the effect of sitting posture on shoulder pain and range of motion. *Man Ther.* 2005;10(1):28–37.
- 52 Lewis J, Wright C, Green A. Subacromial impingement syndrome: the effect of changing posture on shoulder range of movement. *J Orthop Sports Phys Ther.* 2005;35(2):72–87.
- 53 Neer C. Impingement lesions. *Clin Orthop Relat Res.* 1983;173:70–7.
- 54 Guyatt G, Oxman A, Vist G, Kunz R, Falck-Ytter Y, Alonso-Coello P, *et al.* GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ.* 2008;336(7650):924–6.

Appendix 1: CPR Criteria - Mintken *et al.*³⁶

A clinical prediction rule is used to identify patients likely to respond to a specific treatment modality. The below criteria attempts to identify patients likely to respond to TMT. Satisfaction of more than three of these criteria could increase response rate from 61% to 89%, and if all five are satisfied 100% of patients are expected to respond.³⁶

-
- CPR criteria – Mintken *et al.*³⁶
 - Pain-free shoulder flexion < 127°
 - Shoulder internal rotation < 53° at 90° abduction
 - Negative Neer's impingement test
 - Not taking medication for shoulder pain
 - Symptoms < 90 days
-