Systematic Review

Thoracic manipulation versus mobilization in patients with mechanical neck pain: a systematic review

Jodi L. Young, Doug Walker, Shane Snyder, Kelly Daly

Franklin Pierce University, Goodyear, AZ, USA

Objectives: Thoracic manipulation is widely used in physical therapy and has been shown to be effective at addressing mechanical neck pain. However, thoracic mobilization may produce similar effects. The purpose of this systematic review was to evaluate the current literature regarding the effectiveness of thoracic manipulation versus mobilization in patients with mechanical neck pain.
Methods: ProQuest, NCBI-PubMed, APTA's Hooked on Evidence, Cochrane Library, CINAHL and SPORTDiscus were searched to identify relevant studies. Fourteen studies meeting the inclusion criteria were analyzed using the Physiotherapy Evidence Database (PEDro) scale and the GRADE approach.
Results: The literature as assessed by the PEDro scale was fair and the GRADE method showed overall quality ranging from very low to moderate quality. The 14 included studies showed positive outcomes on cervical pain levels, range of motion, and/or disability with the use of thoracic manipulation or mobilization. There was a paucity of literature directly comparing thoracic manipulation and mobilization.
Discussion: Current limitations in the body of research, specifically regarding the use of thoracic mobilization, limit the recommendation of its use compared to thoracic manipulation for patients with mechanical neck pain. There is, however, a significant amount of evidence, although of varied quality, for the short-term benefits of thoracic manipulation in treating patients with this condition. Further high quality research is necessary to determine which technique is more effective in treating patients with mechanical neck pain.

Keywords: Manipulation, Mechanical neck pain, Mobilization, Systematic review, Thoracic

Introduction

Neck pain is a common occurrence within the general population, estimated to affect 10% of the adult population at any given time.[1] It is thought that approximately 50–70% of individuals will experience neck pain at least once during their lifetime and up to 60% of patients continue to report chronic pain 5 years after onset of symptoms.[1–3] There is a tremendous economic burden associated with neck pain, resulting in increased visits to health care providers, missed work, and loss of productivity, and it is responsible for the second highest annual workers' compensation costs in the United States.[1,4–6]

A common classification of neck pain is mechanical neck pain.[7] Although the definition varies among different research studies, mechanical neck pain is most commonly defined as pain located in the cervical spine or cervicothoracic junction that is elicited and/or exacerbated by cervical motion and/or palpation of cervical musculature.[7–12]

Neck pain may be accompanied by neurological deficits and/or referred or radiating pain into the upper extremities, or headaches with a cervical origin (termed 'cervicogenic headaches');[12,13] however, these signs/symptoms are often excluded when referring to mechanical neck pain.[7] The current physical therapy clinical practice guidelines for neck pain have separated the clinical findings of patients presenting with neck pain into categories, with headaches and referred or radiating pain into the upper extremities having their own individual categories.[13] Patients presenting with headaches and/or radiating pain may respond to physical therapy interventions, specifically thoracic manipulation and mobilization, differently than those with mechanical neck pain. Thus, the focus of this systematic review is mechanical neck pain, with the exclusion of radiculopathy and cervicogenic headaches.

Mechanical neck pain is commonly treated conservatively with physical therapy.[2] In fact, approximately

Correspondence to: Jodi Young, 14455 West Van Buren Street, Suite 100, Building A, Goodyear, AZ 85338, USA. Email: youngj@franklinpierce.edu

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one-quarter of all patients visiting an outpatient physical therapy clinic have neck pain as their chief complaint.[14] A common intervention utilized by physical therapists to address mechanical neck pain is manual therapy, which is intended to increase tissue extensibility and range of motion, mobilize or manipulate soft tissue and joints, and to decrease pain.[15] Specific manual therapy techniques such as mobilization/manipulation are skilled passive movements to joints and/or related soft tissues which are applied at varying speeds and amplitudes.[15]

In recent years, clinicians and researchers have begun to investigate manual therapy techniques applied to the thoracic spine for the treatment of mechanical neck pain.

Although the exact mechanisms by which this approach garners positive results are not completely understood, it is widely thought that the conceptual model of regional interdependence is involved.[2,16–18] This model theorizes that restrictions or dysfunction in a body region may be treated by mobilization of adjacent body segments.[2] This has led to an increased focus in clinical research on treatment of biomechanically linked segments, such as treating the thoracic spine for neck pain. Neurophysiological effects may also be involved.[11,16] Bialosky *et al.*[19] proposed a model in which a mechanical stimulus (provided by a manual therapy technique) may induce neurophysiologic effects such as hypoalgesia, neuromuscular responses, endocrine responses and more via peripheral, spinal, and supraspinal mechanisms.[19] Bialosky *et al.*[19] also discuss the possibility of a combined effect of both biomechanical and neurophysiological mechanisms rather than independent effects.

There is a growing body of evidence that manual therapy directed to the thoracic spine, particularly thoracic manipulation, is effective at improving patient outcomes such as reducing pain and disability and increasing range of motion, in patients with neck pain, regardless of the number or location of cavitations achieved.[3,7,9,16,17,20] Recent evidence seems to favor the use of thoracic high-velocity low-amplitude thrust (HVLA) manipulation over non-thrust mobilization; however, based on current evidence it is difficult to make the determination as to which is superior, as only one study, to our knowledge, has made a direct comparison between the two techniques.[14]

Three systematic reviews[7,12,16] have been published comparing thoracic manipulation versus other controls in the treatment of mechanical neck pain. However, one of these reviews[12] included cervical mobilizations and manipulations and did not exclude patients with cervicogenic headache and/or radicular symptoms. Only one systematic review[12] compared thoracic manipulation to thoracic mobilization, but notably the only published study[14] to directly compare the two treatments was not included in any of these reviews. No review has been published that specifically examined patient outcomes for thoracic manipulations versus thoracic mobilizations in patients with mechanical neck pain (without cervicogenic headache and/or radicular symptoms). The objective of this systematic review is to determine the effectiveness of thoracic manipulation versus thoracic mobilization in improving outcomes in patients with mechanical neck pain.

Methods

Data sources and searches

A review of six databases was conducted by four individuals (KD, NH, SS, DW) from June to September of 2012. Included databases were ProQuest, NCBI-PubMed, American Physical Therapy Association's (APTA) Hooked on Evidence, Cochrane Library, Cumulative Index to Nursing and Allied Health Literature (CINAHL), and SPORTDiscus. There was no limitation in the date ranges for the search so all relevant research was included in this review. Due to the variability of the terms 'thrust', 'non-thrust', 'mobilization', and 'manipulation' used in the literature, the Boolean operator 'OR' was used to return all possible search results. The search terms used in all six of the databases for thoracic manipulation included: '(thrust OR manipulation) AND (neck OR cervical) AND thoracic'; the search terms used for mobilization included '(non-thrust OR mobilization) AND (neck OR cervical) AND thoracic'.

Study selection

In an effort to be as thorough as possible, databases were searched for published research of any study design and methodological quality. To be included in this systematic review, studies must have been published in English from a peer-reviewed journal. Titles and abstracts were screened for inclusion of: (1) mechanical neck pain, (2) intervention to the thoracic spine, or (3) an outcome for the neck/cervical spine. Remaining studies were excluded if they: (1) examined non-mechanical neck pain (radiculopathy, whiplash, etc), (2) utilized only non-thoracic mobilization or manipulation, (3) did not have at least one intervention in which manipulation or mobilization was directed to the thoracic spine only, or were: (4) a book review, (5) an evidence summary, (6) non-published research, (7) a systematic review of thoracic manipulation or mobilization in the treatment of mechanical neck pain, or (8) an incomplete study.

Data extraction

Studies that met eligibility criteria were screened for relevant demographic information, including sample size, age, gender, duration of symptoms, interventions, outcome measures, treatment frequency, follow-up, and controls used. As the intent of this review was to compare general outcomes, all possible outcome measures were examined. Outcome measures from all 14 studies were enumerated by two authors (KD, SS) for assessment. All relevant statistical analyses for these outcome measures were aggregated for further analysis by four individuals (KD, NH, SS, DW).

Quality assessment

To assess the quality of studies in this review, the Physiotherapy Evidence Database (PEDro) Scale was used. The PEDro scale was developed by a group of clinical trial experts in an effort to support and advance research quality of trials within Physiotherapy/Physical Therapy.[21,22] It is comprised of 11 criteria designed to reflect both internal and external validity while assessing quality of clinical trials and lower level evidence.[21,23] Of these 11 criteria, 10 evaluate internal validity while only one evaluates external validity. The first item of the PEDro scale is related to external validity, but as the intent of the PEDro score in its use for this review was to address the studies' internal validity, it was not calculated in the scoring.[21] If a reviewer answers 'yes' to a particular criterion, a score of one is given. If a reviewer answers 'no', a score of zero is given. Refer to Table 1 for individual criterion. After scoring the criteria in the PEDro scale, the final score is added up for that specific study, which can range from zero to 10 points.[23]

Of the 14 studies selected for this systematic review, nine[2,4,8,11,14,17,20,24,25] had already received a published and peer-reviewed PEDro score, with which all the current authors agreed upon individual review of the published scores.[21] According to Maher[23] the reliability of the PEDro scale is considered 'fair to good' when studies were rated by a committee. Therefore, four individuals (KD, NH, SS, DW) individually rated the remaining five studies[3,9,10,26,27], and discrepancies in the scoring of four studies[3,9,26,27] were resolved by discussion until a consensus was met. The trials included in this review were assigned methodological quality ratings proposed by Walser *et al.*[16] A study was considered to be of 'high' quality if it received a PEDro score of seven or above.[16] Similarly, a study was found to be of 'fair' quality if it received a score of five to six, and of 'poor' quality if the score was four or below.[16]

To assess the overall body of evidence, the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach[28] was also utilized on all included studies. There are five domains used in the GRADE system, including limitations in study design, inconsistency of results, indirectness of evidence, imprecision, and reporting bias.[28,29] After

Table 1 PEDro scoring of included studies

Reference	2	3	4	5	6	7	8	9	10	11	Total score	Study quality
Fernández-de-las-Peñas *et al.*[9]	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	9	High
González-Iglesias *et al.*[10]	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	9	High
Cleland *et al.*[8]	Y	Y	Y	Y	N	Y	Y	N	Y	Y	8	High
Lau *et al.*[20]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8	High
Cleland *et al.*[4]	Y	Y	Y	N	N	N	Y	Y	Y	Y	7	High
Cleland *et al.*[14]	Y	Y	Y	N	N	N	Y	Y	Y	Y	7	High
González-Iglesias *et al.*[24]	Y	Y	Y	N	N	Y	Y	N	Y	Y	7	High
Martínez-Segura *et al.*[11]	Y	Y	Y	N	N	Y	Y	N	Y	Y	7	High
Puentedura *et al.*[2]	Y	Y	Y	N	N	Y	N	Y	Y	Y	7	High
Krauss *et al.*[17]	Y	Y	Y	N	N	Y	N	N	Y	Y	6	Fair
Fernández-de-las-Peñas *et al.*[25]	N	N	N	N	N	N	Y	Y	Y	Y	4	Poor
Savolainen *et al.*[26]	Y	N	Y	N	N	N	N	N	Y	Y	4	Poor
Cleland *et al.*[3]	N	N	N	N	N	N	Y	N	Y	Y	3	Poor
Ko *et al.*[27]	N	N	Y	N	N	N	N	N	Y	Y	3	Poor
Total of 'yes' scores	11	10	12	3	0	8	10	7	14	14		
% of 'yes' per criterion	79%	71%	86%	21%	0%	57%	71%	50%	100%	100%		
									Score Average		6.36	Fair
									Standard Deviation		2.06	

Y=Criterion satisfied; N=Criterion not satisfied.
2. Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received).
3. Allocation was concealed.
4. The groups were similar at baseline regarding the most important prognostic indicators.
5. There was blinding of all subjects.
6. There was blinding of all therapists who administered the therapy.
7. There was blinding of all assessors who measured at least one key outcome.
8. Measurements of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups.
9. All subjects for whom outcome measurements were available received the treatment or control condition as allocated, or where this was not the case, data for at least one key outcome were analyzed by 'intention to treat'.
10. The results of between-group statistical comparisons are reported for at least one key outcome.
11. The study provides both point measurements and measurements of variability for at least one key outcome.

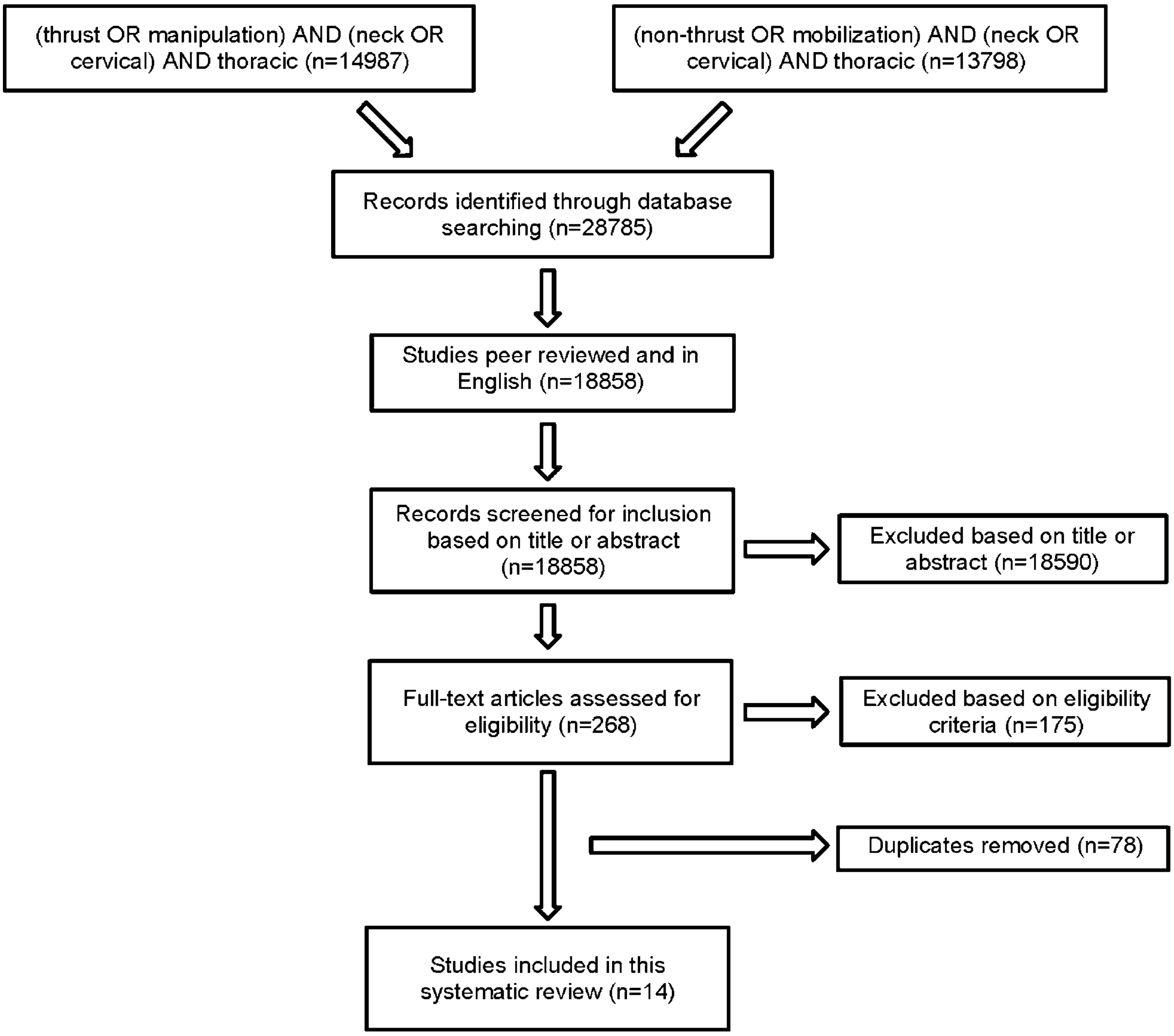

Figure 1 Flow diagram for study selection.

appraising the evidence, each outcome is classified as one of the following:[28,29]

- High quality evidence – Further research is very unlikely to change our confidence in the estimate of effect, all domains are met
- Moderate quality evidence – Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate, one of the domains is not met
- Low quality evidence – Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate, two of the domains are not met
- Very low quality evidence – Any estimate of effect is very uncertain, three of the domains are not met

Randomized controlled trials begin with a high quality evidence classification, but may be downgraded if one or more of the above described domains is present.[28] Observational studies, on the other hand, start with a low quality evidence classification, and may be upgraded if a dose response relation is found or if the treatment effect is very large.[28] Hence, although some studies may score high on the PEDro scale, it is possible that their quality rating via the GRADE approach may be low because the GRADE approach accounts for some different methodological qualities. After assessing the studies, an overall strength of recommendation for the included studies was made.

Results

A total of 29 studies were identified for potential inclusion. After review of the abstracts, only 14 met the inclusion criteria (Fig. 1). Ten of the included studies were randomized controlled trials.[2,4,8,10,11,14,17,20,24,25] The remaining four studies included one quasi-experimental study lacking randomization[27], one prospective cohort study[3], one case series[26], and one secondary analysis of a randomized controlled trial.[9] The 14 included studies had a mixed population of men and women. All of the patients were diagnosed with mechanical neck pain. Each of the patients had varying symptom duration and ages ranging from 18 to 60 years old. Thirteen different outcome measures were used across the 14 studies reviewed. The two most commonly used outcome measures in the included studies were the NPRS[2–4,10,11,14,20,26] and the NDI.[2–4,14,27] The physical impairment of cervical ROM was measured post-intervention in six of the studies.[9–11,17,20,24,26] All of these have been shown to be reliable as measures of improvement in the clinic.[30–33] Follow-up times ranged from immediately post-intervention to 6 months or longer. (Table 2)

Methodological quality assessment

PEDro scores for each study are presented in Table 1. The scores of the included studies ranged from two to nine with a mean score of 6.36 (SD 2.06), indicating that the average quality of the included research is 'fair'. Nine[2,4,8–11,14,20,24] studies were found to be of 'high' quality, one[17] of 'fair' quality, and four[3,25–27] of 'poor' quality. Two PEDro criteria were seen in all of the included studies: comparing between groups and reporting of point measures and variability.[2–4,8–11,14,17,20,24–27] None of the studies blinded the treating clinicians and only three met criterion five[5,9,10] regarding blinding of subjects. Blinding of the treating clinicians, of course, is not feasible in studies involving manual therapy.

The quality assessment also included classifying the evidence according to the GRADE approach.[28,29] The literature is sparse for direct comparisons between thoracic manipulation and mobilization, as well as for the use of thoracic mobilization. There are several studies that utilize thoracic manipulation, but most are in conjunction with another intervention.[2–4,8–11,17,20,24–26]

The lone study[14] we found that directly compared thoracic manipulation to mobilization was of moderate quality via the GRADE assessment, and the one study that included thoracic mobilization[27] was very low quality evidence according to the GRADE criteria. All of the other included studies[2–4,8–11,17,20,24–26] incorporating manipulation compared it to another intervention, and their quality ranged from very low to moderate.

From the GRADE assessment, an overall strength of recommendation for the included studies was determined, which ranged from very low to high. Although the quality of five studies[9,10,14,20,24] was moderate, the recommendation is high because four[10,14,20,24] of the five studies were randomized controlled trials, all were without serious limitations, and all had significant findings in their assessed outcomes. Conversely, three studies[3,17,26] were of low quality evidence as per the GRADE method, but the strength of recommendation is very low because the evidence is from a prospective cohort study[3], a case series[26], and only one randomized controlled trial[17], all with low PEDro scores and study limitations. See Table 3 for the GRADE classification of evidence and strength of recommendation for all included studies.

Thoracic manipulation vs thoracic mobilization

Cleland *et al.*[14] (PEDro score=7) was the only study we found that directly compared thoracic manipulation to thoracic mobilization, with each group having 30 subjects. The results demonstrated clinically and statistically significant reductions in disability ($P<0.001$) and pain ($P<0.001$), as well as statistically significantly increased perceived recovery ($P<0.01$) at 2–4-day follow-up for the manipulation group. In addition, no significant differences were observed in the number of side effects experienced by the manipulation or mobilization groups. The reported side effects included aggravation of symptoms, muscle spasm, neck stiffness, headache, and radiating symptoms.[14]

Thoracic manipulation

Four studies[9,10,20,24] utilized thoracic manipulation with modalities compared to a modality only or a modality and education group. The sample sizes ranged from 45[9,10,24] to 120 patients.[20] González-Iglesias *et al.*[10] (PEDro score=9) and Lau *et al.*[20] (PEDro score=8) demonstrated that the thoracic manipulation groups experienced significant and clinically meaningful decreases in pain at 1 week[10] ($P<0.001$) and up to 6 months[20] follow-up ($P<0.05$), whereas Fernández-de-las-Peñas *et al.*[9] (PEDro score=9) and González-Iglesias *et al.*[24] (PEDro score=7) demonstrated a significant and clinically meaningful improvement in pain immediately[9,24] ($P<0.001$) and at 2- and 4-week follow-ups ($P<0.001$).[24] Three of the studies[10,20,24] also demonstrated statistically significant improvements in disability at follow-ups ranging from immediately post-intervention ($P<0.001$[24], $P=0.018$[20]), one week ($P<0.001$)[10] and up to 6 months duration ($P=0.007$).[20] Lau *et al.*[20] demonstrated statistically significant improvements in the cranio-vertebral angle up to 6 months post-treatment and in health-related quality of life throughout the study. All four of the studies[9,10,20,24] demonstrated statistically significant increases in cervical range of motion ($P<0.001$,[9,10] $P<0.05$).[20,24]

Cleland *et al.*[8] (PEDro score=8) compared thoracic manipulation to a placebo intervention in 36 patients. The study demonstrated a significant and clinically meaningful improvement in pain immediately post-intervention for the 19 patients in the thoracic manipulation group ($P<0.001$).

Cleland *et al.*[4] (PEDro score=7) and Puentedura *et al.*[2] (PEDro score=7) examined the use of thoracic manipulation along with an exercise regimen. Puentedura *et al.*[2] also included a cervical manipulation

Table 2 Study characteristics

Article	Control group	Experimental group	Intervention	Frequency	Assessment Post-Intervention	Follow-Up	Results
Cleland *et al.*[8]	n=17	n=19	Experimental: supine thoracic manipulation	One time treatment	VAS	Immediate	Manipulation: immediate reduction in pain over placebo. Experimental group averaged 15.5 mm change in VAS, placebo group averaged 4.2 mm change.
			Control: placebo thoracic manipulation				
Cleland *et al.*[3]	None	n=78	Six thoracic manipulations per session via three different techniques and CROM exercise	1–2 sessions maximum	GROC, NPRS, NDI	2–4 days	Established six predictor variables. If patient=4/6, post-test probability of success=93%. If 3/6, post-test probability=86%
Cleland *et al.*[14]	n=30	n=30	Thoracic manipulation vs thoracic mobilization with both groups performing CROM exercise	One time treatment	NDI, NPRS	2–4 days	Manipulation: clinically and statistically significant reductions in disability and pain and statistically significant improvement in GROC scores.
Cleland *et al.*[4]	n=70	n=70	Experimental: thoracic manipulation and exercise	Experimental: two sessions of manipulation and CROM followed by three sessions of exercise	NDI, NPRS, GROC	1 week, 4 weeks, 6 months	Manipulation: clinically significant short and long-term reduction in disability, short-term (1 week) reduction in pain and improved perceived recovery at 4 weeks and 6 months
			Control: exercise only	Control: five sessions over 4 weeks			
Fernández-de-las-Peñas *et al.*[26]	None	n=7	Thoracic manipulation	One time treatment	NPRS, CROM	Immediate, 2 days	Manipulation: clinically and statistically significant decrease in pain immediately, which was sustained at 2-day follow-up. CROM: improvement in all motions but none were statistically significant at either follow-up.
Fernández-de-las-Peñas *et al.*[9]	n=22	n=23	Experimental: thoracic manipulation once per week (1st, 3rd, and 5th sessions)+control interventions	Five sessions over 3 weeks	VAS, CROM	Immediate	Manipulation: clinically meaningful and statistically significant reduction in pain, as well as significant improved CROM (all motions)
			Control: electrotherapy and thermotherapy program				
González-Iglesias *et al.*[10]	n=22	n=23	Experimental: thoracic manipulation once per week for 3 weeks+control intervention	six sessions over three consecutive weeks	NPRS, CROM, NPQ	1 week	Manipulation: statistically significant and clinically meaningful reduction in pain and statistically significant decreased disability and improved CROM (all motions)

Table 2 Continued

Article	Control group	Experimental group	Intervention	Frequency	Assessment Post-Intervention	Follow-Up	Results
González-Iglesias *et al.*[24]	*n*=22	*n*=23	Control: electrotherapy, superficial thermotherapy +STM Experimental: thoracic manipulation once per week (1st, 3rd, and 5th session)+ control intervention	five sessions over 3 weeks	VAS, CROM, NPQ	Immediate, 2 weeks, 4 weeks	Manipulation: statistically significant and clinically meaningful decrease in pain immediately and at 2 and 4 weeks. Also statistically significant improvement in CROM and disability immediately and at 2 weeks.
Ko *et al.*[27]	*n*=26	*n*=27	Control: electro and thermotherapy program Experimental: thoracic mobilizations+control intervention	Three times per week for 6 weeks	VAS, NDI, muscular endurance of deep cranio-cervical flexors	Immediate	Mobilization: statistically significant reduction in disability and pain as well as increased cervical muscle endurance
Krauss *et al.*[17]	*n*=10	*n*=22	Control: cranio-cervical flexor exercises Experimental: thoracic manipulation	One time treatment after initial evaluation	FPS, CROM	Immediate	Manipulation: statistically significant increase in bilateral cervical rotation and statistically significant improvement in pain
Lau *et al.*[20]	*n*=60	*n*=60	Control: no intervention Experimental: thoracic manipulation +control interventions	Two times per week for eight sessions	CV angle, NPRS, NPQ, SF36Q, CROM	Immediate, 3 months, 6 months	Manipulation: statistically significant and clinically meaningful decrease in pain immediately and up to 6 months. Statistically significant improvements in disability, CV angle and CROM at all follow-ups.
Martínez-Segura *et al.*[11]	None	Cervical *n*=57; Thoracic *n*=33	Control: infrared radiation therapy and a standard set of education materials Cervical: midcervical, midrange manipulation; Thoracic: AP end range upper thoracic manipulation	One time treatment	PPTs, CROM, NPRS	Immediate	Thoracic group: statistically significant and clinically meaningful decrease in pain. Improvements in PPT and CROM were shown, but were not significant.

Table 2 Continued

Article	Control group	Experimental group	Intervention	Frequency	Assessment Post-Intervention	Follow-Up	Results
Puentedura *et al.*[2]	None	Cervical n=14; Thoracic n=10	Cervical: cervical manipulation; Thoracic: thoracic manipulation;	five sessions over 2 weeks	NDI, NPRS, FABQ, GROC	1 week, 4 weeks, 6 months	Thoracic manipulation: 10% of patients met or exceeded the MDC/MCID at 4 weeks and 6 months for NDI. 40% of patients met or exceeded MDC/MCID for pain at 4 weeks whereas only 20% did so at 6 months. 20% of patients reported GROC scores equal to/greater than +5 at all follow-ups.
Savolainen *et al.*[25]	None	Exercise group n=32; Manipulation group n=43	Both groups: standard exercise program Exercise group: program instructed by a PT; Manipulation group: four thoracic manipulations by a physiatrist	Exercise group: not stated; Manipulation group: 1 week intervals	VAS	6 months, 12 months	Manipulation: statistically significant lower level of perceived worst pain at 12-month follow-up. Both groups demonstrated statistically significant decreases in muscular tenderness and tender thoracic levels at all follow-ups.

Note: NDI, Neck Disability Index; NPRS, Numeric Pain Rating Scale; FABQ, Fear Avoidance Beliefs Questionnaire; FABQPA, Fear Avoidance Beliefs Questionnaire physical activity subscale; GROC, Global Rating of Change; FPS, Faces Pain Scale; CROM, Cervical Range of Motion; VAS, Visual Analog Scale; NPQ, Northwick Park Neck Disability Questionnaire; CV Angle, Craniovertebral Angle; SF36Q, SF-36 Health Questionnaire; PPTs, Pressure Pain Thresholds.

Table 3 GRADE scoring of included studies

Intervention	Outcomesassessed	Trial limitations	Inconsistency	Indirectness	Imprecision	Publication bias	GRADE quality of evidence	Strength of recommendation
Thoracic manipulation versus mobilization[14]	Disability pain	None	N/A	No indirectness	-1[#]	None	Moderate	High
Manipulation with modality versus modality[9,10,20,24]	CV Angle pain CROM	None	No inconsistency	−1[^]	No imprecision	None	Moderate	High
Thoracic manipulation versus cervical manipulation[11]	Pain	None	N/A	No indirectness	−1[#]	None	Moderate	Moderate
Thoracic manipulation with exercise[2,4]	Disability pain	None	−1[x]	−1[^]	No imprecision	None	Low	Low
Thoracic manipulation versus placebo thoracic manipulation[8]	Pain	None	N/A	−1[^]	−1[#]	None	Low	Low
Thoracic manipulation only[3,17,26]	Disability pain CROM	−1*	No inconsistency	−1[^]	No imprecision	None	Low	Very low
Thoracic manipulation versus exercise[25]	Pain CROM	−1*	N/A	−1[^]	−1[#]	None	Very low	Very low
Thoracic mobilization with exercise[27]	Disability pain	−1*	N/A	−1[^]	−1[#]	None	Very low	Very low

CROM, Cervical Range of Motion; CV Angle, Craniovertebral Angle; N/A, Not Applicable.
*Quality point deducted for high risk of bias (PEDro score<6/10).[29]
[x]Quality point deducted for conflicting results between studies, leading to inconsistency.[29]
[^]Quality point deducted for indirectness from comparison/control group receiving intervention that is expected to be less effective than standard treatment and/or inclusion of a co-intervention (i.e. exercise, modality).
[#]Quality point deducted for imprecision due to only one study reporting data.[29]

group, but for the purpose of this review, only the thoracic manipulation data were extracted. Cleland *et al.*[4] found that the 70 patients receiving manipulation experienced clinically and statistically greater short and long-term reduction in disability ($P=0.003$ at 1 week, $P=0.001$ at 4 weeks, $P<0.001$ at 6 months) and short-term reduction in pain ($P<0.001$ at 1 week) than the 70 patients given the exercise regimen. In addition, although there was no significant difference in perceived recovery between groups at 1-week follow-up, the manipulation group demonstrated clinically and statistically significant improvement at both 4-week ($P=0.01$) and 6-month follow-ups (*P* value not reported). Puentedura *et al.*[2] found that only one of the 10 patients in the thoracic manipulation and exercise group experienced statistically significant and clinically meaningful reductions in disability upon follow-up at 4 weeks and 6 months (*P* value not reported). Forty percent of patients experienced clinically and statistically significant reductions in pain at the 4-week follow-up but this decreased to 20% by 6 months (*P* value not reported). In addition, only 20% of the patients in the thoracic manipulation group demonstrated a clinically and statistically significant improvement in perceived recovery at all follow-up intervals (*P* value not reported).

Martínez-Segura *et al.*[11] (PEDro score=7) compared the short-term effects of thoracic manipulation to cervical spine manipulation on patients' pressure pain threshold (cervical spine, lateral epicondyle, and tibialis anterior), pain levels, and cervical range of motion in 90 patients. For the purpose of this review, only the thoracic manipulation data were extracted. The 33 patients in the thoracic manipulation group demonstrated a statistically significant and clinically meaningful decrease in pain ($P<0.001$) immediately post intervention. Although this study demonstrated improvements in pressure pain thresholds and active cervical range of motion, these improvements were not statistically significant.

Two studies, a randomized clinical trial by Krauss *et al.*[17] (PEDro score=6) and a case series by Fernandez *et al.*[26] (PEDro score=4), utilized a single thoracic manipulation without any supplemental exercise program. Fernandez *et al.*[26] included seven patients in their study and demonstrated increases in all cervical ranges of motion, but none of these were statistically significant ($P<0.05$). The 22 patients in the experimental group in the Krauss *et al.*[17] study demonstrated statistically significant increases in bilateral cervical rotation immediately post intervention ($P<0.05$). In addition, Krauss *et al.*[17] exhibited statistically significantly decreased pain immediately post intervention ($P<0.05$), while the Fernandez *et al.*[26] patients demonstrated both clinically and statistically significant decrease in pain immediately post intervention ($P<0.001$). The Fernandez *et al.*[26] subjects maintained this significant decrease in pain two days post intervention.

Savolainen *et al.*[25] (PEDro score=4) compared a thoracic manipulation group of 43 patients to an exercise only group of 32 patients. Patients in the manipulation group demonstrated statistically significantly lower pain levels at 12-month follow-up ($P<0.05$). Additionally, both the thoracic manipulation and exercise groups demonstrated statistically significant decreases in muscular tenderness and tender thoracic levels at 6 and 12-month follow-ups ($P<0.001$). However, 34 drop-out subjects who attended the 12-month follow-up demonstrated similar improvements as well, with no significant differences noted between all three groups.

A clinical prediction rule derivation study including 78 patients by Cleland *et al.*[3] (PEDro score=3) aimed to identify patients with mechanical neck pain most likely to benefit from thoracic manipulation. This study demonstrated that if subjects met three out of six specific criteria, the post-manipulation probability of perceived recovery increased from 54 to 86%. The probability of perceived recovery increased even higher to 93% if subjects met four out of the six criteria.

Thoracic mobilization

One of the lowest quality studies utilized in this review investigated thoracic mobilization. Ko *et al.*[27] (PEDro score=3) examined the use of thoracic mobilization. Ko *et al.*[27] compared thoracic spine mobilization and cranio-cervical flexor exercises to exercise alone in 53 patients. The mobilization with exercise group demonstrated a clinically and statistically significant reduction in neck disability, statistically significant reduced pain and increased cervical muscle endurance compared to the exercise only group ($P<0.05$).

Discussion

Due to the noticeable paucity of high level research addressing thoracic mobilization to treat mechanical neck pain, the quality of the evidence included in this review is considered to be 'fair' with the use of the PEDro scale. The GRADE method was also used to examine the quality of evidence and then determine an overall recommendation of the strength of intervention for the included studies. The quality of evidence ranged from very low to moderate, but the strength of recommendations regarding the studies ranged from very low to high.

There were various issues with blinding in many of the included studies.[2,4,8–11,17,20,24] The absence of blinding in these studies introduces the potential for multiple biases, including cointervention and expectation biases and could result in an exaggerated or diminished treatment effect.[34–36]

The studies in this review included follow-ups ranging from immediately post-intervention to 12 months duration. However, only four of the studies[2,4,20,25] reported follow up data after 1 month, significantly limiting the evidence for long-term outcomes. Additionally, multiple issues related to limited sampling were evident in the included studies. Only four of the studies[2,4,14,17] collected data at more than one clinical location, and one[27] used a sample of women exclusively, thus limiting the application of the studies' findings to a wider population.

In manual therapy, there are multiple techniques used to achieve the desired treatment effect. This was evident in the studies included in this review, as the differences seen in technique in the application of manipulation were either an anterior to posterior (AP) thoracic manipulation in supine[2–4,8,11,14,17,20,26] or a seated distraction manipulation.[2–4,9,10,24] One study[25] did not indicate the manipulative technique utilized. At this time, the authors of this review are unaware of any published study to date that examines the effectiveness of one thoracic manipulation technique over the other. In an effort to be as inclusive as possible and in the absence of a clearly superior technique, this review included all techniques utilized. In terms of specific mobilization techniques, only two studies[14,27] included mobilization. These studies utilized different techniques including central posterior to anterior (PA) mobilizations (grades III and IV) in prone[14] and central anterior to posterior (AP) mobilizations (grades II and III) in supine.[27]

Only one study[14] in this review directly compared thoracic manipulation to thoracic mobilization, demonstrating superior short-term outcomes for the manipulation group. Cleland *et al.*[14] included 60 patients randomly assigned to either a manipulation or mobilization group. The manipulation group received one upper thoracic and one middle thoracic spine manipulation, and the mobilization group received a 3-minute treatment session of prone grade III–IV joint mobilizations from T1–T6. Both groups received a cervical AROM exercise for use at home. All patients had follow-up visits 2–4 days after intervention to complete outcome measures and a questionnaire regarding side effects from treatment. While the authors improved the generalizability of their findings by utilizing a standardized treatment program that did not target a specific segmental restriction, their failure to blind subjects, therapists, and assessors, along with the failure to collect long-term follow-up data, are significant limitations and worthwhile considerations for future studies.

When thoracic manipulation was examined along with modalities,[9,10,20,24] significant short-term (up to 1 week) improvements in pain, range of motion[9,10,20,24] and disability[10,20,24] were shown. However, only two studies[20,24] examined follow-up beyond 1 week and only one[20] demonstrated long-term benefits (up to 6 months) with regards to pain, disability, range of motion, and neck posture. While three studies[9,10,24] only utilized patients with acute mechanical neck pain, Lau *et al.*[20] examined patients with chronic mechanical neck pain. In addition, three of the four studies[9,10,24] excluded patients older than 45 years of age. While potential biases are present in all of the studies, particularly concerning is the timing bias evident in Lau *et al.*,[20] as the manipulation group received more treatment time. However, all of these studies blinded the assessors and two[9,10] blinded the subjects, helping to mitigate some of the potential biases.

Compared to placebo intervention, Cleland *et al.*[8] showed that thoracic manipulation resulted in immediate improvements in pain. However, the failure to collect long-term follow-up data is a significant limitation and the utilization of subjects from only one clinic presents a significant sampling bias. In addition, the utilization of segmental mobility testing via palpation to guide the level of thoracic manipulation is problematic due to the lack of reliability in identifying segmental motion restrictions.[8] Although this is common for a clinical setting and occurred in quite a few of this review's studies, this subjects the study to measurement and proficiency biases and is a consideration for future studies.

Positive, yet conflicting, results were demonstrated when thoracic manipulation was examined along with exercise in two studies.[2,4] The conflicting results may be due to different exercise regimens utilized in the studies including a lack of manual stretching in Puentedura *et al.*,[2] as well as a difference in patients' mean duration of symptoms (18.8 days for Puentedura *et al.*[2] versus 63.5 days for Cleland *et al.*[4]). In addition, although Puetendura *et al.*[2] blinded the assessors, it had a small sample size from two locations and involved treatment by only one practitioner. A study from Savolainen *et al.*[25] included exercise, and it was rife with potential biases and thus should be interpreted judiciously. No details are provided on the manipulative techniques or exercises utilized. Particularly problematic is the fact that 34 subjects dropped out with no further information provided, introducing probable withdrawal bias. No intent to treat analysis was performed. Furthermore, in addition to a lack of blinding, no duration of symptoms was provided for the subjects.

One study[11] compared thoracic manipulation to cervical manipulation with no other interventions involved. While thoracic manipulation demonstrated immediate benefits in pain reduction, no long-term follow-up was performed, only one therapist treated all the patients and no control group was utilized. In addition, only one treatment session occurred, which makes it difficult to extrapolate the results to the multiple sessions typically involved in a plan of care in the clinical setting. However, at this point no suitable dose response rate has been determined, and further research would be helpful in establishing the appropriate quantity of manual therapy that is necessary to produce a positive outcome.

When compared to no intervention at all, a single thoracic manipulation demonstrated short-term improvements in pain[17,26] and range of motion;[17] however, the results varied amongst the studies. Interpreting and generalizing these results is particularly problematic as Krauss *et al.*[17] did not state the duration of their subjects' neck pain, and Fernandez *et al.*[26] only included seven patients and one therapist. In addition, Krauss *et al.*[17] directed the manipulation to a thoracic segmental restriction identified through a palpatory technique whereas Fernandez *et al.*[26] utilized a standardized manipulation for all subjects.

Although Cleland *et al.*[3] yielded a poor rating on the PEDro scale due to PEDro's inherent lack of fit for prospective cohort studies, it helped to identify criteria for classifying neck pain patients most appropriate for thoracic manipulation. However, this is not a validated clinical prediction rule;[4] therefore, the results should be interpreted carefully. Despite a subsequent study's failure to validate the clinical prediction rule, thoracic manipulation was still recommended for patients with mechanical neck pain.[4]

Significant benefits were demonstrated for thoracic mobilization,[27] yet generalizing these results to the clinical setting should be done very circumspectly. Specifically, Ko *et al.*[27] only utilized females with chronic mechanical neck pain in their patient population. In addition, they only examined the immediate effects of intervention with no further follow-up.

Limitations

Several possible limitations have emerged in this review. The lack of high quality evidence examining thoracic mobilization in the treatment of mechanical neck pain made it necessary to include lower level evidence in an attempt to establish a meaningful recommendation for clinic use and future research. The inclusion of these lower quality studies limits the strength of this review and may influence the reader's interpretation of the information contained within. Also, due to the presence of varying methodology and an equally wide distribution of techniques, follow-up times and outcome measures utilized, it is difficult to make a specific recommendation for clinical use. Another limitation in this review is the exclusion of studies in a language other than English.

Recommendations for Future Research

It is recommended that future research directly compare the use of thoracic manipulation versus mobilization in the treatment of mechanical neck pain. Future studies also need to include long-term follow-up since the preponderance of studies in the current body of literature only examine short-term outcomes. Future study design should also include multicenter trials to help ensure that a representative sample of all mechanical neck pain patients is utilized, incorporate multiple treating clinicians to improve generalizability to the clinical setting and blind the assessor at minimum, to mitigate potential biases including expectation bias. Finally, future research needs to examine the various thoracic manipulation techniques to determine if a specific technique achieves superior patient outcomes.

Conclusion

As a result of methodological concerns associated with the current research on the use of thoracic mobilization in the treatment of mechanical neck pain, there is no definitive evidence to support its clinical efficacy. In contrast, there is a significant amount of evidence, although of varied quality, that exists to support the use of thoracic manipulation in the treatment of mechanical neck pain for short-term improvements in neck pain, range of motion, and disability. Further research will be required to explore the value of thoracic manipulation in long-term relief of mechanical neck pain.

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