The Effectiveness of Thoracic Spine Manipulation for the Management of Musculoskeletal Conditions: A Systematic Review and Meta-Analysis of Randomized Clinical Trials

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Spinal manipulation is a treatment intervention practiced by a number of professions including physical therapists, who often utilize manipulation of the thoracic spine[1]. *The Guide to Physical Therapist Practice*[2] defines "mobilization/manipulation" as "skilled passive movements to joints and/or related soft tissue that are applied at varying speeds and amplitudes, including small-amplitude/high-velocity therapeutic movements". For the purpose of this paper, thoracic spine manipulation (TSM) is defined as a high-velocity/low-amplitude movement or "thrust" directed at any segment of the thoracic spine, including the cervicothoracic junction.

Since 2004, there has been an increase in published research investigating the effectiveness of thoracic spine manipulation using different techniques, mostly for treatment of musculoskeletal conditions[3-23]. This recent research includes the development of a clinical prediction rule (CPR) focused on the use of TSM for the treatment of mechanical neck pain[12].

ABSTRACT: Thoracic spine manipulation (TSM) is an intervention practiced by different professions, and recently an incursion of research using TSM has been published. The purpose of this review was to examine the effectiveness of TSM for the management of musculoskeletal conditions and the quality of trials that included TSM techniques. A comprehensive search of online databases was performed, and first authors of studies identified were contacted. Thirteen randomized clinical trials were included in the final review. The methodological quality of all studies was assessed using the 10-point PEDro scale. Seven of the 13 studies were of high quality. Three studies looked at TSM for treatment of shoulder conditions; however, there is limited evidence to support the use of TSM for shoulder conditions. Nine studies used TSM for the management of neck conditions. The meta-analysis identified a subset of homogeneous studies evaluating neck pain. The value of the pooled estimator (1.33) was statistically significant for the treatment effect of TSM in the studies with researcher effect removed (95 % confidence interval: 1.15, 1.52). This analysis suggests there is sufficient evidence to support the use of TSM for specific subgroups of patients with neck conditions. This review also identifies the need for further studies to examine the effectiveness of TSM to treat shoulder conditions and the effectiveness of TSM on neck conditions with long-term follow-up studies.

KEYWORDS: Meta-Analysis, Shoulder, Spinal Manipulation, Systematic Review, Thoracic Spine

Much of this recent focus on TSM has evaluated the effects of TSM in regions of the body adjacent to the thoracic spine, such as the neck and shoulder, rather than the areas of the thoracic spine itself, a concept known as *regional interdependence*[24]. For example, there is evidence that reduced mobility of upper thoracic segments is related to neck-shoulder pain[25-27]. However, why relationships like this exist is not fully understood and is a topic of debate[24,28,29]. Bialosky et al[28] asserted that the neurophysiological effects of manipulation (such as hypoalgesia) or other non-specific mechanisms (such as placebo or patient expectation) are possibly the cause of regional interdependence. Others have advocated that biomechanical effects associated with manipulation at one vertebral segment may influence adjacent vertebral segements[30,31]. Apart from what exactly is happening as a result of spinal manipulation/TSM, regional interdependence is a concept that experts agree occurs and that should be considered in clinical decision-making[24,28,29].

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The purpose of this review is to evaluate the effectiveness of TSM for the management of musculoskeletal conditions and examine the quality of trials that include any TSM technique. In particular, this study examines pooled estimates of the effect of TSM techniques on regions outside the parameters of the thoracic spine.

Methods

Search Strategy

A comprehensive online search was performed using the following databases: PubMed (1969–November 2008), the Cumulative Index of Nursing and Allied Health (CINAHL) (1997–November 2008), Physiotherapy Evidence Database (PEDro) (1995–November 2008), SportDiscus (1991–November 2008), and the Cochrane Central Register of Controlled Trials (1991–November 2008). Key phrases used in CINAHL, PEDro, SportDiscus, and Cochrane Database searches included: *thoracic spine manipulation, thoracic spine mobilization*, *manual therapy, thoracic spine.* The Boolean operator, *AND*, linked the latter two phrases. The same key phrases were used in PubMed searches; however, the results yielded an excessive number of unrelated studies with each search. Therefore, the following phrases were used in PubMed, which includes the previously mentioned Boolean operator: *thoracic spine manipulation AND physical therapy, thoracic spine mobilization AND physical therapy*.

All titles found in searches from the above databases were screened by one investigator (RW) to identify the articles that might meet eligibility criteria. Those articles were then retrieved to evaluate for inclusion. The reference lists of all retrieved articles were manually reviewed for other potentially eligible articles. Finally, in an attempt to include all pertinent articles in this review, the contact authors of articles that met the eligibility criteria were emailed and provided with a list of eligible articles identified, and asked if they were aware of other articles not listed, including those in press. Authors who did not respond to the first email within 6 days were emailed a second time with the same request. The articles obtained through manually searching references and from published manuscripts went through the same scrutiny as the articles initially found in database searches. All articles that met eligibility criteria were included in this review. No systematic reviews examining the effectiveness of TSM were identified during the database searches.

Selection Criteria

Articles selected met the following eligibility criteria:

Inclusion criteria

- Randomized controlled/clinical trial
- "Thrust" or "high-velocity/low-amplitude" manipulations of the thoracic spine or cervicothoracic junction was performed as at least part of one group's intervention
- Outcomes focused on musculoskeletal conditions

Exclusion criteria

- Mobilizations were used instead of "manipulation" or "thrust" or "high-velocity/low-amplitude" movements
- Articles in a language other than English
- Subjects less than 18 years old
- Only abstract available

For this review, outcomes focused on musculoskeletal conditions were those that could be inherently related to the musculoskeletal system. Such outcomes could include pain, range of motion (ROM), muscle tenderness, disability, strength, and perceived recovery.

In studies where "thrust" or "high-velocity/low-amplitude" was not indicated, but where "manipulation" was noted, the article was deemed to have met eligibility criteria. An exception occurred if "manipulation" was stated but further analysis showed that mobilizations (grades I–IV) were used; in that case, the article was excluded.

Data Extraction and Analysis

Information of interest was extracted from the articles that met eligibility criteria in a standardized form. The extracted information included sample size, age, sex, symptom duration, outcome measures, treatment performed (including manipulation technique or approach), treatment frequency, results, and follow-up. Information not available from articles was marked as "not stated." Studies that examined the results of TSM on the same anatomical area of the body (such as neck or shoulder) were analyzed by comparing the findings of outcomes (such as pain or ROM).

Studies evaluating individuals with neck pain only were further analyzed for homogeneity. Studies focusing on different symptoms were not analyzed because there were simply too few such studies. The neck study effect size estimates were first corrected for bias[32]. A chi square test as described by Hedges and Olkin[32] was then performed to determine homogeneity of the corrected effect size estimates across studies. Homogeneity confirmed, the corrected effect size estimates were then pooled according to the methods described by Hedges and Olkin[32]. The confidence interval (CI) for the pooled estimate uses Hedge's[32] estimate of the variance of the pooled treatment estimate and a critical value from the standard normal distribution.

Methodological Quality Assessment

The methodological quality of the articles was assessed by using the Physiotherapy Evidence Database (PEDro) scale. The PEDro scale is possibly the most useful scale to assess the methodological quality of physical therapy trials[33] and has been shown to have *fair* to *good* interrater reliability with an ICC of .55 (95% CI .41, .72) for individual raters[34]. The PEDro scale consists of 11 items to assess the methodological quality of trials. The first item in the scale deals with the external validity and items 2–11 assess the internal validity of an article. Each item in the scale was scored *yes* or *no*; a "1" was given for each *yes* and "0" for each *no*. The first item is not included in the total PEDro score of the article; therefore, a maximum of 10 points was possible to score the internal

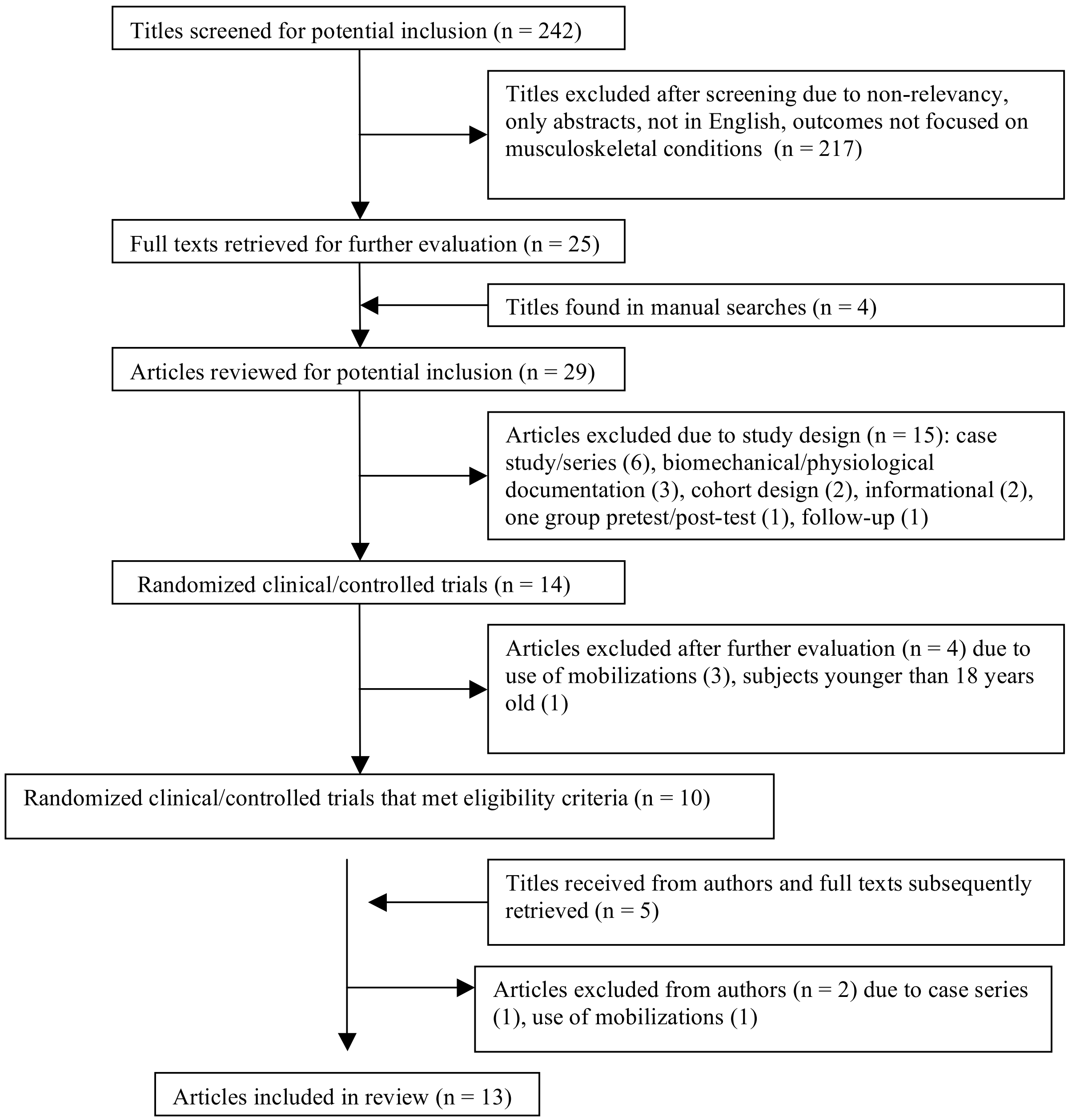

FIGURE 1. Flow chart of study selection.

validity of each article, with a range of 0 to 10.

Maher et al[34] found from 2 studies of randomized clinical trials that yes responses were common (greater than 50% of the time) for 5 of the 10 internal validity PEDro items; possibly indicating that articles with scores of 5 on the PEDro scale would be of average quality. In those same studies 7 of the 10 items were found to be noted in articles at least 18% of the time. Therefore, to more narrowly identify the articles of higher methodological quality in this review, articles with scores of 7 or higher were noted as *high* quality, 5-6 of *fair* quality, and 0–4 of *poor* quality. The studies were grouped according to the region of the body targeted. Due to some potential overlap, the shoulder group studies were those that primarily focused on mainly affecting the shoulder girdle region, while the neck group studies primarily focused on affecting the cervical region.

TABLE 1. Breakdown of PEDro scores.

Author	2	3	4	5	6	7	8	9	10	11	PEDro scores
González-Iglesias et al [18]	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	9
González-Iglesias et al[17]	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	9
Bergman et al[4]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Cleland et al[13]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Cleland et al[10]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Cleland et al[8]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Fernández-de-las-Peñas et al[16]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Fernández-de-las-Peñas et al[14]	Y	N	Y	N	N	N	Y	Y	Y	Y	6
Krauss et al[19]	Y	Y	Y	N	N	Y	N	N	Y	Y	6
Winters et al[46]	Y	Y	N	N	N	Y	N	Y	Y	Y	6
Savolainen et al[21]	Y	N	N	N	N	Y	Y	N	Y	Y	5
Parkin-Smith and Penter[47]	Y	N	Y	N	N	N	N	N	Y	Y	4
Strunk and Hondras[22]	Y	Y	N	N	N	N	Y	Y	N	N	4
Total "yes" scores and percentage (%) of "yes" scores in each criterion	**13 (100)**	**10 (77)**	**10 (77)**	**2 (15)**	**0 (0)**	**10 (77)**	**10 (77)**	**10 (77)**	**12 (92)**	**12 (92)**	

Y = Criterion was satisfied; N = Criterion was not satisfied
2 = Subjects were randomly allocated in groups
3 = Allocation was concealed
4 = Groups were similar at baseline
5 = Subjects were blinded
6 = Therapists who administered the treatment were blinded
7 = Assessors were blinded
8 = Measures of key outcomes were obtained from more than 85% of subjects
9 = Data analyzed by intention-to-treat
10 = Statistical comparisons between groups were conducted
11 = Point measures and measures of variability were provided

One author (RW) conducted all searches, determined eligibility of studies, and read and scored all eligible articles. One author (BM) extracted data for statistical analysis, and another author (TB) performed the meta-analysis of trials.

Results

Article Selection

A total of 242 titles were identified in database searches and screened for relevancy and potential eligibility in this review. Four articles were identified from manually searching references of articles found in database searches, and an additional five articles were obtained from authors. Figure 1 illustrates the results of search strategy for potential articles. Following the initial exclusion of articles from database searches and after a review of potentially relevant articles obtained from database searches, manual searches, and authors, 21 obtained articles were excluded for the following reasons: case study/series[3,6,9,15,20,23,35], use of mobilization instead of manipulation[36-39], purpose being biomechanical/physiological documentation[30,40,41], cohort designs[11,12], primarily informational[42,43], one group pretest/post-test design[5], follow-up of a previous RCT[44], or subjects were younger than 18 years of age[45].

Eight authors were identified and emailed to find out if they were aware of other articles on TSM. Two authors did not have email addresses listed on their articles. Emails were successfully sent to the other six authors and a response from three of them was received from the first email attempt. The other three were sent a second email and one responded. As noted above, this strategy yielded five potential articles. Through all search strategies, 13 studies met eligibility criteria and were included in this review.

Methodological Quality

The systematic assessment of the articles in this review revealed PEDro scores ranging from 4 to 9 out of 10, with a mean of 6.85 (SD, 1.77). The mean of 6.85 indicates that RCTs using TSM exhibited overall *fair* methodological quality. Seven of the studies were considered of *high* quality, four of *fair* quality, and two of *poor* quality. The most frequently satisfied PEDro criterion was *subjects randomly allocated to groups* (100%), because the inclusion criteria of this review required use of RCTs. Other PEDro criteria were also frequently satisfied; two criteria with 92%, and five criteria with 77%. One criterion, *therapists who administered the treatment were blinded*, was not met by any of the articles; and another criterion, *subjects were blinded to treatment*, was satisfied by 15% of articles. An official attempt was made in two of the articles[17,18] to blind subjects to the treatment received and therefore satisfied that criterion. Table 1 shows a detailed breakdown of PEDro scores for individual articles.

Study Characteristics

All 13 studies included male and female subjects with the number of subjects ranging from 6[22] to 198[46]. The average age of subjects was variable but ranged from 25 (SD, 5)[16] to 53.5 (SD, 12.5)[46]. Symptom duration was also variable. Two studies[8,16] included asymptomatic subjects and symptom duration was not stated in four studies[19,21,22,47]. Demographic data from eligible studies is in Table 2.

The TSM technique used was not noted in three of the studies[21,22,46]. The most common TSM technique used was a supine anterior-to-posterior manipulation. Pain was the outcome measure most often used in the studies. Two studies did not use a pain scale as an outcome measure[8,16], and the most common pain scale used was the visual analog scale.

Statistical Results

The chi square test statistic for homogeneity of all studies evaluating neck pain was 658.01 (95% chi-square cutoff: 30.14), indicating heterogeneity across studies. When one study evaluating only asymptomatic individuals[16] and another outlier study that produced a significant researcher effect[14] were removed, the chi square test statistic for homogeneity was 134.56 (95% chi-square cutoff: 24.99). The chi square test statistic for homogeneity without researcher effect was 22.25 (95% chi-square cutoff: 24.99). Figures 2 and 3 illustrate the forest plots of the effect-size CI from each study with and without researcher effects. Heterogeneity is apparent in the plot with researcher effects (Figure 2). Homogeneity was achieved by removing the researcher effect (Figure 3). Thus, a pooled estimator of all the effect sizes was possible. The value of the pooled estimator (1.33) was statistically significant for the treatment effect of TSM in the studies with researcher effect removed (95 % CI: 1.14, 1.52).

Shoulder

Three studies used TSM in the treatment of shoulder conditions, one *high*-quality study[4] and two *fair* quality studies[21,46]. Subject reported *full recovery* or being *cured* was used as an outcome measure in two studies[4,46]; both reported a notable difference in favor of groups who received TSM. However, Winters and colleagues[46] reported that the group that received corticosteroid injections improved faster and a greater number of subjects considered themselves *cured*

TABLE 2. Demographic data from studies.

Study	n	Male/Female	Average Age (SD)	Symptom Duration (SD)
Shoulder				
Bergman et al[4]	150	71/79	47.8 (11.8), 48.4 (12.4)	< 6 weeks to > 26 weeks
Winters et al[46]	198	87/111	43.9 (12.6), 46.4 (11.2), 53.5 (12.5), 46.7 (12.1), 53.1 (12.6)	3,4,8,9,4*
Savolainen et al[21]	75	18/57	43 (7), 46 (6)	Not stated
Trunk				
Cleland et al[8]	40	19/21	34.7 (12), 31.4 (12)	Asymptomatic
Neck				
González-Iglesias et al[18]	45	24/21	34 (5)	18.7 (3.9), 19.5 (4.5) days
González-Iglesias et al[17]	45	20/25	34 (4)	17 (5), 18 (6) days
Cleland et al[13]	60	27/33	43.3 (12.7)	56.1 (27.6), 54.9 (46) days
Cleland et al[10]	36	9/27	36 (9.8)	12.2 (3.5), 13.2 (4.2) weeks
Fernández-de-las-Peñas et al[16]	30	13/17	25 (5), 27 (6), 25 (4.5)	Asymptomatic
Fernández-de-las-Peñas et al[14]	88	40/48	31.2	3 weeks to 3 months
Krauss et al[19]	32	6/26	34.2 (9.56), 35 (10.51)	Not stated
Parkin-Smith & Penter[47]	30	19/11	35.4	Not stated
Strunk & Hondras[22]	6	1/5	48 (12)	Not stated

* = Number of weeks before consultation.
Average ages (with standard deviations) of groups are separated by comma.

than those in the physiotherapy or manipulation groups. Savolainen et al[21] noted in a *fair* study that there was no long-term difference in muscle tenderness or tender thoracic levels between subjects who received either a personal exercise program or TSM and those who dropped out of the study.

Trunk

One *high* quality study[8] investigated the effects of TSM on lower trapezius muscle strength. Subjects who received TSM had significant changes in increased peak strength and percentage of increased strength over those who received a sham manipulation. Although this was a *high* quality study, the subjects were asymptomatic and hence the generalizability to a patient population is questionable.

Neck

Nine studies investigated the effects of TSM on cervical conditions, five studies were of *high* quality[10,13,16-18], two of *fair* quality[14,19], and two of *poor* quality[22,47]. Four studies of *high* quality[10,13,17,18] showed significant improvement in pain from subjects who received TSM over those in comparison groups; similar results were found in one *fair* study[14]. Krauss et al[19] reported in a *fair* study that significant improvement in end range pain during right and left cervical rotation occurred in the group that received TSM. Fernández-de-las-Peñas et al[16] noted in a study with asymptomatic subjects that the group that received TSM had a significant difference in pressure pain threshold, with the right side (dominant side) having greater improvements than the left side. Again, the generalizability of this study to a patient population is questionable due to the use of asymptomatic subjects. In two *high* quality studies, González-Iglesias and colleagues[17,18] found cervical range of motion to be significantly improved in all directions in favor of TSM groups. One *fair* study[19] and one *poor* study[47] found significant within-group changes in bilateral cervical rotation in the groups that received TSM. In the same *poor* study[47], there was also a significant within-group change in bilateral cervical rotation in subjects who received cervical manipulations. Two studies, one *high* quality[13] and one *poor* quality[22], looked at the Neck Disability Index (NDI) to consider improvement in disability. Cleland et al[13] found significant improvement in disability in favor of the TSM group, while Strunk and Hondras[22] found no significant changes in disability.

Discussion

Evidence for TSM for shoulder conditions is limited, but the studies included in this review[4,21,46] do indicate that TSM may accelerate improvement in conditions treated, at least in the short term. Winters and colleagues[46] performed a long-term follow-up study[44] that showed no significant differences between groups when there were differences at the short term. Subject reported improvement such as *full recovery* or being *cured* was the main outcome measure for two studies[4,46]. Cleland and Durall[48] noted that the Winters et al[46] article was not clear on the meaning of *cured*, whether it meant complete symptom reduction or satisfying predetermined criteria. Whatever the case, there is sufficient information provided in these randomized clinical/controlled trials to encourage pursuit of future studies on the effect of TSM on various shoulder conditions.

Four high quality studies[10,13,17,18] used TSM as part of a treatment regimen for neck conditions. The four studies showed significant short-term improvement in pain, and three of the studies[13,17,18] showed significant short-term improvement in disability. The longest follow-up from all neck studies was 4 weeks[18]. A CPR developed by Cleland et al[12] also indicated effective short-term treatment management for a subgroup of patients with neck pain. Together, the high-quality studies, the CPR, and the pooled data of the meta-analysis, which included each of the *high* quality neck studies along with one *fair* study[19] and one *poor* study[47], indicate there is sufficient evidence for the use of TSM for short-term results in specific subgroups of patients, and practitioners can confidently use the results of these articles to support their treatment rationale. Research is needed to investigate the long-term results of the effectiveness of these treatment regimens in similar subgroups of subjects.

Krauss et al[19] in a *fair* study found significant within-group changes in pain at end range of right rotation. This result is different from what was found in the *high* quality studies in this review because pain was rated at end range instead of at rest[19]. This is an intriguing manner of assessment that associates pain with cervical rotation and, subsequently, indirectly assesses activities such as driving. Several studies[17-19,47] reported significant changes in cervical range of motion, including cervical rotation, when TSM was used as a treatment. Obtaining the increased range of cervical motion could, for example, improve the ability to effectively perform the aforementioned activity.

Although the neurophysiological effects are not definitively known, there are several theories that explain what may be occurring as a result of spinal manipulation. In a comprehensive review of the neurophysiological effects of spinal manipulation, Picker[49] found that current evidence supports the following mechanisms as contributory to the effects of spinal manipulation: changes in group Ia and group II mechanoreceptor discharge, sensory processing facilitation in the spinal cord, and control of skeletal muscle reflexes. In addition, it has been hypothesized that serotonergic and noradrenergic receptors use descending inhibitory pathways to mediate an analgesic response from spinal manipulation[50]. Electromyographical studies have suggested that thrust manipulations may elicit muscle activation in muscles adjacent to and opposite of the manipulation site[51,52], with muscle activation possibly originating from type II articular mechanoreceptors in the spine[51]. In a later study, Herzog et al[53] did not note the origin of reflex responses but did report specific EMG responses in distinct areas of the body in response to spinal manipulation. The

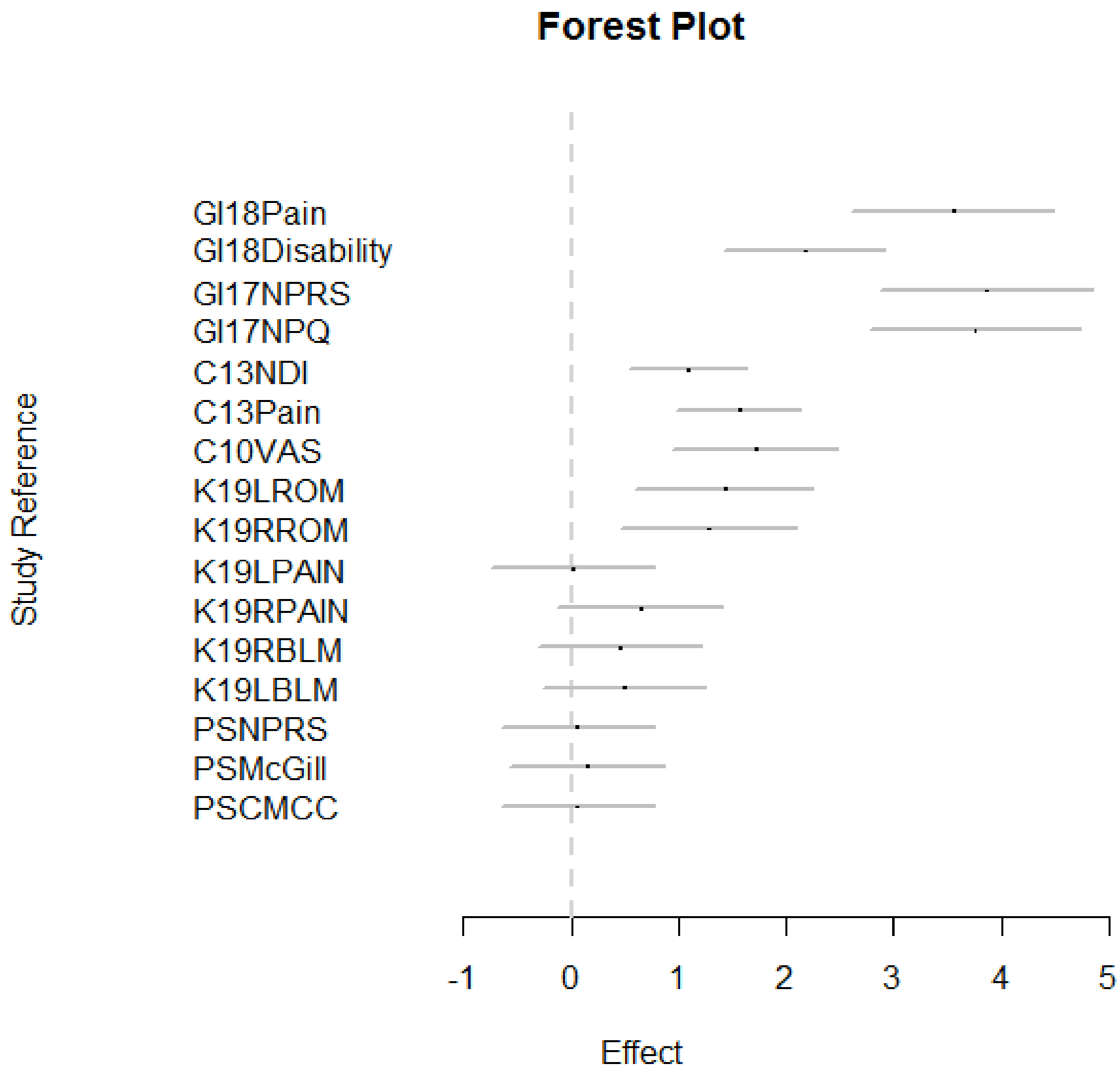

FIGURE 2. Forest plot of the effect-size confidence intervals of all studies evaluating neck pain with researcher effect. Results are heterogeneous.

results included clear EMG responses from TSM in back muscles extending to the deltoid of the upper extremity of the side of the spine that was manipulated.

Although the evidence is abundant that some type of neurophysiological effect occurs following spinal manipulation, the placebo effect must also be considered. If a subject in a study is informed of the potential benefits of spinal manipulation, the expectation of the benefits could contribute to placebo analgesia from the treatment[54]. This manifests the importance of carefully informing subjects of necessary and required information relating to treatment procedures, which will minimize expectation bias in studies.

In the past, the risks of adverse events when performing spinal manipulation have influenced the use of manipulation in physical therapist practice[1]. However, it can be assumed that due to the increased research including TSM in recent years, spinal manipulation may be used more frequently in practice by physical therapists. The risk of adverse events is a concern that may be encountered in practice and research as the documentation of adverse events associated with spinal manipulation is plentiful[55]; but adverse events associated with TSM appear to be much less frequent than those associated with cervical and lumbar manipulations[1,56,57].

Limitations

There are several limitations to this review. First, the methodological scoring of the studies was performed by one person. Although scoring by one person could

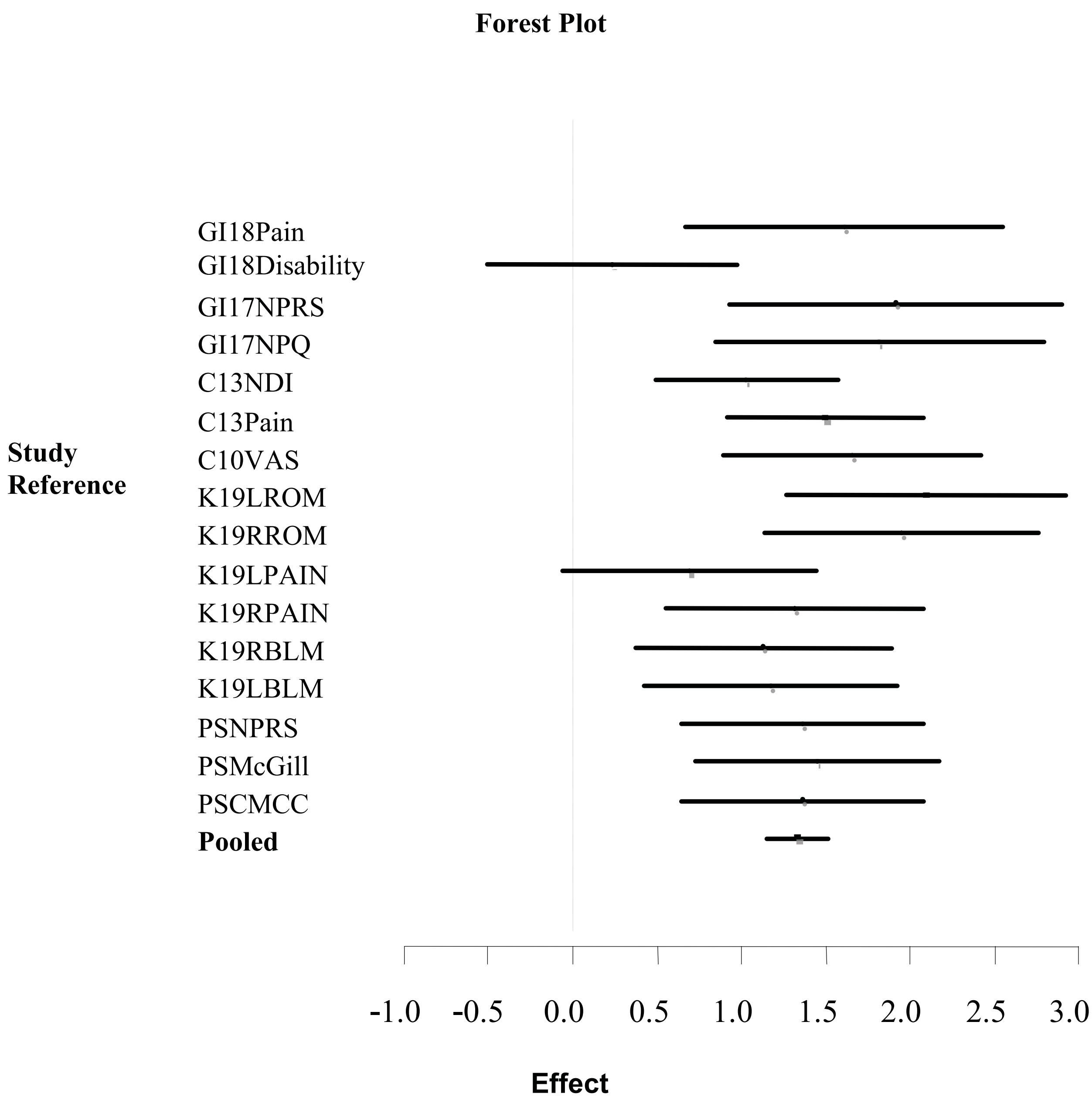

FIGURE 3. Forest plot of the effect-size confidence intervals of all studies evaluating neck pain without researcher effect. Results are homogenous and the pooled estimate is statistically significant.

Abbreviations for Figures 2 and 3: C10 = Cleland[10]; C13 = Cleland[13]; CMCC = CMCC Neck Disability Index; GI17 = González-Iglesias et al[17]; GI18 = González-Iglesias et al[18]; K = Krauss et al[19]; LBLM = left cervical bilateral motion; LROM = left cervical range of motion; McGill = McGill Short-form Pain Questionnaire; NPQ = Northwick Neck Pain Questionnaire; NPRS = Numeric Pain Rating Scale; NDI = Neck Disability Index; PS = Parkin-Smith and Penter[47]; RBLM = right cervical bilateral motion; RROM = right cervical range of motion; VAS = visual analog scale for pain

potentially be a strong point of the review as all articles were scored using the same critical evaluation process, a method described in other systematic reviews[58,59] that uses at least two scorers and a mediator for any unresolved differences in scoring could be a more effective method of methodological scoring. Second, limitations associated with the search strategy were the inclusion of articles only in English and the linking of *physical therapy* to the key phrases. Studies were found in searches that may have been appropriate for this review, but they were not in English. Other potential studies may have been found without the addition of *physical therapy* in the key phrases; however, as noted in the methods section, this yielded an excessive amount of unrelated results. Third, the author who selected and scored articles was not blinded to author names.

Conclusion

There is limited evidence to support the use of TSM for shoulder conditions, but there is enough evidence to encourage the pursuit of additional research to determine if TSM is effective for such treatment. There is currently sufficient evidence to support the use of TSM for the management of neck conditions in specific subgroups of patients for short-term outcomes. Long-term follow-up studies should now be done to determine the effectiveness of TSM past the short term for subjects with neck conditions. Additionally, symptomatic subjects should be used in future studies using TSM to increase the generalizability of the results. Considering the studies in this review and the meta-analysis performed, the future appears promising for the use of TSM for the management of certain musculoskeletal conditions.

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