

# Efficacy of spinal manipulative therapy in older adults with chronic spinal conditions: an updated systematic review

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**Background:** *This systematic review evaluated the efficacy of SMT for chronic spinal conditions in adults aged 55 years and older.*

**Methods:** *We searched multiple databases for randomized controlled trials (RCTs) on SMT for older adults with chronic spinal conditions (≥ 12 weeks) published from February 2016 through October 2024. Additionally, studies from the prior article being updated were included as appropriate. Eligible studies compared SMT to active or inert comparators, measuring pain, function, or quality of life.*

**Efficacité de la thérapie de manipulation vertébrale chez les personnes âgées atteintes de troubles chroniques de la colonne vertébrale: une étude systématique (mise à jour)**

**Contexte:** *Cette étude systématique a évalué l'efficacité de la thérapie de manipulation vertébrale (TMV) pour les troubles chroniques de la colonne vertébrale chez les adultes âgés de 55 ans et plus.*

**Méthodes:** *Nous avons effectué des recherches dans plusieurs bases de données pour des essais contrôlés aléatoires (ECA) sur la TMV visant des personnes âgées souffrant de conditions chroniques de la colonne vertébrale (au moins 12 semaines) publiés de février 2016 à octobre 2024. De plus, les études citées à l'article précédent qui est mis à jour ont été incluses, le cas échéant. Les études admissibles comparaient la TMV à des comparateurs actifs ou inertes, mesurant la douleur, la fonction ou la qualité de vie.*

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## Conflicts of Interest:

The authors wish to disclose that Robert J. Trager, an author on this study, reports earning royalties from authoring texts on the topic of sciatica, and received consulting fees from Merck for participation in an expert input meeting on chronic low back pain (October 2025). The authors have no further disclaimers or competing interest to report in the preparation of this manuscript. Partial funding for this study was received from both Clinical Compass and the NCMIC Foundation.

Results: Nine reports were included, evaluating SMT for chronic low back pain (5 RCTs, n=544), chronic neck pain (2 RCTs, n=241), lumbar spinal stenosis (1 RCT, n=259), and combined neck/back disability (1 RCT, n=182).

Conclusion: SMT may offer comparable or modestly greater benefit than other treatments for chronic spinal conditions in older adults, particularly for neck pain and LSS. Evidence certainty remains very low to moderate.

Registration: PROSPERO (CDR42024615084)

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KEY WORDS: musculoskeletal manipulations; aged; chronic pain; low back pain; neck pain; older adults; spinal manipulation; lumbar spinal stenosis; chiropractic

## Introduction

Low back pain (LBP) is the leading cause of years lived with disability globally, with prevalence and disability increasing with age, peaking from ages 80 to 84 years.<sup>1</sup> Neck pain (NP) is ranked 11<sup>th</sup> in terms of years lived with disability globally, having a peak prevalence between age 50 and 74.<sup>2</sup> Despite these conditions being highly prevalent, there remain limitations in the evidence for efficacious treatments in older adults.<sup>1,2</sup> In general, older adults exhibit a slower recovery from new episodes of back pain, and have a greater tendency to develop chronic symptoms.<sup>3</sup> Compared to younger adults, older adults are more likely to be severely debilitated by LBP, have decreased mobility, reduced independence, and require greater healthcare needs.<sup>4</sup>

Although chiropractic services are used less by older patients ( $\geq 55$  years) compared to the general population,<sup>5</sup> at least 20% of chiropractic patients are older adults.<sup>6</sup> Non-surgical, non-pharmacologic interventions such as spinal manipulative therapy (SMT), massage, and exercise, are recommended as first-line approaches to care for LBP.<sup>7-9</sup> SMT is a treatment offered by chiropractors, physical therapists with advanced training, and some

Résultats: Neuf rapports ont été inclus, lesquels évaluaient la TMV pour traiter la lombalgie chronique (5 ECA, n = 544), la cervicalgie chronique (2 ECA, n = 241), la sténose lombaire (1 ECA, n = 259) et les incapacités dues à une combinaison de cervicalgie et de lombalgie (1 ECA, n = 182).

Conclusion: La TMV peut offrir des avantages comparables ou modestement plus importants que d'autres traitements pour les troubles lombaires chroniques chez les personnes âgées, en particulier pour la cervicalgie et la sténose lombaire. La certitude des données probantes demeure très faible à modérée.

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MOTS CLÉS : manipulations musculosquelettiques; âgé; douleur chronique; lombalgie; cervicalgie; personnes âgées; manipulation vertébrale; sténose lombaire; chiropratique

osteopaths and may be appropriate for older adults with chronic spine pain. Several observational studies have reported that SMT for older adults with spine pain is associated with reductions in cost and escalation of health care service utilization (e.g. imaging, injections, surgeries).<sup>10-12</sup> Best practices guidelines for the chiropractic management of older adults have been available since 2010,<sup>13</sup> with a subsequent update in 2017.<sup>14</sup> However, there are notable gaps in high quality evidence syntheses evaluating the efficacy of SMT derived from randomized controlled trials (RCTs) in older adults.<sup>15</sup>

Over the past decade, two systematic reviews on the topic of SMT for older adults have been conducted. Hawk *et al.* (2017) conducted a systematic review, which was used alongside a Delphi process to create best practices statements for chiropractors caring for older adults.<sup>14</sup> Hawk *et al.* identified six efficacy or effectiveness studies and concluded that there were evidence gaps regarding SMT in older adults, with current best practice recommendations being supported by expert opinion. Jenks *et al.* (2022) conducted an individual participant data meta-analysis including 10 studies with 786 patients total, with a search date ending in 2020.<sup>16</sup> The meta-analysis

found that SMT provided similar outcomes to recommended interventions for pain and functional disability in the older adult with chronic LBP, ultimately supporting SMT as an intervention. Despite these promising findings, evidence synthesis is needed for conditions beyond LBP, including stenosis with claudication, and NP. An updated literature synthesis is also needed to capture potential growth in the scientific literature.

Considering potential growth in available evidence since these previously reported systematic reviews on this topic, there is a need for an updated review on the topic of efficacy of SMT in older adults with chronic spinal conditions. The purpose of this systemic review was to investigate the efficacy of SMT for chronic spinal conditions in older adults. This study is an update of Hawk *et al.*'s 2017 systematic review performed as part of best practice consensus publication.<sup>14</sup> In contrast to the prior update, this review does not include any best practices nor guideline component. However, our results will provide evidence on SMT research to inform a separate clinical practice guideline update for the chiropractic management of older adult patients.

## Methods

### *Registration and protocol*

The study protocol was prospectively registered with the International Prospective Register of Systematic Reviews (PROSPERO) in November 2024 (CDR42024615084). Our reporting adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA-2020).<sup>17</sup>

### *Eligibility criteria*

To evaluate the efficacy of SMT for chronic spinal conditions in older adults, we translated PICOS elements (Population, Intervention, Comparison, Outcome, and Study Type) into eligibility criteria.

### *Population*

We included studies in which the study population had a mean or median age of 65 years or older, or the minimum age for study inclusion was 55 years, to ensure generalizability to an older adult population. Chronic spinal conditions were defined as those persisting for a minimum duration of 12 weeks. We chose an age threshold to ensure generalizability to an older adult population

while allowing inclusion of relevant studies. This decision was made a priori in consultation with the co-author team, considering the variable age definitions of “older adults” used in prior research studies, clinical guidelines, policy documents, and international literature.<sup>18,19</sup> Several factors supported our choice: (1) our review updates a prior systematic review<sup>14</sup> that included an RCT enrolling participants aged  $\geq 55$  years,<sup>20</sup> and we aimed to retain this study for consistency; (2) we aimed to maximize the number of eligible studies; (3) age-related changes to the spine often begin before age 65 and may influence response to SMT;<sup>21</sup> (4) the American Geriatrics Society<sup>22</sup> allows for inclusion of studies with a median age over 65 years, even when some participants are younger; and (5) SMT delivery may be modified for patients in their late 50s or early 60s due to age-related changes, for example reductions in bone density,<sup>23</sup> making this group clinically relevant to our review.

### *Intervention*

The intervention of interest was SMT, defined broadly as manual therapy of the spinal vertebral joints, excluding soft tissue techniques such as massage. More specifically, SMT was defined as both high-velocity low-amplitude (HVLA) techniques and low-velocity low-amplitude techniques applied to the spine. This refers to both manual treatments and mechanically assisted treatment (e.g., instrument techniques, flexion-distraction, drop table). SMT could include any portion of the vertebral column, including the occipital-cervical junction, cervical, thoracic, lumbar, and pelvic regions, including the sacroiliac joints. SMT must have been performed by a licensed health care professional (e.g., chiropractor, physical therapist, osteopath). Other non-pharmacological, non-surgical interventions could be provided in conjunction with SMT. These could include but were not limited to, mind-body interventions, acupuncture, massage therapy, acupressure, electrical modalities, heat or cold, or other manual therapies.

### *Comparators*

Comparison groups could include any active pharmacologic or non-pharmacologic intervention, placebo/sham interventions, waitlist controls, or no treatment. This broad inclusion maximized our ability to draw inferences from the available literature.

### Outcomes

The primary outcomes assessed were pain intensity, physical function, quality of life, and activities of daily living. Secondary outcomes included markers of health service utilization such as surgery, medication, and medical visits when reported among included studies.

### Study type

We considered RCTs published in peer-reviewed journals in English. We excluded commentaries, editorials, letters, reviews, pilot or feasibility studies, non-peer-reviewed publications, surveys, observational studies, conference abstracts, animal studies, study protocols, and studies lacking treatment outcomes. The eligibility criteria are reported in Table 1.

### Information sources

This study included RCTs from Hawk *et al.*'s 2017 systematic review performed on the same topic.<sup>14</sup> Given methodological revisions to expand on the age range of inclusion, restriction to chronic pain conditions, and focus on clinical trials, the three RCTs included in the previous review were all re-screened for eligibility in this update. Our database searches included PubMed, Cochrane Central Register of Controlled Trials, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Allied and Complementary Medicine Database (AMED), Index to Chiropractic Literature, and Physiotherapy Evidence Database (PEDro). The search for Index for Chiropractic Literature was conducted on October 28, 2024, and all other searches were conducted on October 30, 2024. Gray literature searches included citation tracking of included

articles, and consulting topic experts in search of relevant articles, which was performed on December 2, 2024.

### Search strategy

The search strategy was developed in collaboration with a health sciences librarian (SW). A second health sciences librarian evaluated the comprehensiveness of the search strategy using the Peer Review of Electronic Search Strategies (PRESS)<sup>24</sup> checklist. Searches were limited to academic journals and the English language. Search terms were relevant to older adults, chronic musculoskeletal spinal conditions, and manipulation or manual therapy. The search was limited by publication date from February 1, 2016 (following the Hawk *et al.* search end date) through October 2024. As an example, the PubMed search syntaxes can be found in Appendix 1.

### Selection process

Retrieved citations were uploaded to a Zotero<sup>25</sup> library and then the Rayyan<sup>26</sup> online systematic review software. Two reviewers (MP and RW) independently screened titles and abstracts for eligibility and resolved disagreements by discussion. The same two reviewers then performed full-text screening. Disagreements were resolved by discussion between the reviewers, and when needed, a third investigator (AS) assisted until consensus was achieved. In cases where multiple articles were derived from the same RCT, we included secondary reports only when they presented unique outcomes or analyses not available in the primary publication. This included data on responder outcomes, healthcare utilization, or cost-effectiveness. Accordingly, this strategy avoided duplication of primary

Table 1.  
Eligibility criteria

Inclusion Criteria	Exclusion Criteria
<ul style="list-style-type: none"> <li>• Study population age <math>\geq</math> 55 years or population mean or median age <math>\geq</math> 65 years</li> <li>• Chronic spinal condition(s)</li> <li>• Treatment included spinal manipulative therapy</li> <li>• Randomized controlled trial</li> <li>• Human subjects</li> <li>• English language</li> <li>• Published in peer-reviewed journal</li> </ul>	<ul style="list-style-type: none"> <li>• Commentaries/editorials/letters/reviews/pilot studies/feasibility studies</li> <li>• Non-peer-reviewed publications</li> <li>• Surveys and other descriptive cross-sectional studies</li> <li>• Conference abstracts</li> <li>• Observational studies</li> <li>• Animal Studies</li> <li>• Study protocols</li> <li>• No treatment outcomes included</li> <li>• Low-quality studies</li> </ul>

outcomes such as pain and physical function and allowed us to capture a broader range of outcomes relevant to our aims. All included reports were linked to their respective primary RCTs and reported transparently in the data extraction tables. Considering our non-meta-analytic, qualitative approach and broad scope, inclusion of these secondary analyses provided additional data to support evidence synthesis.

### *Data collection process*

Data extraction of the included RCTs was completed independently by two investigators (RT and JS). A third investigator (AS) verified the data, with discussion to resolve discrepancies. Extracted data were entered into a pre-designed Microsoft Excel worksheet. Corresponding authors of two of the included RCTs were contacted for additional information and clarifications,<sup>27,28</sup> which were provided by one author.<sup>27</sup>

### *Data items*

Information collected for each study included the first author's surname, year of publication, sample size, patient age, symptom duration, condition(s)/diagnosis, treatment/intervention groups, sample size at allocation, and description of any group(s) with SMT, intervention group(s) dosage, comparison groups, sample size at allocation, and description of any group(s) without SMT, comparison group(s) dosage, follow-up duration for primary outcomes, pain and disability outcome measures, between-group effect estimate(s) for primary outcomes, responder analysis for within-group differences (if reported/calculated), other health service outcomes, between-group effect estimate(s) for other health service outcomes (if reported/calculated), and a summary of the key findings. We avoided specific requirements for follow-up durations among included studies. Instead, our strategy aimed to include all relevant outcomes reported, emphasizing any study-defined primary outcomes in our analysis. This ostensibly allowed us to capture the range of available evidence given the limited expected number of eligible studies.

For each RCT, we extracted means, standard deviations and confidence intervals (CIs) from the tables, text, or figures, as available. For two studies that did not provide between-group mean differences,<sup>27,29</sup> the values were calculated with assistance from a statistician. For one study,

which did not provide standard deviations (SD),<sup>29</sup> differences were imputed using pooled variance for Oswestry Disability Index (ODI), 36-Item Short Form Survey (SF-36), and Visual Analog Scale (VAS), using the Satterthwaite approximation to calculate degrees of freedom for each.<sup>30</sup> For the other study,<sup>27</sup> we calculated the mean difference in post-treatment pain scores and SDs and used the t-statistic to derive the 95% confidence intervals.<sup>31</sup>

### *Study risk of bias assessment*

Included RCTs were evaluated independently by two investigators (RT and JS) using the Scottish Intercollegiate Guideline Network (SIGN) checklist.<sup>32</sup> Several tools are available to assess the quality and risk of bias of RCTs, including the Cochrane Risk of Bias tools (RoB 1 and RoB 2), the SIGN checklist, tools from the Joanna Briggs Institute, and others. We opted to use the SIGN checklist as it is a practical, straightforward, and validated tool.<sup>33</sup> Each SIGN question was assigned a value of "1" for each "yes" response and a value of "0" for "no" or "not applicable." Disagreements were resolved by including additional reviewers (AS and CD) and discussion until a consensus was reached. The SIGN tool also allows raters to enter free-text comments to support their individual scores, which facilitated discussion and resolution of discrepant scores. The SIGN checklists provided each study with a raw score from 0-10, with single-site trials being scored out of a total of nine points, instead of ten, because one question was only relevant to multisite trials.<sup>32,34</sup> These raw scores were then divided by the total sum of scores across the total of applicable domains and multiplied by 100 to make a percentage scoring system. We operationalized scoring thresholds in alignment with risk of bias assessments and corresponding quality, a strategy which has been used previously for risk of bias assessment.<sup>35-38</sup> We interpreted scores of  $\geq 80\%$  as being "high quality, low risk of bias," 50% to 79% as "acceptable quality, moderate risk of bias," and  $< 50\%$  as "low quality, high risk of bias." For reports of secondary analyses, we evaluated the risk of bias based on their primary RCT. For the SIGN checklist we adapted item four regarding blinding to interpret it in respect to blinding of the outcome to the assessors, rather than clinicians delivering SMT or SMT recipients, to provide a more realistic and practical assessment of RCTs focused on SMT.<sup>39</sup>

### Effect measures

We reported mean differences between groups along with confidence intervals and *P*-values for primary outcomes. Secondary outcomes, when present, included odds ratios or proportions of patients reaching improvement thresholds.

### Synthesis methods

We qualitatively synthesized the extracted data from the included studies. We assessed clinical heterogeneity by comparing study characteristics, including patient population characteristics, condition treated, SMT co-interventions, comparator interventions, outcome measures, and duration of follow-up.

After reviewing previous literature reviews on the topic,<sup>14,16</sup> our team decided a priori to avoid meta-analysis. First, we expected only a small number of studies would meet our inclusion criteria, limiting the ability to pool data meaningfully. Second, the total sample size across eligible studies was expected to be low (e.g., <400 participants), increasing the potential for imprecision.<sup>40</sup> Third, we anticipated clinical heterogeneity across studies from variations in patient populations (e.g., age, baseline symptoms), SMT protocols (e.g., technique, frequency), comparators (e.g., exercise, sham), and outcome measures (e.g., pain scales, functional status tools) which would hinder analysis.

### Reporting bias

To assess potential reporting bias, one investigator (CD) extracted funding sources from included articles and searched ClinicalTrials.gov in February 2025.<sup>41</sup> Funding sources were categorized as either industry or non-industry,<sup>42</sup> and the Clinical Trials database was searched to identify whether any potentially eligible clinical studies had not been published.<sup>43</sup>

### Certainty assessment

We utilized the GRADE (Grading of Recommendations Assessment, Development, and Evaluation)<sup>40,44–48</sup> system to assess the overall quality of the evidence. Two investigators (AS and CD) performed GRADE assessments independently. When there were disagreements, additional investigators (RT and JS) were included and discussed the ratings until consensus was achieved. Outcomes were automatically deemed “very low” certainty

if no trials were identified that reported on that given outcome.

## Results

### Study selection

The search yielded 99 unique citations, and after title and abstract screening, 30 studies were potentially relevant, and the full-text reports were retrieved for assessment (Figure 1). Percentage agreement was 73% for title and abstract screening, and 100% for full-text screening. Five full-text records were identified through reference tracking and expert consultation, and an additional six reports (five studies) from the 2017 Hawk *et al.* study brought the total number of full-texts to be screened to 38; of those, 32 were excluded (reasons for exclusion detailed in Appendix 2).<sup>49–80</sup> A total of six new reports (four studies,<sup>28,81–83</sup> and two secondary analyses<sup>84,85</sup>) were included as a result of the updated database search, in combination with three studies<sup>20,27,29</sup> from the prior 2017 Hawk *et al.* systematic review, resulting in a total of nine reports<sup>20,27–29,81–85</sup> of seven RCTs<sup>20,27–29,81–83</sup> included in this systematic review.

### Study characteristics

Five studies reported on LBP,<sup>20,27–29,85</sup> two reported on NP,<sup>81,84</sup> one reported on both NP and LBP,<sup>82</sup> and one reported on LSS.<sup>83</sup> Regarding the studies reporting on chronic LBP intervention and comparison group: Learman *et al.* compared thrust manipulation plus a home exercise program to non-thrust manipulation plus a home exercise program (standing hamstring stretches, cat and camel, quadruped pelvic rocking, prone press-ups, and supine lying piriformis stretches); Dougherty *et al.* compared SMT to sham treatment (detuned ultrasound); Enix *et al.* compared SMT plus soft tissue manipulation (proprioceptive neuromuscular facilitation stretching, post-isometric exercise relaxation techniques, transverse friction massage, and passive stretching) to multimodal physical therapy exercise (neuromuscular re-education, muscle endurance and strength training exercises, flexibility stretches, interferential electrical stimulation, ultrasound, postural education, and home exercise program); and Schulz *et al.* compared three groups, which were SMT (including up to four minutes of adjunct therapies to facilitate SMT) plus home exercise program (self-care for pain, low load exercises with graded progressions, stretching exercises muscle strength and endurance exer-

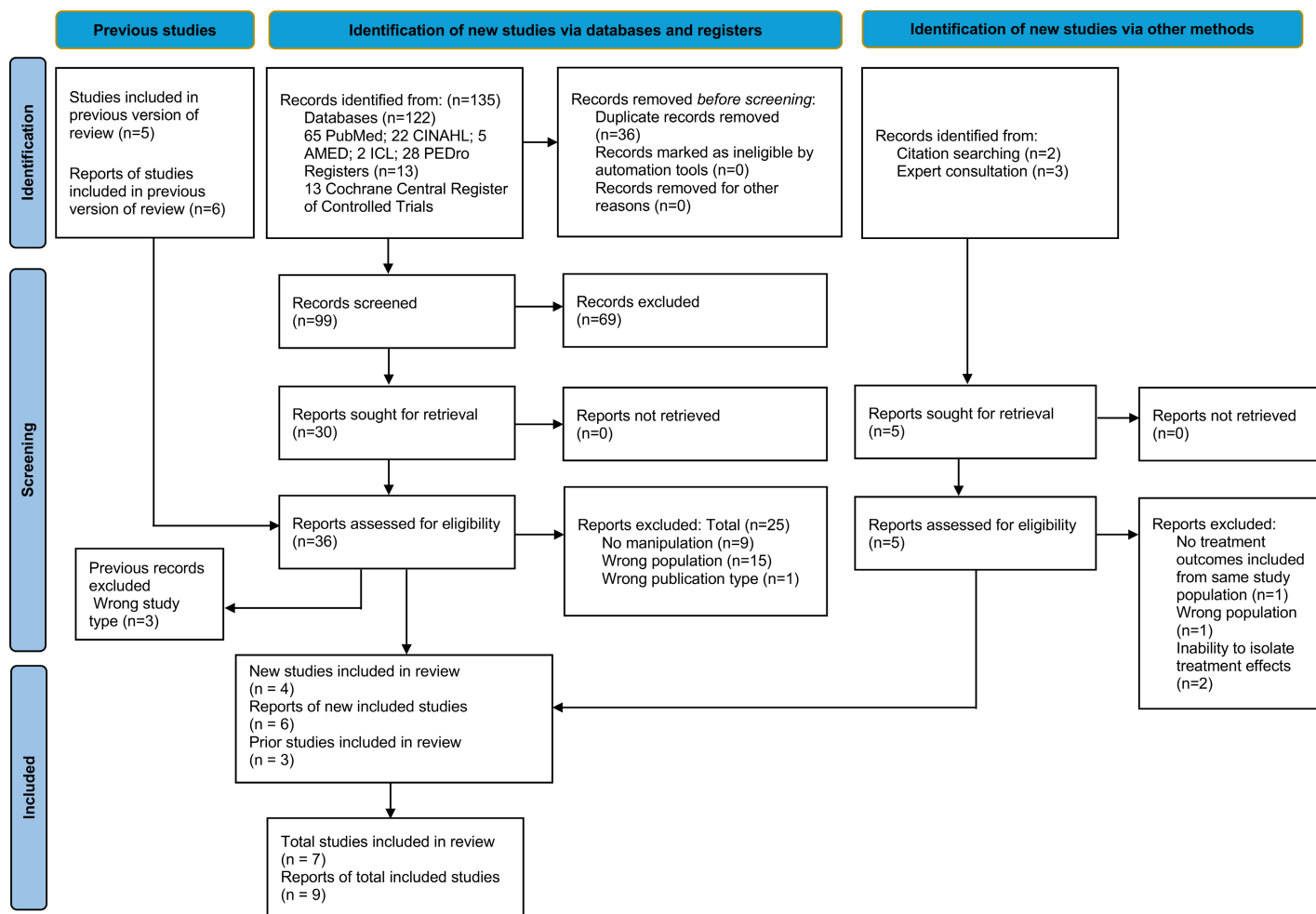


Figure 1.

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram for updated systematic reviews which included searches of databases, registers and other sources. Abbreviations: Cumulative Index to Nursing and Allied Health Literature (CINAHL); Allied and Complementary Medicine Database (AMED), Physiotherapy Evidence Database (PEDro).

cises, and balance exercises), supervised exercise program (self-care for pain, light aerobic warm up on stationary equipment, low load exercise, stretching, strength and balance exercises as described for home exercise program.) plus home exercise program, and home exercise program alone. Maiers *et al.* (2014) reported on chronic NP comparing three groups: SMT plus home exercise and advice (information regarding pain management, consistent messaging to stay active, daily prescribed exercise to improve flexibility, balance, and coordination, as well as enhance trunk strength and endurance); supervised

exercise program plus (one hour session high repetitions of low load exercises with the aim of increasing flexibility, endurance, strength, and balance) home exercise and advice; and home exercise and advice alone. Maiers *et al.* (2019) reported on both chronic NP and chronic LBP and compared treatment duration of SMT plus supervised exercises (aerobic warm up and standardized program of stretching, strengthening, and balance exercises) for 12 weeks versus 36 weeks. Schneider *et al.* reported on LSS and compared three groups which were medical care (oral medication or epidural steroid injections as indicat-

ed), group-based exercise (supervised exercise classes for older adults), as well as manual therapy (including lumbar distraction mobilization, and lumbar/sacroiliac joint mobilization) and individualized exercises. Leininger *et al.* published a secondary analysis of the Maiers *et al.* (2014)

RCT to investigate between group cost-effectiveness, and Maiers *et al.* (2021) published a secondary analysis of Maiers *et al.* (2019) to investigate baseline factors related to response and outcomes for LBP and disability.

Table 2 summarizes study characteristics. In total,

Table 2.  
Study characteristics.

Author and Year	N	Age in years	Symptom duration	Condition	Intervention group(s) with SMT and (N)	Comparison group(s) without SMT and (N)	Outcome measures	Primary follow-up duration(s)
Learman 2013	49	64.5 (SD=8.9); ≥55	22.2 weeks (SD=40.6)	Low back pain	1. TM+HEP (n=19)	2. Non-TM+HEP (n=30)	Primary: NPRS, ODI	Mean 40.0 days (SD=32.9)
Dougherty 2014	136	77; ≥65	≥3 months	Low back pain	1. SMT (n=69)	2. Sham (n=67) “detuned ultrasound” applied over the lumbar spine for 11 minutes	Primary: ODI, SF-36 PFS, VAS Secondary: SF-36 PCS, TUG	5, 12 weeks
Enix 2015	118	72.0 (SD= 6.7); 60-85	>12 weeks	Balance problems and low back pain	1. SMT+soft tissue manipulation (n=61)	2. Multimodal physical therapy exercise, without SMT (n=57)	Primary: 21-point Box Pain Scale	6, 12 weeks
Maiers 2014 Secondary analysis: Leininger 2016	241	1. SMT+HEA 71.7 (SD= 5.2) 2. SRE+HEA 72.6 (SD= 5.6) 3. HEA 72.7 (SD= 5.3)	1. SMT+HEA 6.5 years (IQR= 2.0-19.0) 2. SRE+HEA 7.5 years (IQR= 1.8-20.0) 3. HEA 5.0 years (IQR= 2.0-15.0)	Neck pain	1. SMT+HE (n=80)	2. SRE+HEA (n=82) 3. HEA (n=79)	Primary: 11-Box Pain Scale, NDI, SF-36 PFS Secondary: SF-36 MCS, Improvement, Satisfaction, Cervical spine dynamic motion, Isometric muscle flexion and extension strength, Static muscle endurance, TUG, hand grip strength	12 weeks
Maiers 2019 Secondary analysis: Maiers 2021	182	71.1 (SD= 5.3); 85-87	Neck: 12.7 years (SD=13.1) Back: 17.6 weeks (SD=15.8)	Neck and back disability	1. SMT+ supervised exercise (12 weeks) (n=91)	2. SMT+supervised exercise (36 weeks)	Primary: ODI, NDI, 11-Box Pain Scale, EQ, SPPB Secondary: Improvement, satisfaction, kinesiophobia, self-efficacy, expectations for improvement, hand grip strength	36 weeks
Schneider 2019	259	72.4 (SD=7.8); 60-94	1. MT/IE: 92% >6 months 2. Medical: 92% >6 months 3. Group-based exercise: 86% >6 months	Lumbar spinal stenosis	1. MT/IE (n=87)	2. Medical (n=88) 3. Group-based exercise (n=84)	Primary: SSS, SPWT, daily physical activity	2 months
Schulz 2019	241	1.SMT+HEP 72.5 (SD= 5.6) 2.SEP+HEP 73.6 (SD= 5.3) 3.HEP 74.7 (SD= 5.6)	1. SMT+HEP 13.7 years (SD=15.7) 2. SEP+HEP 12.1 years (SD=15.1) 3. HEP 12.9 years (SD=15.8)	Low back pain	1. SMT+HEP (n=81)	2. SEP+HEP (n=80) 3. HEP (n=80)	Primary: 11-Box Pain Scale, MRS, SF-36 PFS Secondary: SF-36 MCS, Improvement, Satisfaction, Lumbar and spine dynamic motion, Isometric muscle flexion and extension strength, Static muscle endurance, TUG, hand grip strength	12 weeks

Abbreviations: EQ, EuroQol EQ-5D; HEA, Home Exercise and Advice; HEP, Home Exercise Program; IQR, InterQuartile Range; MCS, Mental Component Summary; MRS, Modified Roland Scale; MT/IE, Manual Therapy/Individualized Exercise; NDI, Neck Disability Index; NPRS, Numeric Pain Rating Scale; ODI, Oswestry Disability Index; PCS, Pain Component Summary; PFS, Physical Function Subscale; SD, Standard Deviation; SEP, Supervised Exercise Program; SF-36, 36-Item Short Form Survey; SPPB, Short Physical Performance Battery; SPWT, Self-Paced Walking Test; SRE, Supervised Rehabilitative Exercise; SMT, Spinal Manipulative Therapy; SSS, Swiss Spinal Stenosis Questionnaire; TM, Thrust Manipulation; TUG, Timed Up and Go; VAS, Visual Analog Scale. Listed numbers. (e.g., 1., 2., 3.,) before values correspond to intervention groups, consistent within studies.

1,226 patients were included across all studies, with 579 patients receiving SMT. Mean patient ages varied from 64.5 years to 74.7 years, with the youngest and oldest individual ages reported to be 55 and 94 years, respectively. The number of patients and RCTs per condition were most for LBP with five RCTs including 544 unique patients total, with other conditions only having one RCT and fewer patients (LSS: n=259; NP: n=241; NP and disability and LBP and disability n=182). Symptom duration ranged from >12 weeks to 13.7 years. Follow-up duration for primary outcomes ranged from five weeks to 36 weeks. Accordingly, the maximum durations of follow-up included in the analysis spanned Cochrane-defined windows of short term (closer to four weeks) to intermediate-term (closer to six months) and are reported in Table 2.<sup>86</sup> The most common outcome measures for pain and disability were the ODI (n=3 RCTs), SF-36 (n=3 RCTs), Neck Disability Index (NDI) (n=2 RCTs), and 11-Box Pain Scale (n=3 RCTs). Additional primary

outcome measures, included in only one RCT, were the Numeric Pain Rating Scale (NPRS), VAS, 21-point Box Scale (pain), Modified Roland Scale (MRS), EuroQol EQ-5D (EQ), Short Physical Performance Battery (SPPB), Swiss Spinal Stenosis Questionnaire (SSS), and Self-Paced Walking Test (SPWT).

**Risk of bias in studies**

Table 3 lists the risk of bias of the seven included RCTs. Five studies were assessed as high-quality (low risk of bias),<sup>28,29,81-83</sup> and two were acceptable quality (moderate risk of bias).<sup>20,27</sup> No studies were assessed as low quality (high risk of bias).

**Results of individual studies**

Individual study results are available in Table 4., as well as a responder analysis table and health services outcomes table in the Appendix 3 and Appendix 4, respectively.

*Table 3.*

*Article quality scores. The first column values 1-10 indicate the corresponding response items in the Scottish Intercollegiate Guidelines Network rubric.32 Items: Focused question (1), randomized assignment (2), adequate concealment (3), blinding (4), group baseline similarity (5), treatment is only difference between groups (6), standard, valid, reliable measures of relevant outcomes (7), <20% dropout (8), intention-to-treat (9), multisite comparability – if applicable (10).*

Response item	Learman 2013	Dougherty 2014	Maiers 2014	Enix 2015	Maiers 2019	Schneider 2019	Schulz 2019
1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1
3	0	1	1	0	1	1	1
4	0	1	1	1	1	1	1
5	1	1	1	1	1	1	1
6	1	1	1	0	1	1	1
7	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1
9	0	1	1	1	1	1	1
10	0	1	NA	NA	NA	NA	NA
Overall Quality	Acceptable	High	High	Acceptable	High	High	High

Abbreviations: Not applicable, NA.

Table 4.  
Individual study results.

Author and Year	Condition	Intervention group(s) with SMT	Comparison group(s) without SMT	Between-group effect estimate(s) for spine related pain and physical function, QoL, or ADLs outcomes	Between-group findings and interpretation
Learman 2013	Low back pain	TM+HEP	Non-TM+HEP	Not reported	No significant between-group differences for pain or disability (p=.99)
Dougherty 2014	Low back pain	SMT	Sham (detuned ultrasound)	<p><b>VAS (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>5 weeks: 5.87 [-2.78, 14.52] (F=1.87, p=0.17)</li> <li>12 weeks: 5.61 [-3.12, 14.34] (F=1.68, p=0.19)</li> </ul> <p><b>ODI (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>5 weeks: 2.03 [-2.3, 6.3] (F=1.19, p=0.27)</li> <li>12 weeks: 5.25 [1.24, 9.26] (F=6.95, p&lt;0.001)</li> </ul> <p><b>SF-36 PFS (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>5 weeks: 0.04 [-0.08, 0.16] (F=.42, p=0.52)</li> <li>12 weeks: 0.07 [-0.06, 0.20] (F=1.01, p=0.31)</li> </ul>	No significant between-group differences for VAS and ODI at 5 weeks, or for VAS at 12 weeks. Statistically significant difference at 12 weeks with SMT showing a greater reduction in ODI (p<.001), but not clinically meaningful. Secondary analyses demonstrate a nonspecific therapeutic effect of the intervention.
Enix 2015	Balance problems and low back pain	SMT+soft tissue manipulation	Multimodal physical therapy exercise, without SMT	<p><b>Pain values (all measures)</b></p> <ul style="list-style-type: none"> <li>No significant between-group effects at 6 or 12 weeks for pain (all p-values &gt;0.05)</li> </ul> <p><b>Usual pain (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>6 weeks: 0.4 [-5.91, 6.71]</li> <li>12 weeks: -1.55 [-8.49, 5.39]</li> </ul>	Statistically and clinically significant improvements in pain outcome measures in both the chiropractic care and physical therapy treatment groups at week 6 and at week 12, however there were no significant between-group effects at 6 or 12 weeks for pain.
Maiers 2014	Neck pain	SMT+HE	SRE+HEA and HEA alone	<p><b>Pain MD at 12 weeks (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>SMT+HEA vs. SRE+HEA: -0.55 [-1.10, 0.00] (p≤0.05)</li> <li>SMT+HEA vs. HEA: -1.04 [-1.59, -0.49] (p≤0.01)</li> </ul> <p><b>NDI at 12 weeks (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>SMT+HEA vs. SRE+HEA: -0.27 [-2.55, 2.02] (p&gt;0.05)</li> <li>SMT+HEA vs. HEA: -1.59 [-3.90, 0.73] (p&gt;0.05)</li> </ul> <p><b>SF-36 PFS at 12 weeks (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>SMT+HEA vs. SRE+HEA: -0.14 [-1.75, 1.46] (p&gt;0.05)</li> <li>SMT+HEA vs. HEA: -0.27 [-1.91, 1.36] (p&gt;0.05)</li> </ul>	SMT+HEA yielded greater pain reduction after 12 weeks of treatment compared to both SRE+HEA and HEA alone. There were no statistically significant between-group differences in disability.
Maiers 2019	Neck and back disability	SMT+ supervised exercise (12 weeks)	SMT+ supervised exercise (36 weeks)	<p><b>NDI at 36 weeks (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>1.7 [-0.8, 4.2] (p=0.18)</li> </ul> <p><b>ODI at 36 weeks (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>2.4 [-0.3, 5.1] (p=0.08)</li> </ul> <p><b>Neck pain at 36 weeks (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>0.7 [0.1, 1.2] (p=0.02)</li> </ul> <p><b>Low back pain at 36 weeks (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>0.4 [-0.2, 1.0] (p=0.19)</li> </ul> <p><b>EQ at 36 weeks (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>0.0 [-0.0, 0.0] (p=0.72)</li> </ul> <p><b>SPPB at 37 weeks (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>-0.5 [-1.0, -0.0] (p=0.04)</li> </ul>	There were no significant between-group differences for ODI, NDI, or medication use at 36 weeks' follow-up. However, there were statistically significant differences in favor of long-term management for self-reported improvement in neck pain, as well as functional measures.
Schneider 2019	Lumbar spinal stenosis	MT/IE	Medical Care alone and Group-based exercise alone	<p><b>SSS at 2 months (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>MT/IE vs. medical care: -2.0 [-3.6, -0.4] (p&lt;0.05)</li> <li>MT/IE vs. group exercise: -2.4 [-4.1, -0.8] (p&lt;0.05)</li> </ul> <p><b>SPWT at 2 months (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>MT/IE vs. medical care: 122.9 [-25.7, 271.6]</li> <li>MT/IE vs. group exercise: 43.0 [-111.8, 197.9]</li> </ul>	MT/IE yielded a greater reduction in SSS score compared to medical care, and group exercise, yet did not reach a minimal clinically important difference of 3.02 points. There was no meaningful difference in SPWT, with comparisons of MT/IE vs. medical, and MT/IE vs. general exercise.

Author and Year	Condition	Intervention group(s) with SMT	Comparison group(s) without SMT	Between-group effect estimate(s) for spine related pain and physical function, QoL, or ADLs outcomes	Between-group findings and interpretation
Schulz 2019	Low back pain	SMT+HEP	SEP+HEP and HEP alone	<p><b>Short Term Pain at weeks 4 to 12 (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>• SMT+HEP minus HEP: -0.48 [-1.00, 0.03]</li> </ul> <p><b>Long term pain at weeks 4 to 52 (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>• SMT+HEP minus HEP: -0.13 [-0.59, 0.34]</li> </ul> <p><b>Short-term MRS at weeks 4 to 12 (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>• SMT+HEP minus HEP: 0.78 [-3.99, 5.54]</li> </ul> <p><b>Long-term MRS at weeks 4 to 52 (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>• SMT+HEP minus HEP: -1.42 [-5.88, 3.04]</li> </ul> <p><b>Short-term SF-36 PFS at weeks 4 to 12 (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>• SMT+HEP minus HEP: 0.56 [-1.09, 2.21]</li> </ul> <p><b>Long-term SF-36 PFS at weeks 4 to 52 (MD w/ 95% CI)</b></p> <ul style="list-style-type: none"> <li>• SMT+HEP minus HEP: -0.34 [-1.87, 1.2]</li> </ul>	Adding SMT to HEP alone did not significantly improve pain or disability outcomes in the short- or long-term. There were no significant or meaningful between-group differences with respect to pain, Modified Roland Scale, or SF-36 PFS.

Abbreviations: CI, Confidence Intervals; EQ, EuroQol EQ-5D; HEA, Home Exercise and Advice; HEP, Home Exercise Program; MD, mean difference; MRS, Modified Roland Scale; MT/IE, Manual Therapy/Individualized Exercise; NA, not applicable/present; NDI, Neck Disability Index; NPRS, Numeric Pain Rating Scale; ODI, Oswestry Disability Index; OR, Odds Ratio; PFS, Physical Function Subscale; QALY, Quality-Adjusted Life Year; SF-36, 36-Item Short Form Survey; SPPB, Short Physical Performance Battery; SPWT, Self-Paced Walking Test; SRE, Supervised Rehabilitative Exercise; SMT, Spinal Manipulative Therapy; SSS, Swiss Spinal Stenosis Questionnaire; TM, Thrust Manipulation; VAS, Visual Analog Scale.

## Results of syntheses

### Low back pain

Across three RCTs,<sup>27-29</sup> SMT showed no significant between-group difference between active or inert comparators for pain measures for LBP. Regarding low back-specific disability, one RCT found a statistically significant but not clinically meaningful benefit favoring SMT over an inert comparator,<sup>29</sup> while another RCT using an active exercise comparator found results favoring the null.<sup>28</sup> Two RCTs found no significant between-group difference in disability or functional status for LBP.<sup>28,29</sup>

Two RCTs evaluated the comparative efficacy of SMT treatment parameters for LBP and disability.<sup>20,82</sup> Learman *et al.* found no significant difference between thrust and non-thrust SMT, while Maiers *et al.* (2019) reported no significant difference related to SMT treatment duration (i.e., 12 weeks versus 36 weeks).

Schulz *et al.* explored responder analyses, noting modest differences favoring SMT at 12 weeks (16% more participants experienced a 30%-49% pain severity reduction [i.e., moderate], and 18% more participants with a 50% or greater [i.e., substantial] pain reduction),<sup>87</sup> although most responder outcomes were similar between groups. Schulz

*et al.* and Maiers *et al.* (2019) reported no significant between-group differences with respect to medication use. A secondary analysis found that among older adults with back disability, a longer duration of symptoms greater than 14.5 years predicted a poorer response to SMT and exercise.<sup>85</sup>

### Lumbar spinal stenosis

One RCT evaluated the efficacy of SMT with individualized exercise for LSS.<sup>83</sup> The SMT group yielded greater reductions in SSS scores compared to medical care and group exercise, although these did not meet a minimal clinically important difference of 3.02 points.<sup>88</sup> No significant between-group differences were observed in SPWT. Secondary outcomes showed a higher proportion of responders in symptoms and walking capacity with SMT/exercise at two months compared to medical care or group exercise and with no meaningful differences in falls, medical co-interventions, or spinal surgery rates at 6 months.

### Neck pain

One RCT studying NP compared the efficacy of three

groups: SMT with home exercise, home exercise alone, and supervised exercises plus home exercise.<sup>81</sup> Results favored the SMT plus home exercise group for pain intensity. However, there was no significant between-group difference for disability nor functional status. A higher proportion of participants receiving SMT achieved  $\geq 50\%$  (i.e., substantial) pain reduction at 12 weeks versus controls, although not at 52 weeks or for other thresholds ( $\geq 30\%$ ,  $\geq 75\%$ ). Medication use showed no significant between-group differences. A secondary analysis found SMT plus home exercise reduced total societal costs and improved pain and disability outcomes over 1 year compared to the control intervention.<sup>84</sup> One RCT evaluated the comparative efficacy of SMT treatment duration parameters for NP and disability and found statistically significant differences in favor of long-term management (36 weeks duration) for NP.<sup>82</sup>

#### *Neck and back-related disability*

For patients with both neck and back-related disability, one RCT did find statistically significant differences in favor of long-term management (36 weeks duration) for functional status, but there were no significant between-group differences for neck or back-related disability, quality of life, or medication use.<sup>82</sup> Additionally, Maiers *et al.* (2019) explored responder analysis but did not find any statistically significant differences between groups receiving 12 or 36 weeks of SMT in the proportions reaching 15%, 30%, or 50% improvement in disability.

#### *Reporting biases*

A search of ClinicalTrials.gov did not identify any RCTs which were completed yet unpublished. Among included studies, one did not receive funding,<sup>20</sup> and six received funding from non-industry sources<sup>27–29,81–83</sup>. The lack of industry funding suggests a low likelihood of publication bias. Specific extracted funding sources from included studies can be found in Appendix 5.

#### *Certainty of evidence*

The certainty of evidence regarding SMT vs. comparator for LBP was low for pain intensity, back-specific disability status, and functional status. The certainty regarding SMT parameters for LBP was very low for pain intensity and back-specific disability status when comparing thrust

vs. non-thrust SMT. The certainty of evidence regarding SMT parameters for LBP was low for pain intensity, back-specific disability status, functional status, and quality of life or activities of daily living (QoL/ADLs) when comparing duration of SMT treatment. The certainty of evidence regarding SMT vs. comparator for LBP was very low for QoL/ADLs. The certainty of evidence regarding SMT for LSS was moderate for back-specific functional status and QoL/ADLs. The certainty of evidence regarding SMT for LSS was very low for pain intensity and was downgraded as no trials were identified that reported this outcome. The certainty of evidence regarding SMT vs. comparator for NP was low for pain intensity, neck-specific disability status, and functional status. The certainty of evidence regarding SMT parameters for NP was low for pain intensity, neck-specific disability status, functional status, and QoL/ADLs when comparing the duration of SMT treatment. The certainty of evidence regarding SMT vs. comparator for NP was very low for QoL/ADLs. All downgrades were due to imprecision, risk of bias, or a lack of identifying studies for the outcome. Appendices 6–10 provide additional detail for graded certainty of evidence for interventions.

#### *Discussion*

This systematic review evaluated the efficacy of SMT for chronic spinal conditions in older adults. All results either favored the null or SMT. Significant between-group differences in outcomes favoring SMT over comparators were NP reduction with low certainty of evidence, and significant but small improvements in back-specific functional status in LSS with moderate certainty of evidence.<sup>88,89</sup> However, there was moderate certainty of evidence favoring the null for QoL in LSS. There was mixed very low and low certainty of evidence for parameters for LBP pain intensity and disability favoring the null. There was very low certainty of evidence for QoL for LBP and NP comparators and LSS pain intensity due to no relevant studies. Several outcomes demonstrated improvement but were not significantly different compared to active comparators, indicating a lack of additive benefit of SMT over other active interventions (e.g., physical therapy-related interventions such as exercise or physiotherapy) and a lack of superiority in head-to-head comparisons. One study found no significant difference versus an inert comparator.<sup>29</sup> Importantly, there were no outcomes where

comparators were superior to SMT. Overall, the certainty of evidence ranged from very low to moderate due to the limited number of trials in this population, imprecision, and risk of bias. A detailed summary of study characteristics can be found in Table 2.

The mixed results identified in the present review may be explained by several factors. First, the focus on chronic condition treatment could lower the likelihood of identifying meaningful changes within and between groups, as the majority of studies were chronic NP and LBP.<sup>90</sup> Second, most RCTs utilized an active treatment as a comparator. Therefore, null outcomes indicate a lack of additional benefit over these comparators rather than a lack of absolute benefit from SMT, and the efficacy of interventions may be better informed by superiority, non-inferiority, and equivalence clinical trial study designs.<sup>91</sup> For example, Enix *et al.* used a head-to-head design demonstrating similar benefits between SMT and physical therapy.<sup>27</sup> Finally, some responder analyses demonstrated favorability towards SMT interventions despite initial null outcomes when looking at within group differences for four<sup>28,81-83</sup> of the included studies as outlined in Appendix 3. This may indicate a trend towards efficacy of SMT or that there are subgroups of patients that respond particularly well to SMT and some that do not. Further research is warranted to clarify these subgroups, as few RCTs of interventions for chronic LBP report responder analyses.<sup>92</sup>

There were limited data across all conditions, with only four RCTs for LBP and one each for LSS, NP, and neck and back disability analyses. Even for LBP, the most studied condition, the available evidence fell short of ideal standards for synthesis, with fewer than 400 patients per comparison and fewer than five studies.<sup>40,93</sup> This small amount of RCTs is not unexpected, considering older adults are often excluded from clinical studies.<sup>94</sup> A recent bibliometric analysis<sup>95</sup> showed that only one in 10 publications on LBP involved older adults. Future research ought to include this population to better understand LBP prevalence and management approaches. The relatively few studies, coupled with clinical heterogeneity, resulted in very low to moderate certainty per GRADE and hindered definitive conclusions despite some positive findings.

Our findings suggest SMT is a viable treatment option for older adults with chronic LBP, LSS, and chronic NP.

While added benefits beyond comparator groups were infrequent in our analyses, there was often a lack of significant differences compared to other standard-of-care comparators like physical therapy or exercise, and there were no unfavorable outcomes for SMT across nine reports of seven RCTs. Non-pharmacological treatments are valued among older adult patients and their clinicians, especially in the context of polypharmacy.<sup>96</sup> Therefore, clinicians should consider SMT as a treatment option when caring for older adults with chronic LBP, chronic NP, or LSS. There are several factors relevant to SMT and older adults that were beyond the scope of this review and which warrant additional study, such as economic considerations, maintenance of function and quality of life, or patient preferences and satisfaction; there is a need for an update of comprehensive guidelines for the use of SMT in managing chronic spinal conditions in older adults.<sup>97</sup>

Limited evidence for SMT in older adults with chronic LBP, LSS, and chronic NP highlights the need for more high-quality large-sample RCTs dedicated to older adult populations to clarify efficacy, enable meta-analysis, and inform clinical practice guidelines. Accordingly, future RCTs should explore areas of research gaps identified herein including pain, disability, identification of SMT responders versus non-responders, cost-effectiveness, and healthcare utilization. Until more robust data become available, clinicians may rely on this review, observational studies (i.e. case series, case-control studies, longitudinal retrospective or prospective cohort studies incorporating medical records or administrative data, or data from clinical registries), and practice guidelines to guide decision-making.

### *Strengths and limitations*

Strengths of this review include protocol registration, adherence to PRISMA 2020 guidelines, a comprehensive search with librarian input and PRESS review, and duplicate independent screening, extraction, and GRADE assessments.

Our findings had several limitations. First, we deviated from the a priori protocol to include a study that defined chronic LBP as greater than 6 weeks, as opposed to the greater than 12 weeks that we had defined. After consideration, we felt it was appropriate to include Schulz *et al.* because, at baseline, 96% of their participants reported that their pain episode duration was 12 weeks or long-

er. Next, we limited our study intervention inclusion to studies that included spinal manipulation as part of the treatment arm. It is unclear if the outcome effects of SMT significantly differ from mobilization, and this limit reduced the number of eligible studies reported. The small number of RCTs and limited sample sizes per comparison, often drawn from single studies per outcome, led to imprecise effect estimates, and as expected, precluded meta-analysis. Focusing on English-language studies may have introduced selection bias. Many extracted outcomes were stand-alone, reported in only one study, limiting robust synthesis. By prioritizing outcomes from RCTs only, the review overlooked broader healthcare utilization and effectiveness measures like cost, surgery likelihood, or medication use in older adults that may be derived from observational studies.<sup>98–101</sup> Inclusion of observational studies may have afforded better real-world generalizability, yet potentially would introduce risk of bias, and was outside the predetermined scope of our review. While we reported individual item responses from the SIGN checklist and discussed them as a team to provide deeper insights into each study's reporting, our evidence certainty assessment primarily relied on overall quality ratings derived from thresholds of total scores. We acknowledge that this approach may oversimplify the risk-of-bias assessment, as certain items may have a disproportionate influence on study outcomes. Future reviews may benefit from using Cochrane tools to assess risk-of-bias at a more granular or domain-based level.

This review did not assess adverse events or safety outcomes, which were beyond the scope of our a priori objectives. Generally, precautions to the use of SMT in older adults include factors that compromise bone density or quality and increase the risk of fracture, such as long-term use of corticosteroids or the presence of osteoporosis.<sup>21,102</sup> An ideal safety evaluation would require a substantially larger sample size than was available in the seven RCTs included herein, which included 1,226 patients. Considering the rarity of serious adverse events (i.e., severe [considerable interference], catastrophic [life-threatening, death]) of 1 per 2 million manipulations to 13 per 10,000 patients receiving SMT,<sup>21,102,103</sup> large observational studies having several thousand patients (e.g., cohort or case-control designs) are better suited to estimate incidence and characterize risk. A separate systematic review focused on the safety of SMT in older adults is currently

in progress, which includes some members of the current author team (PROSPERO CRD42024629286).

## Conclusion

There is very low to moderate certainty that SMT may offer comparable or modestly greater efficacy than other treatments for older adults with chronic LBP, chronic NP, and LSS. NP intensity reduction and LSS functional status favored SMT, but other outcomes demonstrated no additive benefit or superiority over comparators, and no comparators were superior to SMT. These comparators included non-thrust manipulation plus a home exercise program, sham treatment, medical care, multimodal physical therapy exercise, treatment duration as well as different combinations of supervised, home-based, and group-based exercise. Certainty was limited due to relatively few trials, imprecision, and risk of bias. There is need for additional high-quality RCTs to clarify the efficacy of SMT for chronic spinal conditions in the older adult population. Overall, SMT is as efficacious as other conservative treatments and can be considered an option for patients and clinicians, provided there are no contraindications to care.

## Abbreviations

- ADLs – Activities of daily living
- AMED – Allied and Complementary Medicine Database
- CINAHL – Cumulative Index to Nursing and Allied Health Literature
- EQ – EuroQol EQ-5D
- GRADE – Grading of Recommendations Assessment, Development, and Evaluation
- HVLA – High-velocity low-amplitude
- LBP – Low back pain
- LSS – Lumbar spinal stenosis
- MRS – Modified Roland Scale
- NDI – Neck Disability Index
- NP – Neck pain
- NPRS – Numeric pain rating scale
- ODI – Oswestry Disability Index
- PEDro – Physiotherapy Evidence Database
- PICOS – Population, Intervention, Comparison, Outcome, and Study Type
- PRESS – Peer Review of Electronic Search Strategies

- PRISMA – Preferred Reporting Items for Systematic Reviews and Meta-Analyses
- PROSPERO – International Prospective Register of Systematic Reviews
- QoL – Quality of life
- RCT – Randomized controlled trial
- SF-36- 36-Item Short Form Survey
- SIGN – Scottish Intercollegiate Guideline Network
- SMT – Spinal manipulative therapy
- SPPB – Short Physical Performance Battery
- SPWT – Self-Paced Walking Test
- SSS – Swiss Spinal Stenosis Questionnaire
- VAS – Visual analog scale

#### *Availability of data and materials*

All data generated or analyzed for this study are available from the corresponding author upon reasonable request. Available documentation include the complete PRESS checklist, full search strategy and strings, and all extracted data.

#### *Authors' contributions*

AS and CD contributed to the design, implementation and supervision of the study. All authors contributed to the study methodology. SW developed and completed the literature search. MP and RW performed title, abstract and full-text screening. RT and JS extracted and interpreted the data and performed risk of bias assessment, and reporting bias was evaluated by CD. GRADE assessment was performed by AS and CD with assistance from RT and JS. AS, CD, RT, and JS all participated in drafting the manuscript. All authors read and provided critical review of the manuscript.

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100. Trager RJ, Gliedt JA, Labak CM, Daniels CJ, Dusek JA. Association between spinal manipulative therapy and lumbar spine reoperation after discectomy: a retrospective cohort study. *BMC Musculoskelet Disord.* 2024;25(1):46. doi:10.1186/s12891-024-07166-x
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### Appendix 1.

#### *PubMed literature search strategy for efficacy of spinal manipulative therapy in older adults with chronic spinal conditions*

PubMed 10.30.24

#1	chronic	1,794,233
#2	pain	1,091,864
#3	musculoskeletal or back or neck or spine or spinal or thoracic or lumbar or cervical or vertebral or pelvic or pelvis or occipital or sacroiliac or sacrum or lumbosacral or coccyx or “SI joint” or intervertebral disc degeneration or intervertebral disc displacement or sciatic* or spondylosis	2,300,335
#4	#1 and #2 and #3	62,844
#5	manual therapy or spinal manipulation or musculoskeletal manipulations or manipulation, osteopathic or manipulation, chiropractic or manipulation, spinal or manipulation, orthopedic or chiropract*	61,947
#6	#4 and #5	2,834
#7	geriatric* or aged[mh] or aged, 80 and over[mh] or older person* or older adult* or older patient*	3,906,896
#8	#6 and #7	495
#9	#8 and 2016/02/01:2024[dp]	227
#10	#9 and English[la]	221
#11	Limit article type: randomized controlled trial	65

PubMed as search string:

((((((chronic) AND (pain)) AND (musculoskeletal or back or neck or spine or spinal or thoracic or lumbar or cervical or vertebral or pelvic or pelvis or occipital or sacroiliac or sacrum or lumbosacral or coccyx or “SI joint” or intervertebral disc degeneration or intervertebral disc displacement or sciatic\* or spondylosis)) AND (manual therapy or spinal manipulation or musculoskeletal manipulations or manipulation, osteopathic or manipulation, chiropractic or manipulation, spinal or manipulation, orthopedic or chiropract\*)) AND (geriatric\* or aged[mh] or aged, 80 and over[mh] or older person\* or older adult\* or older patient\*)) and 2016/02/01:2024[dp]) and English[la] and randomized controlled trial[pt]

Appendix 2.

*Reasons for exclusion (32 total)*

No applicable treatment outcomes included (1)

- Maiers M, Evans R, Hartvigsen J, Schulz C, Bronfort G. Adverse events among seniors receiving spinal manipulation and exercise in a randomized clinical trial. *Man Ther.* 2015;20(2):335-341. doi:10.1016/j.math.2014.10.003

Wrong publication type (4)

- Kendall JC, French SD, Hartvigsen J, Azari MF. Chiropractic treatment including instrument-assisted manipulation for non-specific dizziness and neck pain in community-dwelling older people: a feasibility randomised sham-controlled trial. *Chiropr Man Therap.* 2018;26:14. doi:10.1186/s12998-018-0183-1
- Weigel PA, Hockenberry J, Bentler SE, Wolinsky FD. The Comparative Effect of Episodes of Chiropractic and Medical Treatment on the Health of Older Adults. *J Manipulative Physiol Ther.* 2014;37(3):143-154. doi:10.1016/j.jmpt.2013.12.009
- Holt KR, Haavik H, Elley CR. The effects of manual therapy on balance and falls: a systematic review. *J Manipulative Physiol Ther.* 2012;35(3):227-234. doi:10.1016/j.jmpt.2012.01.007
- Weigel PA, Hockenberry J, Bentler S, Wolinsky FD. Chiropractic Use and Changes in Health among Older Medicare Beneficiaries: A Comparative Effectiveness Observational Study. *J Manipulative Physiol Ther.* 2013;36(9):10.1016/j.jmpt.2013.08.008. doi:10.1016/j.jmpt.2013.08.008

No manipulation included (1)

- Buyukturan O; Buyukturan B; Sas S; Kararti C; Ceylan I. The effect of Mulligan mobilization technique in older adults with neck pain: a randomized controlled, double-blind study. *Pain Research & Management* 2018 May 15;(2856375):Epub. Published online 2018.

Wrong population (24)

- Rodríguez-Sanz J, Malo-Urriés M, Corral-de-Toro J, et al. Does the Addition of Manual Therapy Approach to a Cervical Exercise Program Improve Clinical Outcomes for Patients with Chronic Neck Pain in Short- and Mid-Term? A Randomized Controlled Trial. *Int J Environ Res Public Health.* 2020;17(18). doi:10.3390/ijer-ph17186601
- Ulger O, Demirel A, Oz M, Tamer S. The effect of manual therapy and exercise in patients with chronic low back pain: Double blind randomized controlled trial. *J Back Musculoskelet Rehabil.* 2017;30(6):1303-1309. doi:10.3233/BMR-169673
- Avila L, da Silva MD, Neves ML, et al. Effectiveness of Cognitive Functional Therapy Versus Core Exercises and Manual Therapy in Patients With Chronic Low Back Pain After Spinal Surgery: Randomized Controlled Trial. *Phys Ther.* 2024;104(1). doi:10.1093/ptj/pzad105
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Appendix 3.

Study responder analysis results (not applicable for Learman 2013, Dougherty 2014, or Enix 2015)

Author Surname and Year	Condition	Responder Analysis for within group differences	Between-group effect estimate(s) for other health services outcomes
Maiers 2014	Neck pain	The proportion of patients with $\geq 50\%$ pain reduction was meaningfully greater among those receiving SMT+HEA compared to HEA alone at week 12, yet not meaningfully different at week 52, or for either timepoint for $\geq 30\%$ and $\geq 75\%$ pain reduction.	Duration of medication use at 12 weeks (MD w/ 95% CI) <ul style="list-style-type: none"> <li>• SMT+HEA vs. HEA: -0.31 [-0.94, 0.31] (<math>p &gt; .05</math>)</li> <li>• SMT+HEA vs. SRE+HEA: -0.33 [-0.96, 0.30] (<math>p &gt; .05</math>)</li> </ul>
Maiers 2019	Neck and back disability	No statistically significant differences in proportions reaching 15%, 30% or 50% improvement in disability at 12 or 36 weeks. Baseline self-efficacy and improvements in self-efficacy and kinesiophobia were individually associated with clinically important reductions in disability post-intervention, although not in adjusted models when LBP duration was included. There were statistically significant between group differences in the SPPB overall score, and in the SPPB balance test sub-score in favor of the long-term management group.	No significant between-group difference for medication use.  Medication use at 36 weeks (MD w/ 95% CI) <ul style="list-style-type: none"> <li>• 0.5 (95% CI: -0.2, 1.1) <math>p = 0.16</math></li> </ul>
Schneider 2019	Lumbar spinal stenosis	MT/IE had a greater proportion of responders ( $\geq 30\%$ improvement) in symptoms and physical function (20%) and walking capacity (65.3%) at 2 months compared with medical care (7.6% and 48.7%, respectively) or group exercise (3.0% and 46.2%, respectively). No between-group differences in physical activity responder rates were found at 2 months (difference in percentage for MT/IE vs medical care [95% CI], -7% [-21% to 7%]; difference in percentage for MT/IE vs group exercise [95% CI], 1% [-15% to 16%].)	There were no between-group differences in the number of self-reported falls or medical cointerventions between the end of care and 6-month follow-up. At 6 months, only a small minority of participants reported having spinal surgery (medical care: 2 of 79 [3%]; group exercise: 1 of 67 [2%]; manual therapy/individualized exercise: 1 of 80 [2%])
Schulz 2019	Low back pain	Similar between group responder analysis for no pain reduction, or pain reductions of $\geq 30\%$ (meaningful improvement), $\geq 50\%$ (substantial improvement), $\geq 75\%$ , and 100%. Differences in proportions for reduction of LBP severity were mostly below 10%. The largest differences were for SMT+HEP over HEP alone at week 12 where 16 and 18% more participants had pain severity reductions of 30% and 50%, respectively.	Short Term medication use at weeks 4 to 12 (MD w/ 95% CI) <ul style="list-style-type: none"> <li>• SMT+HEP minus HEP: -0.08 [-0.42, 0.27]</li> </ul> Long term medication use at weeks 4 to 52 (MD w/ 95% CI) <ul style="list-style-type: none"> <li>• SMT+HEP minus HEP: 0.09 [-0.22, 0.40]</li> </ul>

Abbreviations: CI, Confidence Intervals; HEA, Home Exercise and Advice; HEP, Home Exercise Program; MD, mean difference; MT/IE, Manual Therapy/Individualized Exercise; SPPB, Short Physical Performance Battery; SRE, Supervised Rehabilitative Exercise; SMT, Spinal Manipulative Therapy.

Appendix 4.

Study health service outcomes for secondary analysis RCT reports only

Author Surname and Year	Condition	Other health service outcomes for secondary analysis	Findings of secondary analysis
Leininger 2016  Secondary Analysis of Maiers 2014	Neck pain	<p>Total costs for SMT+HEA were 5% lower than HEA (mean difference: -\$111; 95%CI -\$1,354 to \$899) and 47% lower than SRE+HEA (mean difference: -\$1,932; 95%CI -\$2,796 to -\$1,097).</p> <p>SMT+HEA also resulted in a greater reduction of neck pain over the year relative to HEA (0.57; 95%CI 0.23 to 0.92) and SRE+HEA (0.41; 95%CI 0.05 to 0.76)</p> <p>SMT+HEA yielded greater reductions of neck disability and QALY gains compared to HEA (disability = 1.67 95%CI: -0.15; 3.41; QALYs = 0.009 95%CI: -0.011; 0.029) and SRE+HEA (disability=1.85; 95%CI: 0.06; 3.57; QALYs=0.009 95%CI: -0.009; 0.027)</p>	<p>On average, SMT+HEA resulted in better clinical outcomes and lower total societal costs relative to SRE+HEA and HEA alone, with a 0.75 to 0.81 probability of cost-effectiveness for willingness to pay thresholds of \$50,000 to \$200,000 per QALY.</p> <p>If adopting a healthcare perspective, costs for SMT+HEA were 66% higher than HEA (mean difference: \$515; 95%CI \$225 to \$1,094), resulting in an ICER of \$55,975 per QALY gained.</p>
Maiers 2021  Secondary Analysis of Maiers 2019	Back pain and disability	<p>Back pain duration was significantly and inversely associated with 12-week back disability recovery in older adults with back pain duration of 14.5 to 30 years OR = 0.321 [95%CI: 0.13, 0.740] (p=0.008), and &gt;30 years OR 0.333 [95%CI: 0.127, 0.874] (p=0.026)</p>	<p>Among older adults with back disability, a longer duration of symptoms greater than 14.5 years predicts a poorer response to SMT and exercise</p>

Abbreviations: CI, Confidence Intervals; HEA, Home Exercise and Advice; OR, Odds Ratio; QALY, Quality-Adjusted Life Year; SRE, Supervised Rehabilitative Exercise; SMT, Spinal Manipulative Therapy.

Appendix 5.  
 Extracted funding sources from included studies

First Author Last Name and Year	Funding Source
Learman 2013	None.
Dougherty 2014	The trial was funded by the U.S. Department of Health and Human Services (HHS), Resources and Services Administration (HRSA), Bureau of Health Professions (BHP), Division of Medicine and Dentistry (DMD), grant number R18HP15127.
Enix 2015	The trial was funded by the U.S. Department of Health and Human Services (HHS), Resources and Services Administration (HRSA), Bureau of Health Professions (BHP), Division of Medicine and Dentistry (DMD), grant number R18HP15127.
Maiers 2014	The trial was funded by the U.S. Department of Health and Human Services (HHS), Resources and Services Administration (HRSA), Bureau of Health Professions (BHP), Division of Medicine and Dentistry (DMD), grant number R18HP15127, Chiropractic and Exercise for Seniors with Neck Pain.
Maiers 2019	The trial was funded by the U.S. Department of Health and Human Services (HHS), Resources and Services Administration (HRSA), Bureau of Health Professions (BHP), Division of Medicine and Dentistry (DMD), grant number R18HP15127.
Schneider 2019	This study was funded through Patient-Centered Outcomes Research Institute award CER-1410-25056.
Schulz 2019	Research reported in this publication was supported by the Department of Health and Human Services (HHS), Health and Human Services Resources and Services Administration (HRSA), Bureau of Health Professions (BHP), Division of Medicine and Dentistry (DMD) under award number R18HP01425 and the National Center For Complementary & Integrative Health of the National Institutes of Health (NIH) under award number K01AT008965.

Appendix 6  
 Certainty of evidence for intervention – Efficacy of SMT vs comparator for Low back pain

Outcomes	No. of participants randomized (Studies)	Results favor (SMT, null, comparator)	Risk of Bias (low, acceptable, high)	Certainty of the evidence	Comments (Reasons for downgrade/ upgrade)
<b>Pain Intensity</b> Scale: VAS, 11-Point Scale, 21-Point box scale	495(3 RCT)	3 favor null	2 low risk, 1 acceptable risk	⊕⊕○○ Low	Imprecision
<b>Back-Specific Disability Status</b> Scale: ODI, MRS	377 (2 RCT)	1 favors SMT 1 favors null	2 low risk	⊕⊕○○ Low	Imprecision
<b>Functional Status</b> Scale: SF-36 physical function subscale	377(2 RCT)	2 favors null	2 low risk	⊕⊕○○ Low	Imprecision
<b>Quality of Life/ Activities of daily living</b>	No trials were identified that reported on this outcome.			⊕○○○ Very Low	No Relevant Studies

Abbreviations: RCT, randomized controlled trial; SF, short form; SMT, spinal manipulative therapy, VAS, verbal/visual pain scale, ODI, Oswestry Disability Index, MRS, Modified Roland Scale

Appendix 7.

*Certainty of evidence for intervention – Efficacy of SMT parameters for Low back pain*

Outcomes	No. of participants randomized (Studies)	Parameter	Results favor (SMT, null, parameter)	Risk of Bias (low, acceptable, high)	Certainty of the evidence	Comments (Reasons for downgrade/ upgrade)
<b>Pain Intensity</b> Scale: NPRS, 11-Point box pain scale	49 (1 RCT)	Thrust SMT vs Non-thrust SMT	1 favors null	1 acceptable risk	⊕○○○ Very Low	Imprecision Risk of bias
	182 (1 RCTs)	12 weeks SMT vs 36 weeks SMT	1 favors null	1 low risk	⊕⊕○○ Low	Imprecision
<b>Back-Specific Disability Status</b> Scale: ODI	49 (1 RCT)	Thrust SMT vs Non-thrust SMT	1 favors null	1 acceptable risk	⊕○○○ Very Low	Imprecision Risk of bias
	182 (1 RCTs)	12 weeks SMT vs 36 weeks SMT	1 favors null	1 low risk	⊕⊕○○ Low	Imprecision
<b>Functional Status</b> Scale: SPPB	182 (1 RCTs)	12 weeks SMT vs 36 weeks SMT	1 favors 36 weeks	1 low risk	⊕⊕○○ Low	Imprecision
<b>Quality of Life/ Activities of daily living</b> Scale: EQ	182 (1 RCTs)	12 weeks SMT vs 36 weeks SMT	1 favors null	1 low risk	⊕⊕○○ Low	Imprecision

Abbreviations: NPRS, numerical pain rating scale; ODI, Oswestry Disability Index; RCT, randomized controlled trial; SMT, spinal manipulative therapy; SPPB, Short Physical Performance Battery; EQ, EuroQol EQ-5D

Appendix 8.

*Certainty of evidence for intervention – Efficacy of SMT vs comparator for Lumbar Spinal Stenosis*

Outcomes	No. of participants randomized (Studies)	Results favor (SMT, null, comparator)	Risk of Bias (low, acceptable, high)	Certainty of the evidence	Comments (Reasons for downgrade/ upgrade)
<b>Pain Intensity</b>	No trials were identified that reported on this outcome.			⊕⊕○○ Very Low	No Relevant Studies
<b>Back-Specific Functional Status</b> Scale: SSS	259 (1 RCT)	1 favors SMT	1 low risk	⊕⊕⊕○ Moderate	Imprecision
<b>Quality of Life/ Activities of daily living</b> Scale: SPWT, daily physical activity	259 (1 RCT)	1 favors null	1 low risk	⊕⊕⊕○ Moderate	Imprecision

Abbreviations: RCT, randomized controlled trial; SMT, spinal manipulative therapy; SSS, Swiss Spinal Stenosis Questionnaire; SPWT, Self-paced walking test

Appendix 9.

*Certainty of evidence for intervention – Efficacy of SMT vs comparator for Neck pain*

Outcomes	No. of participants randomized (Studies)	Results favor (SMT, null, comparator)	Risk of Bias (low, acceptable, high)	Certainty of the evidence	Comments
<b>Pain Intensity</b> Scale: 11- Point box scale	241(1 RCT)	1 favors SMT	1 low risk	⊕⊕○○ Low	Imprecision
<b>Neck-Specific Disability Status</b> Scale: NDI	241 (1 RCTs)	1 favors null	1 low risk	⊕⊕○○ Low	Imprecision
<b>Functional Status</b> Scale: SF-36 physical function subscale	241 (1 RCTs)	1 favors null	1 low risk	⊕⊕○○ Low	Imprecision
<b>Quality of Life/ Activities of daily living</b>	No trials were identified that reported on this outcome.			⊕○○○ Very Low	No Relevant Studies

Abbreviations: NDI, Neck Disability Index; RCT, randomized controlled trial; SF, short form, SMT, spinal manipulative therapy

Appendix 10.

*Certainty of evidence for intervention – Efficacy of SMT parameters for Neck pain*

Outcomes	No. of participants randomized (Studies)	Parameter	Results favor (SMT, null, parameter)	Risk of Bias (low, acceptable, high)	Certainty of the evidence	Comments (Reasons for downgrade/ upgrade)
<b>Pain Intensity</b> Scale: 11-Point box pain scale	182 (1 RCTs)	12 weeks SMT vs 36 weeks SMT	1 favors 36 weeks	1 low risk	⊕⊕○○ Low	Imprecision
<b>Neck-Specific Disability Status</b> Scale: NDI	182 (1 RCTs)	12 weeks SMT vs 36 weeks SMT	1 favors null	1 low risk	⊕⊕○○ Low	Imprecision
<b>Functional Status</b> Scale: SPPB	182 (1 RCTs)	12 weeks SMT vs 36 weeks SMT	1 favors 36 weeks	1 low risk	⊕⊕○○ Low	Imprecision
<b>Quality of Life/ Activities of daily living</b> Scale: EQ	182 (1 RCTs)	12 weeks SMT vs 36 weeks SMT	1 favors null	1 low risk	⊕⊕○○ Low	Imprecision

Abbreviations: NDI, Neck Disability Index; RCT, randomized controlled trial; SMT, spinal manipulative therapy; SPPB, short physical performance battery; EQ, EuroQol EQ-5D