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Evidence-informed management of chronic low back pain with spinal manipulation and mobilization

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Abstract

EDITORS' PREFACE: The management of chronic low back pain (CLBP) has proven very challenging in North America, as evidenced by its mounting socioeconomic burden. Choosing among available nonsurgical therapies can be overwhelming for many stakeholders, including patients, health providers, policy makers, and third-party payers. Although all parties share a common goal and wish to use limited health-care resources to support interventions most likely to result in clinically meaningful improvements, there is often uncertainty about the most appropriate intervention for a particular patient. To help understand and evaluate the various commonly used nonsurgical approaches to CLBP, the North American Spine Society has sponsored this special focus issue of *The Spine Journal*, titled Evidence Informed Management of Chronic Low Back Pain Without Surgery. Articles in this special focus issue were contributed by leading spine practitioners and researchers, who were invited to summarize the best available evidence for a particular intervention and encouraged to make this information accessible to nonexperts. Each of the articles contains five sections (description, theory, evidence of efficacy, harms, and summary) with common subheadings to facilitate comparison across the 24 different interventions profiled in this special focus issue, blending narrative and systematic review methodology as deemed appropriate by the authors. It is hoped that articles in this special focus issue will be informative and aid in decision making for the many stakeholders evaluating nonsurgical interventions for CLBP.

Keywords: Chronic low back pain; Spinal manipulative therapy (SMT); Spinal mobilization (MOB); Low back pain, manipulation, spinal; Meta-analysis

Description

Terminology

For the purpose of this review, spinal manipulative therapy (SMT) is defined as the application of high-velocity, low-amplitude manual thrusts to the spinal joints slightly beyond the passive range of joint motion [1]. Spinal mobilization (MOB) is defined as the application of manual force to the spinal joints within the passive range of joint motion that does not involve a thrust.

History

Although the practice of spinal manipulation is now frequently associated with chiropractic—which began as a profession in 1895—it predates any modern health profession and dates back thousands of years. Spinal manipulation is believed to have been practiced in China as far back as 2700 BC [2]. In India, spinal manipulation was historically practiced as an act of hygiene and related techniques were considered

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a component of surgery [2]. Hippocrates, in his book On Joints, was the first to give a formal definition to the technique of manipulation; his belief in the spine as the epicenter of holistic bodily health is well known [2]. As a testament to its long history of use, there are now more randomized controlled trials (RCTs) examining SMT for low back pain (LBP) than any other intervention for that indication [3].

Subtypes

There are many subtypes of SMT currently in use, including several named technique systems combining patient assessment and management. The most common type of SMT technique has been termed ''diversified'' because it incorporates many of the aspects taught in these different systems. It consists of the application of a high-velocity, low-amplitude (HVLA) thrust to the spine with the practitioner's hand to distract spinal zygapophyseal joints slightly beyond their passive range of joint motion into the paraphysiologic space [1]. There are many specific HLVA techniques available to practitioners of SMT that can be modified according to patient need. This type of SMT has also been termed short-lever SMT, because the thrust is applied directly to the spine. It is distinguished from long-lever SMT, originally from the osteopathic tradition, in which force is not provided to the spine directly, but from rotation of the patient's thigh and leg. MOB is defined as the application of manual force to the spinal joints within the passive range of joint motion; it does not involve a thrust and may include traction through the use of specialized treatment tables. There are other types of SMT that are not covered by this review, including instrument-assisted procedures and low-force manual procedures.

General description

Before performing SMT, the practitioner must conduct a thorough physical examination that includes manual palpation of the lumbar and sacral areas to assess local tenderness, inflammation, and identify areas of segmental dysfunction/hypomobility to which SMT will be applied. SMT for LBP is typically performed with the patient in a side-lying position on a cushioned treatment table. The practitioner then positions the patient's torso, hips, arms, and legs according to the desired type of SMT, places the ''stabilizing'' hand on the patient's arms, and contacts the legs using the practitioner's thigh or leg. The practitioner places the thrusting ''treatment'' hand over either the superior or inferior vertebra of the target spinal motion segment to which SMT will be applied. The practitioner introduces a slow force to preload the target spinal joints, and then administers a HVLA thrust with the direction, velocity, and amplitude determined by the examination and desired joint movement. The manual thrust is assisted by a ''body drop'' produced by contraction of the abdominal and leg muscles [4]. This thrust is often accompanied by an audible cracking or popping sound, which represents the formation and dissolution of small gas bubbles within the joint cavity resulting from pressure changes as the articular surfaces momentarily separate in response to the HVLA thrust [5,6].

Practitioner, setting, and availability

In most jurisdictions, SMT is considered a controlled health act and must be delivered by a licensed health practitioner. The vast majority of SMT (previously estimated at 94%) in North America is provided by Doctors of Chiropractic (DCs), who receive extensive training in manual examination and manual therapies during their 4 years of education and clinical internship; licensing requirements differ considerably outside the United States [7]. A minority of SMT is provided by Doctors of Osteopathy and physical therapists, who receive additional training in SMT where permitted by state licensure laws, and naturopathic doctors where permitted. SMT is most often administered in the private practice of DCs. In rare cases, SMT may be performed in conjunction with anesthesia or injections, which would require that it be performed in an outpatient surgical center. Medicine assisted manipulation, including manipulation under anesthesia, is discussed elsewhere in the supplement. SMT is widely available throughout the United States, with an estimated 60,000 licensed DCs practicing across the country.

Reimbursement

Pertinent Current procedural terminology (CPT) codes include: 98940, Chiropractic manipulative treatment (CMT); spinal, one to two regions; 98941, CMT; spinal, three to four regions; 98942, CMT; spinal, five regions. The cost of a single session of SMT, which may include multiple applications of SMT, is approximately $50, though charges and reimbursement vary considerably among practitioners and payers. Additional CPT codes and charges may apply if adjunct therapies are administered in conjunction with SMT, such as heat, ice, electrical stimulation, assisted stretching, myofascial release, massage, or exercise.

Cost comparisons have been performed alongside only in a few of the randomized studies. On the basis of the retrospective cost estimations in the British Meade trial [8], the authors argued that the potential cost savings over a 3-year period were higher for patients with LBP managed by chiropractors than for patients managed by hospital outpatient departments [8,9]. In the trial by Cherkin et al. [10], the mean costs of care over a 2-year period were very similar for the physical therapy and chiropractic groups, but were about three times higher compared with the booklet group. Skargren et al. [11] found no difference in the cost-effectiveness ratio between chiropractic and physical therapy in the management of neck and back pain in Sweden. The UK BEAM trial [12] is the largest study with a prespecified comprehensive cost-effectiveness design,

and the authors concluded that SMT is a cost-effective addition to ''best care'' for back pain in general practice. SMT alone probably gives better value for money than SMT followed by exercise.

SMT is routinely reimbursed by a variety of third-party payers including Medicare, Medicaid, worker's compensation insurance, motor vehicle collision health insurance, and various forms of managed care health insurance including preferred provider organizations and health maintenance organizations. Many of these payers have established upper limits on the number of sessions of SMT that are reimbursed for specific conditions or time periods, subject to modifications if adequate documentation and justification are provided.

Theory

Mechanism of action

Many hypotheses related to the mechanism of action for SMT and MOB focus on the immediate consequences of applying external force to the tissues of the spine. It is thought that if target tissues are relatively rigid (eg, bone), the applied force may cause the tissue to displace, whereas if the target tissue is relatively nonrigid, the applied force may cause it to deform. Several studies related to SMT and MOB have examined the immediate effects of tissue displacement or deformation, including (1) altering orientation or position of anatomic structures, (2) unbuckling of structures, (3) release of entrapped structures, and (4) disruption of adhesions [13,14].

Other hypotheses regarding the mechanism of action for SMT and MOB have focused on the consequences of tissues being displaced or deformed by such procedures, including the response of neurological, cell, or matrix systems to the input forces of SMT and MOB [15]. The greatest body of evidence in this area relates to the neurological system, where evidence suggests that SMT impacts primary afferent neurons from paraspinal tissues, the motor control system, and pain processing [16].

Focusing mainly on the immediate and consequential mechanism of action underscores the complementary nature of biomechanical studies compared with studies that investigate downstream system effects or attempt to segregate these interactions [14]. Although work to date is encouraging, it must be emphasized that at present, the exact mechanisms of action for any effects attributable to SMT or MOB remains unknown [15]. Although this does not negate their clinical efficacy, it may act to hinder their acceptance and delivery by the wider scientific and healthcare communities [16].

Diagnostic testing required

Given that the cause of chronic low back pain (CLBP) cannot be identified in the majority of cases, meaningful tests to identify alterations in entities relevant to LBP is difficult at best. As a result of these circumstances, and assuming that the chronicity of a complaint is unrelated to a diagnosable entity that has gone undetected, diagnostic testing as a precursor to the application of SMT is performed typically to rule out the presence of certain contraindications or red flags [17]. These red flags often suggest the presence of malignancy, infection, spondyloarthritis, or neurological conditions that are not appropriate to treat with conservative interventions such as SMT [18]. In the absence of these red flags, imaging or other laboratory-based diagnostics are of limited value.

Indications and contraindications

Various countries and organizations have published clinical practice guidelines for the treatment of LBP-based systematic reviews of evidence. In general, the recommended indication for SMT or MOB is nonspecific mechanical CLBP.

Contraindications for SMT include ''red flags'' as described by the AHCPR guidelines (fever, unrelenting night pain or pain at rest, pain with below knee numbness or weakness, leg weakness, loss of bowel or bladder control, progressive neurological deficit, direct trauma, unexplained weight loss, and history of cancer) [17]. Other contraindications specific to SMT or MOB include fracture, severe osteoporosis, or trauma causing tissue disruption to the treated area.

Little research has been performed to evaluate which CLBP patients are best suited for SMT or MOB. Generally, SMT or MOB may be recommended for CLBP patients who do not have contraindications as discussed above. In addition, SMT or MOB may not be the best choice for patients who cannot increase activity/workplace duties, are physically deconditioned, and have psychosocial barriers to recovery [19].

Recent work on acute LBP has begun to identify characteristics that distinguish which patients may respond favorably to SMT including (1) duration of LBP less than 16 days; (2) symptoms that remain proximal to the knee; (3) fear-avoidance belief questionnaire (FABQ) scores less than 19; (4) hypomobility of the lumbar spine; and (5) hip rotation greater than 35 degrees [20]. In a 6-month follow-up, when three of these five markers were present, subjects were observed to experience significantly greater benefits from manipulation. More studies are needed to identify which CLBP patients are likely to benefit from SMT or MOB.

Evidence of efficacy

Review methods

The purpose of this study was to assess the efficacy of SMT and MOB for the management of CLBP by updating a previous systematic review that included literature published through 2002 [3]. An updated literature search

(through 2006) for RCTs evaluating the therapeutic efficacy of SMT or MOB for CLBP was performed using the same strategy [3]. Additionally, citation tracking of references in relevant publications was used, including the nonindexed chiropractic, osteopathic, physical therapy, and medical journals. Abstracts from proceedings and unpublished trials were not included.

To be included in this review, each study was required to have greater than or equal to 10 subjects receiving SMT or MOB and main outcome measures had to be patient oriented (eg, pain, global improvement, low-back disability, recovery time, work loss, medication use, and functional health status).

A best evidence synthesis incorporating explicit information about outcome measures, interventions, magnitude of treatment differences, and associated p-values was used to evaluate treatment efficacy [21–23]. Two authors (MH and GB) independently extracted and recorded relevant data from each article. Outcomes were normalized to a 0- to 100 (percentage)-point scale whenever possible and between-group differences are reported in the text in percentage points on the 100-point scale. Studies were classified into two categories: CLBP (≥12 wk) and mixed duration with >50% CLBP.

Follow-up was defined as short term if less than 3 months, and long term if equal to greater than 3 months.

A list of eight items was used to assess methodological quality [3,24,25] (Table 1). Two reviewers performed the methodological scoring of the RCTs independently (MH and GB), and differences were resolved by consensus. The trials for which GB was the primary author were scored by two other authors of this review. Because of their familiarity with the literature, the reviewers could not be blinded.

The criteria for determining the level of evidence of efficacy is detailed in a previous publication [3] and summarized in Table 2. All eligible RCTs were considered regardless of their results. Statistical pooling of two or more trials was considered if they were homogeneous in terms of patient population, interventions, outcomes, and follow-up time points. Methodological quality and statistical significance were then considered to determine the evidence level.

Table 1
Critical evaluation list for randomized clinical trials (operational definitions of items provided in a previous publication [3])

1	Similarity of baseline characteristics or adjusted effects reported
2	Concealment of treatment allocation
3	Blinding of patients
4	Blinding of provider/attention bias
5	Blinding of assessor/unbiased outcome assessment
6	Dropouts reported and accounted for in the analysis
7	Missing data reported and accounted for in the analysis
8	Intension-to-treat analysis/balanced cointervention

Scoring: The critical evaluation list contains eight items with three choices: YES (+), PARTIAL (P), and NO (−). 1 point is awarded for a YES rating, ½ point is assigned for a PARTIAL rating, and 0 points is given for a NO rating. The quality score is determined by dividing the point total by 8 and multiplying the result by 100 to create a 100-point scale.

Table 2
Summary conclusions from national clinical guidelines during the past decade that include an assessment of the efficacy of spinal manipulation for chronic low back pain

Country and year [reference]	Chronic
Switzerland, 1997 [75]	?
Denmark, 1999 [76]	+
Germany, 2002 [77]	?
Sweden, 2000 [78]	+
Finland, 2001 [79]	?
European, 2004 [44]	+

+=Recommends spinal manipulation as a treatment option; ?=evidence unclear.

An RCT was excluded from evidence synthesis under the following conditions: (1) the main outcome measure was not patient rated; (2) there was inadequate quantitative information for the main outcome; (3) the trial was designed to test the immediate postintervention effect of a single treatment without a follow-up period; and (4) SMT or MOB was combined with other therapies and it was not possible to isolate its unique contribution to the overall treatment effect.

The search strategy identified 42 studies assessing SMT/MOB for CLBP, eight more than the previous systematic review [3]. Comparison therapies included acupuncture, back school, bed rest, corset, diathermy, education advice, electrical modalities, exercise, heat, injections, massage and trigger point therapy, medication, no treatment, placebo, physical therapy, sham SMT, and ultrasound. The number of SMT treatments varied from 1 to 24 and follow-up from immediate posttreatment to 3 years. Among the studies considered in evidence, 11 trials (n=1,199) assessed CLBP and 8 trials (n=3,422) investigated a mix of acute and CLBP patients. The methodological quality scores of the studies ranged from 6 to 81 (Table 3). The 20 LBP studies excluded from evidence and the reasons for ineligibility are summarized in Table 4. The primary exclusion criterion was the inability to isolate a unique contribution of SMT/MOB to the treatment effect.

The studies were too dissimilar in terms of patient characteristics, outcome measures, time points, and type of treatment comparisons to allow for statistical pooling.

Thirteen RCTs on CLBP were identified, including nine for SMT and four for MOB [26–39]; two RCTs were excluded [40,41] (Table 5). Of the trials remaining in evidence, the methodological quality scores ranged from 38 to 81 and five were of moderate to high quality (score ≥50) (Table 6).

Clinical guidelines

Since 1990, official LBP guidelines have been developed by national health-care agencies and advisory groups in North America, Europe, Israel, New Zealand, and Australia. These guidelines can quickly become outdated as the number

Table 3
Methodological quality scores for low back pain trials in evidence

First author	Year	Item 1	2	3	4	5	6	7	8	Validity % score
Bronfort [26]	1996	+	+	−	p	+	+	+	+	81
Burton [27]	2000	+	p	−	−	+	−	−	p	38
Cambron [32]	2006	+	+	−	−	+	+	p	+	69
Coxhead [49]	1981	−	p	−	−	p	−	−	+	25
Evans [40]	1978	−	p	−	−	p	−	−	p	19
Gibson [50]	1985	−	p	p	p	p	p	−	p	38
Giles [28]	1999	p	p	−	−	p	p	−	p	31
Giles [29]	2003	p	+	−	−	p	−	−	p	31
Gudavalli [31]	2005	+	+	−	−	+	+	p	+	69
Haas [33]	2004	+	+	−	−	+	+	p	+	69
Hemmilä [52]	1997, 2002	−	+	−	−	+	+	+	+	63
Herzog [55]	1991	−	−	−	−	p	−	−	−	6
Hurwitz [56]	2002	−	+	−	−	+	+	+	+	63
Koes [34,35]	1992	p	p	+	−	p	−	p	+	50
Meade [8,9]	1990, 1995	p	−	−	−	p	+	p	p	31
Muller [30]	2005	p	+	−	−	+	−	−	p	38
Pope [74]	1994	p	+	−	−	p	−	−	+	38
Postacchini [41]	1988	p	−	−	−	−	−	−	−	6
Rasmussen-Barr [36]	2003	+	−	−	−	+	p	−	p	38
Ritvanen [37]	2007	+	+	−	−	+	−	−	p	44
Skargren [11]	1997	+	p	−	−	+	p	−	+	50
Timm [38]	1994	p	−	−	−	p	−	−	+	25
Triano [54]	1995	-	+	p	p	p	−	−	−	31
UK Beam [12]	2004	+	+	−	−	+	−	−	+	50
Waagen [39]	1986	p	−	+	p	+	−	−	p	44

+=yes; −=no; p=unclear/partly.
See Table 1 for list of validity items.

of trials increases and the methodology of both trials and guideline development improves. The most recent and most comprehensive evidence-based guideline efforts addressing CLBP have occurred in Europe [42]. A summary of the national guideline conclusions regarding recommendation for the use of SMT for CLBP is shown in Table 2.

Systematic reviews

A recent review of systematic reviews of RCTs on SMT by Ernst and Canter concluded that SMT is not an effective intervention and given the possibility of adverse effects, suggests that SMT is not a recommendable treatment [43]. The

Table 4
Randomized trials of spinal manipulation and mobilization for chronic low back pain excluded from evidence

First author	Year	Duration	Quality score	Reason for exclusion from evidence
Andersson [75]	1999	a/c	50	Proportion of chronic low back pain participants cannot be determined
Arkuzewski [76]	1986	c	13	Outcomes not rated by patients
Aure [77]	2003	c	75	Unique contribution of manipulation to treatment effect could not be isolated
Beyerman [78]	2006	?	25	Proportion of chronic low back pain participants cannot be determined
Bronfort [79]	1989	a/c	31	Proportion of chronic low back pain participants was less than 50%
Cherkin [10]	1998	a/c	50	Proportion of chronic low back pain participants was less than 50%
Doran [80]	1975	a/c	25	Proportion of chronic low back pain participants was less than 50%
Hoehler [81]	1981	a/c	25	Proportion of chronic low back pain participants was less than 50%
Hsieh [82]	2002	a/c	63	Proportion of chronic low back pain participants cannot be determined
Kinalski [83]	1989	?	13	Outcomes not rated by patients
Ongley [84]	1987	c	88	Unique contribution of manipulation to treatment effect could not be isolated
Pope [74,85]	1994	a/c	38	Proportion of chronic low back pain participants cannot be determined
Rasmussen [86]	1979	a	38	Outcomes not rated by patients
Rupert [87]	1985	a/c	19	Inadequate information about main outcome
Seferlis [88]	1998	a	19	Unique contribution of manipulation to treatment effect could not be isolated
Sims-Williams [89]	1978	c	44	Unique contribution of manipulation to treatment effect could not be isolated
Sims-Williams [90]	1979	c	44	Unique contribution of manipulation to treatment effect could not be isolated
Waterworth [91]	1985	a	31	Unique contribution of manipulation to treatment effect could not be isolated
Wreje [92]	1992	a/c	13	Proportion of chronic low back pain participants was less than 50%
Zylbergold [93]	1981	?	38	Proportion of chronic low back pain participants cannot be determined

LBP=low back pain; NP=neck pain; a=acute; c=chronic; a/c=mix of acute and chronic; ?=unknown.

Table 5
Randomized trials of spinal manipulation and mobilization for chronic low back pain

First author	Year	Study groups (n)	# tx	Results: Between-group differences in percentage points unless otherwise specified. Positive score indicates advantage for Group 1 (G1)
Bronfort [26]	1996	G1: SMT-DC & strength exercise (71) G2: NSAID & strength exercise (52) G3: SMT-DC & stretch exercise (51) (cannot isolate effect of SMT with G3)	20 20 20	Pain: G2 vs. G1: 5 wk: 02 3 mo: 08 1 y: 08 [adjusted differences] Disability: G2 vs. G1: 5 wk: 02 3 mo: 06 [adjusted differences]
Burton [27]	2000	G1: SMT-DO, (20) G2: Chemonucleolysis (20)	6–18 m = 11 1	Pain: G2 vs. G1: 2 wk: 11* 6 wk: 13* 1 y: 09 Disability: G2 vs. G1: 2 wk: 15* 6 wk: 13 1 y: 06
Evans [40]	1978	G1: SMT-MD (17) G2: Analgesics (15)	3 3	Pain improvement: G2 vs. G1: 3 wk: 07 Improvement (difference in % of patients rating treatment effective/highly effective): G2 vs. G1: 3 wk: 42*
Giles [28]	1999	G1: SMT-DC (32) G2: Acupuncture (18) G3: Medication (19)	6 6	Pain improvement: G2 vs. G1: 4 wk: 33 [median scores] G3 vs. G1: 4 wk: 28 Disability improvement: G2 vs. G1: 4 wk: 09 [median scores] G3 vs. G1: 4 wk: 09
Giles/Muller [29,30]	2003/2005	G1: SMT-DC (35) G2: Acupuncture (34) G3: NSAID (40)	18 18 18	Pain: G2 vs. G1: 9 wk: 10 1 y: 02 G3 vs. G1: 9 wk: 20 1 y: 02 [difference between medians] Disability: G2 vs. G1: 9 wk: 24 1 y: −06 G3 vs. G1: 9 wk: 36 1 y: 16 [difference between medians]
Gudavalli/Cambron [31,32]	2005/2006	G1: MOB (flexion-distraction), US, cold (123) G2: exercise, US, cold (112)	12 12	Pain improvement G2 vs. G1: 1 mo: 8* 3 mo: 4 6 mo 9* 12 mo 5 Disability improvement G2 vs. G1: 1 mo: 2 3 mo: −1 6 mo 2 12 mo 1
Haas [33]	2004	Factorial design: 4 visit × 2 intervention. G1: 1 visit/wk & SMT or SMT + PM (18) G2: 2 visit/wk & SMT or SMT + PM (18) G3: 3 visit/wk & SMT or SMT + PM (18) G4: 4 visit/wk & SMT or SMT + PM (18)	3 6 9 12	Pain Adjusted effect of 1 visit/wk increment: 4 wk: 06* 12 wk: 06* [wk/PM] 00 [wk/o PM] Disability Adjusted effect of 1 visit/wk increment: 4 wk: 05* 12 wk: 0
Koes [34,35]	1992	G1: SMT/MOB-PT (36) G2: Massage, ex, heat, PT (36) G3: MD: Analgesic/anti-inflam, rest, ex, posture (32) G4: Detuned PT modalities (40)	14 6 — ?	Main complaint improvement: G2 vs. G1: 6 wk: 04 12 wk: 05 12 mo: 13* G3 vs. G1: 6 wk: 14* 12 wk: −03 G4 vs. G1: 6 wk: 14* 12 wk: 07 Physical function improvement: G2 vs. G1: 6 wk: 05 12 wk: 09 12 mo: 07 G3 vs. G1: 6 wk: 10 12 wk: −01 G4 vs. G1: 6 wk: 16* 12 wk: 10
Postacchini [41]	1988	G1: SMT-DC? (87) G2: Drugs (81) G3: Massage + diatherm (78) G4: Bed rest (29) G5: Back school (50) G6: Placebo ointment (72)	11–17 10–15	Global improvement (pain, disability, finger-floor distance, and SLR): G2 vs. G1: 3 wk: −03 2 mo: −04 6 mo: 00 G3 vs. G1: 3 wk: −06 2 mo: −06 6 mo: −07 G5 vs. G1 3 wk: 07 2 mo: −03 6 mo: −13 G6 vs. G1: 3 wk: 3 wk: 09 2 mo: 08 6 mo: 12 [Statistical significance for most contrasts is indeterminate]
Rasmussen-Barr [36]	2003	G1: MOB-PT (23) G2: Stabilizing exercises (24)	6 6	Pain improvement: G2 vs. G1: 6w: −05 3 mo: −09 12 mo: −06 [difference between median improvement] Disability improvement G2 vs. G1: 6 wk: −7 3 mo: −1 12 mo: −6 [difference between median improvement]
Ritvanen [37]	2007	G1: MOB-bonesetter (35) G2: massage & exercise (35)	5 5	Pain G2 vs. G1: 5 wk 05 Disability G2 vs. G1: 5 wk 05

(*continued*)

Table 5 (*continued*)

First author	Year	Study groups (n)	# tx	Results: Between-group differences in percentage points unless otherwise specified. Positive score indicates advantage for Group 1 (G1)
Timm [38]	1994	G1: MOB-PT (50)	24	Disability:
		G2: Hot packs, TENS, u-sound (50)	24	G2 vs. G1: 8 wk: 05
		G3: Low-tech exercise (50)	24	G3 vs. G1: 8 wk: −18*
		G4: High-tech exercise (50)	24	G4 vs. G1: 8 wk: −17*
		G5: No treatment control (50)	24	G5 vs. G1: 8 wk: 05
Waagen [39]	1986	G1: SMT-DC (11)	m = 5	Pain:
		G2: Sham SMT-DC (18)	m = 4	G2 vs. G1: After 1st tx: 06 2 wk: 17 [statistical significance is indeterminate]

MD=medical doctor; DO=osteopathic doctor; PT=physiotherapist; DC=chiropractor; MT=manual therapist; d=day; wk=week; mo=month; y=year; G1=Group 1; G2=Group 2; G3=Group 3; tx=treatment; SMT=spinal manipulative therapy; MOB=spinal mobilization; ex=exercise; ed=education; cold=cryotherapy; US=ultrasound; PM=physical modalities; ?=information not available; m=mean; NSAID=nonsteroidal anti-inflammatory drug.

*$p < .05$ for unadjusted pair-wise comparisons.

Ernst review is severely limited in its approach because of an incomplete quality assessment, lack of prespecified rules to evaluate the evidence, and several erroneous assumptions [44]. Ernst goes further to conclude that bias exists in systematic reviews performed by chiropractors, particularly members of our group. We refuted this assertion [44], and have attempted to be as transparent as possible in our methodology, which details a priori defined standard and acceptable methods for conducting systematic reviews [45,46]. Table 7 summarizes the conclusions from the latest systematic reviews. The conclusion of this review, which includes the results of the latest published RCTs, is consistent with the latest high-quality evidence-based systematic reviews [47,48].

Clinicians should exercise caution when generalizing the findings of systematic reviews to clinical practice. Disparate patient populations are likely to be included in reviews and potentially important distinguishing characteristics, such as condition severity, are not always carefully defined. In addition, diverse SMT/MOB therapeutic approaches are applied by providers with different backgrounds and training, which may affect outcomes.

Chronic low back pain

The literature provides moderate evidence for several conclusions regarding SMT and MOB for CLBP (Table 8). In terms of patient-rated pain, SMT with strengthening exercise is similar in effect to prescription nonsteroidal anti-inflammatory drugs with exercise in both the short term and long term [26]. There is also moderate evidence that SMT/MOB is superior to usual medical care and placebo for patient improvement [34,35]. High-dose SMT is superior to low-dose SMT for pain in the very short term and similar in the short term [33]. Flexion-distraction MOB

Table 6
Definition of levels of evidence

Level of evidence of efficacy or inefficacy		Requirements: Number of RCTs with validity score: ≥50	Requirements: Number of RCTs with validity score: 20–49	Requirements: Statistically significant results
A. Strong	1.	≥2	—	Yes*
	2.	≥2	—	No†
B. Moderate	1.	1	—	Yes*
	2.	1	—	No†
C. Limited	1.	—	≥1	Yes*
	2.	—	≥1	No†
	3.	1	—	No‡
	4.	—	≥2	No‡
D. Inconclusive/conflicting	1.	Minimal standards for classification as limited evidence were not met.		
	2.	Preponderance of evidence was conflicting, in terms of number and quality of eligible RCTs.		

RCT = randomized controlled trial.

* For efficacy: superior in effect to placebo, no treatment, established efficacious treatment, or commonly used therapies. For inefficacy: inferior in effect to established efficacious treatment, commonly used therapy, placebo, or no treatment.

† Studies must be adequately powered. For efficacy: similar in effect to established efficacious treatment. For inefficacy: similar in effect to placebo or no treatment. For similarity: similar in effect to therapy not established as efficacious.

‡ For efficacy: superior in effect to placebo, no treatment, efficacious treatment, or commonly used therapies. For inefficacy: inferior in effect to established efficacious treatment, commonly used therapy, placebo, or no treatment.

Table 7
Summary conclusions for systematic reviews of spinal manipulation for low back pain based on all available RCTs at the time of review

Systematic reviews (first author and year [reference])	Chronic
van Tulder, 1997 [94]	+
Bronfort, 2004 [3]	+
Ferreira, 2002 [95]	?
Assendelft, 2004 [47]	+
Ernst, 2006 [43]	−
van Tulder, 2006 [48]	+

+=Conclusions and recommendations in favor of spinal manipulation efficacy, −=conclusions and recommendations not supporting spinal manipulation efficacy; ?=inconclusive evidence of spinal manipulation efficacy.

is superior to a combined exercise program for pain in the short term and superior/similar in the long term [31,32]. Flexion-distraction MOB also has a similar effect on disability as a combined exercise program [31,32] There is limited evidence in the short term for the following in pain/disability reduction: SMT is superior to chemonucleolysis, medication, and acupuncture; and MOB is inferior to exercise for disc herniation [27–30,38]. The evidence is inconclusive as to whether SMT is superior to sham SMT for pain in the short term [39] and whether MOB is similar in effect to exercise for pain in both the short term and long term [36,37].

Mixed duration predominantly CLBP

Nine trials addressed mixed populations that had predominantly CLBP. Eight met the criteria for admissibility, six of which dealt exclusively with SMT, one dealt with MOB, and one with SMT/MOB [8,9,11,12,49–54]. One trial was excluded [55] (Table 9). The methodological quality scores for the mixed trials considered for evidence ranged from 31 to 63, and three of the studies were of moderate to high quality (score >50).

The literature provides moderate to strong evidence regarding the efficacy of SMT for mixed (but predominantly chronic) LBP (Table 10). In terms of short- and long-term patient-rated pain and disability, there is strong evidence that SMT is similar in effect to a combination of medical care with exercise or exercise instruction [12,56] There is also moderate evidence that SMT is superior to usual medical care alone [12] and that SMT is similar to physical therapy [57], both in the short term and long term. There is moderate evidence that SMT/MOB is superior to physical therapy and to home exercise in the long term [51,52].

There is limited evidence of short- and long-term superiority of SMT to hospital outpatient care for pain and disability [8,9], and short-term superiority of SMT to sham SMT [54]. There is also limited evidence of short-term superiority of SMT/MOB to physical therapy, home back exercise, traction/exercise/corset, no treatment, and placebo diathermy [49,51,52]. A sensitivity analysis was conducted to evaluate the effect of changing the quality scores required for each level of evidence in Table 2. We assessed the effect of changing the threshold for high- and low-quality studies ±10 points in the 100-point quality scale. Overall, sensitivity analysis showed that changing the rules of evidence would have produced little impact on the main conclusion of our review.

Table 8
Evidence of efficacy for chronic low back pain

			Short term		Long term	
SMT and/or MOB	Comparison intervention	Primary outcome(s)	Direction of effect*	Evidence level	Direction of effect*	Evidence level
SMT (with strengthening exercise)	Prescription NSAID (with strengthening exercise) [26]	Pain	Similar	Moderate	Similar	Moderate
SMT/MOB	Placebo [34,35] GP management [34,35]	Improvement	Superior	Moderate	Inconclusive	Inconclusive
SMT high dose	SMT low dose [33]	Pain	Superior/similar	Moderate	No evidence	No evidence
Flexion-distraction MOB	Exercise (strength, stretching, and cardiovascular) [31,32]	Pain	Superior	Moderate	Superior/similar	Moderate
Flexion-distraction MOB	Exercise (strength, stretching, and cardiovascular) [31,32]	Disability	Similar	Moderate	Similar	Moderate
SMT	Chemonucleolysis for confirmed disc herniation [27]	Pain Disability	Superior	Limited	No evidence	No evidence
SMT	Medication [28] Acupuncture [28]	Pain	Superior	Limited	Similar	Inconclusive
MOB	High- and low-Tech back exerciseafter disc herniation surgery [38]	Disability	Inferior	Limited	No evidence	No evidence
SMT	Sham SMT [39]	Pain	Superior	Inconclusive	No evidence	No evidence
MOB	Exercise [36,37]	Pain	Similar	Inconclusive	Similar	Inconclusive

SMT=spinal manipulative therapy; MOB=spinal mobilization; NSAID=nonsteroidal anti-inflammatory drug.
* Effect of SMT and/or MOB in relationship to comparison intervention.

Table 9
Randomized trials of spinal manipulation and mobilization for a mixed duration predominantly chronic low back pain (>50%)

First author	Year	Study groups (n)	# tx	Results:Between-group differences in percentage points unless otherwise specified. Positive score indicates advantage for Group 1 (G1)
Coxhead [49]	1981	Factorial design: All combinations of: 1. SMT-PT, back school, diathermy 2. Traction, back school, diathermy 3. Exercise, back school, diathermy 4. Corset, back school, diathermy	5–10	Pain: Main effect of SMT vs. no SMT: 4 wk: 10* Improvement (difference in % patients rating themselves better): Main effect of SMT vs. no SMT: 4 wk: 9 4 mo: 5
Gibson [50]	1985	G1: SMT/MOB-DO (41) G2: Diathermy active (34) G3: Detuned diathermy (34)	4 12 12	Pain (reported here as pain improvement): G2 vs. G1: 2 wk: 00 4 wk: −03 12 wk: 02 [between-group statistics not possible] G3 vs. G1: 2 wk: −10 4 wk: −07 12 wk: −20 [severity at baseline not comparable]
Hemmila [51,52]	1997, 2002	G1: MOB-bonesetter (45) G2: PT (35) G3: Exercise (34)	m=8 m=10 m=5	Disability improvement: G2 vs. G1: 6 wk: 10 3 mo: 02 6 mo: 10* 1 y: 08 G3 vs. G1: 6 wk: 10 3 mo: 04 6 mo: 12* 1 y: 12*
Herzog [55]	1991	G1: SMT-DC (19) G2: Back education & exercise (18)	10 10	Pain improvement: G2 vs. G1: 4 wk: −08 Disability improvement G2 vs. G1: 4 wk: 00
Hurwitz [53]	2002	G1: SMT-DC & ex instruction (169) G2: Care-MD including ex instr (170) [2 other groups identical to G1 and G2 but with PT modalities]	1–21 m=6 1–23 m=4	Pain: G2 vs. G1: 2 wk: 00 6 wk: 02 6 mo: 02 Disability: G2 vs. G1: 2 wk: 01 6 wk: 02 6 mo: 03
Meade [8,9]	1990, 1995	G1: SMT-DC (384) G2: PT, SMT-PT (357)	9 6	Pain improvement: G2 vs. G1: 6 wk: 03* 6 mo: 04* 1 y: 02 2 y: 04* 3 y: 03* Disability improvement: G2 vs. G1: 6 wk: 02 6 mo: 03* 1 y: 02 2 y: 03* 3 y: 03*
Skargren [11]	1997	G1: SMT-DC (138) G2: Physiotherapy (115)	m=7 m=8	Pain improvement: G2 vs. G1: After tx: 04 6 mo: 00 1 y: 00 Disability improvement: G2 vs. G1: After tx: 03 6 mo: 01 1 y: 00
Triano [54]	1995	G1: SMT-DC (70) G2: Sham SMT-DC (70) G3: Back Education (69)	12 12 12	Pain: G2 vs. G1: 2 wk: 06 4 wk: 08 G3 vs. G1: 2 wk: 06 4 wk: 02 Disability: G2 vs. G1: 2 wk: 12* 4 wk: 07 G3 vs. G1: 2 wk: 06 4 wk: 02
UK Beam [12]	2004	G1: GP & SMT-DC, DO, PT (353) G2 GP (338) G3 GP & Exercise (310) G4 GP & SMT-DC, DO, PT & ex (333)	≤8 ≤8 ≤8 ?	Pain: G2 vs. G1: 3 mo: 09* 12 mo: 06* G3 vs. G1: 3 mo: 04 12 mo: 00 Disability: G2 vs. G1: 3 mo: 07* 12 mo: 04* G3 vs. G1: 3 mo: 02 12 mo: 02

Key: MD=medical doctor; DO=osteopathic doctor; PT=physiotherapist; DC=chiropractor; MT=manual therapist; d=day; wk=week; mo=month; y=year; G1=Group 1; G2=Group 2; G3=Group 3; tx=treatment; SMT=spinal manipulative therapy; MOB=spinal mobilization; ex=exercise; ed=education; GP=general practice; ?=information not available; m=mean.

*$p < .05$ for unadjusted pair-wise comparisons.

Limitations

Optimally, reviews should include all trials regardless of language [58]. Because of the languages spoken by the authors, this review was restricted to English, Scandinavian, and Dutch languages. Although an attempt was made to identify trials in other languages, this approach was not fully systematic and may have overlooked some relevant trials. However, none of the over 50 reviews previously reviewed by Assendelft et al. [59] included RCTs that were published in languages other than those addressed in this review. Another possible limitation of the current review is publication bias [60]. No exhaustive effort was made to identify unpublished research, which is more likely to have negative outcomes [61–63]. It is recognized that attempts to retrieve unpublished data from trials are also likely to be biased [62].

Ongoing studies

At least three full-scale RCTs assessing the role of SMT in the management of CLBP are in progress at the time of this review: one compares trunk exercise to SMT, one assesses the effectiveness of SMT in the elderly, and one evaluates pretreatment prediction rules for positive outcomes.

Harms

SMT can be associated with relatively benign temporary side effects including mild localized soreness or pain, which typically does not interfere with activities of daily living [64]. A large, prospective observational study of

Table 10
Evidence of efficacy for mixed duration predominantly chronic low back pain

SMT and/or MOB	Comparison intervention	Primary outcome(s)	Short term		Long term	
			Direction of effect*	Evidence level	Direction of effect*	Evidence level
SMT (with instruction in exercise)	Medical care with exercise or instruction in exercise [12,53]	Pain Disability	Similar	Strong	Similar	Strong
SMT	General practice MD [12]	Pain Disability	Superior	Moderate	Superior	Moderate
SMT (as main part of chiropractic management)	Management by physical therapists [57]	Pain Disability	Similar	Moderate	Similar	Moderate
SMT (Lay Bonesetters)	Physical therapy or home back exercise [52]	Disability	Superior	Limited	Superior	Moderate
SMT (as main part of chiropractic management)	Hospital outpatient management including SMT [8]	Small advantage in disability and pain	Superior	Limited	Superior	Limited
SMT	Sham SMT [54]	Disability	Superior	Limited	No evidence	No evidence
SMT/MOB	Placebo diathermy [49] No treatment [49] Traction, exercise, and corset [49]	Pain	Superior	Limited	No evidence	No evidence

SMT=spinal manipulative therapy; MOB=spinal mobilization.
* Effect of SMT and/or MOB in relationship to comparison intervention.

1,058 patients who received 4,712 sessions of SMT from 102 DCs in Norway reported the following common adverse events (AEs): local discomfort (53%), headache (12%), tiredness (11%), radiating discomfort (10%), and dizziness (5%) [65]. Most of these AEs occurred within 4 hours of SMT (64%), were of mild-to-moderate severity (85%), and disappeared the same day (74%) [65]. It should be noted that this study included AEs from SMT applied to the cervical, thoracic, or lumbar areas, and was not restricted to CLBP.

Rare AEs that have been reported following SMT in the lumbar region include lumbar disc herniation (LDH) and cauda equina syndrome (CES) [64]. Because of the low incidence of severe AEs, the risk attributable to SMT cannot be evaluated in RCTs. A systematic review on the safety of SMT for LBP uncovered four studies, which reported the following estimates of risk: 1 CES per 128 million SMT, 1 CES per 100 million SMT, <1 CES or LDH per 1 million SMT, 1 LDH per 8 million SMT, and 1 CES per 4 million SMT [66]. It should be noted that some of the cases of CES or LDH included in the above estimates of risk occurred during manipulation under anesthesia, which has been associated with a greater risk of disc injury than SMT. On the basis of the above estimates and other reports of AEs, the review authors estimated the risk of LDH or CES following SMT at 1 event per 3.72 million SMT [66].

Discrepancies in the estimates of risk reported in the four studies discussed above are likely attributable to heterogeneous methodology and retrospective data sources, in addition to the imprecise nature of combining data from case reports and legal malpractice claims to estimate the numerator with utilization data to estimate the denominator. Although underreporting of rare AEs associated with SMT may lead to underestimating the true risk, other reports have wrongly attributed AEs to SMT [67]. Thus, the existing estimates are associated with substantial uncertainty and will only improve when more data become available from well-designed prospective studies [68].

As with all forms of conservative interventions for CLBP, the likelihood of obtaining positive outcomes with SMT is decreased in patients who have severe comorbidities or psychosocial factors associated with poor recovery. Instruments such as the yellow flags questionnaire have defined several factors to identify patients with LBP who are at higher risk of developing chronicity and a worsened prognosis [69]. These factors are not specific to SMT and include beliefs about appropriateness of working with current pain levels, perceived chance of recovery in 6 months, light work, stress, and previous number of sick days [69]. Low patient expectations and low satisfaction with the care received have also been associated with poor outcomes for SMT and LBP, suggesting that patients who do not expect to improve with SMT and respond poorly to an initial trial of care may fare better with other interventions [70,71]. Other factors associated with poor outcomes for SMT and LBP include pain radiating below the knee, baseline levels of pain or disability, income, and smoking [72,73].

Summary

For CLBP, there is moderate evidence that SMT with strengthening exercise is similar in effect to prescription nonsteroidal anti-inflammatory drugs with exercise in both the short term and long term. There is also moderate evidence that flexion-distraction MOB is superior to exercise in the

short term and superior/similar in the long term. There is moderate evidence that a regimen of high-dose SMT is superior to low-dose SMT in the very short term. There is limited to moderate evidence that SMT is better than physical therapy and home exercise in both the short and long term. There is also limited evidence that SMT is as good or better than chemonucleolysis for disc herniation in the short and long term. There is limited evidence that MOB is inferior to back exercise after disc herniation surgery.

For mixed (but predominantly chronic) LBP, there is strong evidence that SMT is similar in effect to a combination of medical care with exercise instruction. There is moderate evidence that SMT is superior to general practice medical care and similar to physical therapy in both the short and long term. There is limited evidence of short- and long-term superiority of SMT over hospital outpatient care for pain and disability. There is also limited evidence of short-term superiority of SMT over medication and acupuncture.

This review included an additional six trials since the previous review. The overall quality of additional studies was moderate to high, and their inclusion strengthened the existing evidence regarding the efficacy of SMT/MOB for CLBP. The preponderance of the evidence for efficacy, including recent high-quality trials, and the estimated very low risk of serious AEs support SMT and MOB as viable options for the treatment of CLBP. SMT and MOB are at least as effective as other efficacious and commonly used interventions.

Future trials should examine well-defined subgroups of LBP patients according to validated and reliable diagnostic classification criteria, establish the optimal number of treatment visits, and evaluate the cost effectiveness of care using appropriate methodology.

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