

Review Article

NASS Contemporary Concepts in Spine Care: Spinal manipulation therapy for acute low back pain

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Abstract

BACKGROUND CONTEXT: Low back pain (LBP) continues to be a very prevalent, disabling, and costly spinal disorder. Numerous interventions are routinely used for symptoms of acute LBP. One of the most common approaches is spinal manipulation therapy (SMT).

PURPOSE: To assess the current scientific literature related to SMT for acute LBP.

PATIENT SAMPLE: Not applicable.

OUTCOME MEASURES: Not applicable.

DESIGN: Systematic review (SR).

METHODS: Literature was identified by searching MEDLINE using indexed and free text terms. Studies were included if they were randomized controlled trials (RCTs) published in English, and SMT was administered to a group of patients with LBP of less than 3 months. RCTs included in two previous SRs were also screened, as were reference lists of included studies. Combined search results were screened for relevance by two reviewers. Data related to methods, risk of bias, harms, and results were abstracted independently by two reviewers.

RESULTS: The MEDLINE search returned 699 studies, of which six were included; an additional eight studies were identified from two previous SRs. There were 2,027 participants in the 14 included RCTs, which combined SMT with education (n=5), mobilization (MOB) (n=4), exercise (n=3), modalities (n=3), or medication (n=2). The groups that received SMT were most commonly compared with those receiving physical modalities (n=7), education (n=6), medication (n=5), exercise (n=5), MOB (n=3), or sham SMT (n=2). The most common providers of SMT were chiropractors (n=5) and physical therapists (n=5). Most studies (n=6) administered 5 to 10 sessions of SMT over 2 to 4 weeks for acute LBP. Outcomes measured included pain (n=10), function (n=10), health-care utilization (n=6), and global effect (n=5). Studies had a follow-up of less than 1 month (n=7), 3 months (n=1), 6 months (n=3), 1 year (n=2), or 2 years

For the Contemporary Concepts on Manipulation, Mobilization, and Massage Task Force of the North American Spine Society.

This Contemporary Concepts in Spine Care review is part of a series of referenced reviews of contemporary issues in spine care produced by the North American Spine Society (NASS). Each review represents the current state of knowledge on a particular topic. Before entering the review process for *The Spine Journal*, the authors were assisted by members of the NASS Committee on Contemporary Concepts: Daniel Brodke, MD, Chair; Christopher Bono, MD; Robert Dawe, MD; and Mitchell B. Harris, MD.

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($n=1$). When compared with various control groups, results for improvement in pain in the SMT groups were superior in three RCTs and equivalent in three RCTs in the short term, equivalent in four RCTs in the intermediate term, and equivalent in two RCTs in the long term. For improvement in function, results from the SMT groups were superior in one RCT and equivalent in four RCTs in the short term, superior in one RCT and equivalent in one RCT in the intermediate term, and equivalent in one RCT and inferior in one RCT in the long term. No harms related to SMT were reported in these RCTs.

CONCLUSIONS: Several RCTs have been conducted to assess the efficacy of SMT for acute LBP using various methods. Results from most studies suggest that 5 to 10 sessions of SMT administered over 2 to 4 weeks achieve equivalent or superior improvement in pain and function when compared with other commonly used interventions, such as physical modalities, medication, education, or exercise, for short, intermediate, and long-term follow-up. Spine care clinicians should discuss the role of SMT as a treatment option for patients with acute LBP who do not find adequate symptomatic relief with self-care and education alone. © 2010 Elsevier Inc. All rights reserved.

Keywords: Spinal manipulation; Low back pain; Systematic review

Introduction

Low back pain (LBP) is a common and often disabling condition. The cumulative 1-year incidence of LBP is approximately 20% [1,2], with most initial episodes being mild [2]. The reported prevalence of LBP varies greatly. The point prevalence ranges from 6% to 33% [3,4] and the 1-year prevalence from 22% to 65% [4]. The lifetime prevalence of LBP is even more variable, likely because of differences in the definitions of LBP used, the populations studied, and the study methodology [5]. There has been a recent effort to promote a common definition of LBP that will allow comparisons to be made between studies [6].

Low back pain is commonly classified as acute (<3 months) or chronic (>3 months) based on its duration [7]. These temporal definitions appear to be based on studies that showed that almost all persons with LBP returned to work within 90 days [8,9]. Although acute LBP does tend to improve with time and generally has a good prognosis, improvement in pain and disability does not correlate well with return-to-work rates [10]. Furthermore, recent studies have shown that a significant proportion of acute LBP sufferers will develop recurrent or chronic LBP. A survey of persons 35 to 45 years old found that LBP resolved quickly in only 27% of subjects, whereas 40% developed persistent LBP [5]. Even among those whose LBP had initially resolved, 29% had recurrent (usually mild) LBP within 6 months [5]. Other studies have found similar trends for recurrence of LBP [2,11]. Although it is difficult to predict who among those with first episodes of LBP will develop recurrent or chronic symptoms, factors related to the determinants of disability and to the prediction of chronic disability appear by 14 days after the onset of pain, supporting that as a cutoff point in the transition from acute to subacute pain [12]. Psychological factors appear to play an important role in that transition and related disability [13].

Low back pain is a significant societal burden. Persons seeking care for LBP constitute a substantial proportion

of patients seen in primary care offices. Direct and indirect costs for LBP have been reported in studies from many countries, but differences in methodology make it difficult to compare the results. A recent review suggested that, although the total yearly cost of LBP (direct and indirect costs) in the United States has been reported to be between \$19.6 and \$118.8 billion per year, the true cost may be much higher [14].

Much can be learned from a brief but thorough history and examination of patients with LBP. Clinical practice guidelines from the United States and various European groups suggest that, in the absence of any “red flags” for serious spinal pathology, advanced diagnostic studies are not needed in the initial evaluation of acute LBP [15,16]. Red flags for LBP are symptoms, findings, or other characteristics that may be indicative of rare but potentially serious spinal pathology, such as spinal tumor, infection, fracture, or cord compromise [17]. Examples of red flags include unexplained weight loss, loss of bowel or bladder function, saddle anesthesia, widespread neurologic symptoms in the lower extremities, recent trauma with osteoporosis or prolonged corticosteroid use, immune suppression, and systemic unwellness [17]. Such an evaluation should be based on the symptoms of the patient and the diagnostic concerns of the physician but may include X-ray; advanced imaging (bone scan, computed tomography, or magnetic resonance imaging); laboratory studies; or electrophysiological studies.

In most cases of acute LBP, an objective cause cannot be found. Such cases are, therefore, described as “nonspecific.” Despite this lack of knowledge regarding the etiology of LBP, there are many interventions available, and many providers who are willing to use them [18]. The provider’s training often biases the choice of treatment for acute LBP. Common primary care approaches include education, reassurance, return to activities, nonsteroidal anti-inflammatory drugs (NSAIDs), and simple analgesics.

Patients with acute LBP who do not improve quickly often seek additional care from both surgical and nonsurgical specialists. One of the most common treatments used in North America and Europe is spinal manipulation therapy (SMT) [19]. Practitioners have used some form of SMT to treat LBP for thousands of years [20].

In North America, SMT is usually provided by Doctors of Chiropractic (DCs) [21]. However, in other countries, particularly in Europe and Australia, it is commonly used by physical therapists (PTs), Doctors of Osteopathy (DOs), and medical doctors (MDs) trained in manual therapy. How SMT works is not completely understood, but there is growing evidence that its effects result from a combination of mechanical, neurological, and biochemical changes in various structures [19]. Like many therapies administered for acute LBP, SMT has a diminishing effect size as the duration of follow-up increases. As a result, its clinical efficacy for acute LBP is still debated despite many randomized controlled trials (RCTs), systematic reviews (SRs), and meta-analyses.

The North American Spine Society (NASS) Contemporary Concepts are a series of evidence-based reviews of contemporary issues in spine care, intended to provide spine clinicians with a general understanding about current practices. Because of the uncertainty of the role of SMT in the care of acute LBP within the community of spine care providers at large, a Complementary Medicine Task Force composed of NASS members (primarily members of the former NASS Complementary Medicine Committee, see Acknowledgments) was appointed to develop a Contemporary Concepts article on SMT for acute LBP.

Methods

Eligibility criteria

The eligibility criteria were based on the Population, Intervention, Control, Outcomes, Study design (PICOS) principle [22] as follows:

Population: adults with acute LBP (ie, pain lasting <12 weeks);

Intervention: SMT or mobilization (MOB);

Control: any control group that did not receive SMT or MOB or allowed for evaluation of the comparative efficacy of different forms of SMT or MOB;

Outcomes: patient-reported pain reduction and functional improvement (primary outcomes), as well as global effect, health-care utilization, and harms (secondary outcomes);

Study design: limited to RCTs

Only RCTs published in English were eligible for inclusion. RCTs were excluded if most of the participants had symptoms for more than 12 weeks, the study design did not permit isolating the effects of SMT (or MOB), SMT

was nonforce, participants had multiple indications and only combined results were reported, studies had fewer than 20 participants enrolled in each study group, or follow-up was less than 1 week after the last intervention.

Information sources

Randomized controlled trials were identified through an electronic search of MEDLINE (OVID Interface) on January 13, 2009, and screening the reference lists of two previous SRs on this topic [23,24].

Search

MEDLINE was searched using strategies that were validated by the Cochrane Back Review Group (CBRG) to identify RCTs (part A of the search strategy) related to spinal disorders (parts B and D), which were combined with search terms related to SMT (Table 1) [25]. The following limits were applied to the search results in OVID: 1) articles published in English; 2) related to adult participants; 3) published from 1999 to 2009; and 4) abstracts available for screening.

Study selection

Two reviewers independently screened the search results using predefined inclusion and exclusion criteria. Reviewers discussed disagreements until consensus was reached. Full-text articles were retrieved for all citations deemed relevant or of uncertain relevance to confirm their eligibility. Reasons for excluding the retrieved full-text articles were noted.

Data collection process

One reviewer used a predefined data extraction instrument to extract the data from the included RCTs. Another reviewer subsequently verified the data to ensure accuracy.

Data items

The main categories of data abstracted for included studies were methods, pain outcome results, functional outcome results, other outcome results (eg, global effect, health-care utilization), and harms. For methods, the following items were abstracted: 1) study setting and population; 2) inclusion criteria; 3) exclusion criteria; 4) description of intervention(s), provider, and regimen (eg, frequency, duration) received by experimental group; 5) description of intervention(s), provider, and regimen (eg, frequency, duration) received by control group(s); 6) number of participants enrolled in experimental group; 7) number of participants enrolled in control group(s); 8) outcome measures and follow-up points. For pain, functional, and other outcome results, the following data were abstracted: 1) group means at baseline and each follow-up point and 2) statistical significance of intra- and intergroup differences

Table 1
MEDLINE search strategy

Part	Number	Search term	Results
A	1	randomized controlled trial.pt.	163,624
	2	controlled clinical trial.pt.	32,285
	3	Randomized Controlled Trials/	48,410
	4	Random Allocation/	27,394
	5	Double-Blind Method/	53,405
	6	Single-Blind Method/	9,686
	7	or/1–6	273,874
	8	Animals/not Human/	1,171,954
	9	7 not 8	250,879
	10	clinical trial.pt.	244,454
	11	exp Clinical Trials/	0
	12	(clin\$ adj25 trial\$.tw.	108,022
	13	((singl\$ or doubl\$ or trebl\$ or tripl\$) adj25 (blind\$ or mask\$)).tw.	52,771
	14	Placebos/	9,323
	15	placebo\$.tw.	66,502
	16	random\$.tw.	292,640
	17	Research Design/	32,314
	18	(Latin adj square).tw.	1,321
	19	or/10–18	547,776
	20	19 not 18	546,455
	21	20 not 9	333,876
	22	Comparative Study/	678,390
	23	exp Evaluation Studies/	108,482
	24	Follow-up Studies/	202,953
	25	Prospective Studies/	171,107
	26	(control\$ or prospective\$ or Volunteer\$.tw.	1,172,285
	27	Cross-Over Studies/	20,599
	28	or/22–27	1,880,043
	29	28 not 8	1,494,884
	30	29 not (9 or 21)	1,183,155
	31	9 or 21 or 30	1,767,910
B	32	dorsalgia.ti.ab.	17
	33	exp Back Pain/	11,382
	34	backache.ti.ab.	517
	35	(lumbar adj pain).ti.ab.	446
	36	coccyx.ti.ab.	149
	37	coccydynia.ti.ab.	20
	38	sciatica.ti.ab.	955
	39	sciatica/	1,040
	40	spondylosis.ti.ab.	679
	41	lumbago.ti.ab.	294
	42	or/32–41	13,847
D	43	exp Spine/	37,943
	44	discitis.ti.ab.	269
	45	exp Spinal Diseases/	27,250
	46	(disc adj degeneration).ti.ab.	925
	47	(disc adj prolapse).ti.ab.	150
	48	(disc adj herniation).ti.ab.	1,493
	49	spinal fusion.sh.	6,642
	50	spinal neoplasms.sh.	3,454
	51	(facet adj joints).ti.ab.	473
	52	intervertebral disk.sh.	3,270
	53	postlaminectomy.ti.ab.	79
	54	arachnoiditis.ti.ab.	245
	55	(failed adj back).ti.ab.	213
	56	or/43–55	52,714
	57	42 or 56	61,286
	58	31 and 57	22,643

(continued)

Table 1 (continued)

Part	Number	Search term	Results
SMT	59	chiropract\$.mp.	1,994
	60	manipulati\$.mp.	35,194
	61	mobili?ation.mp.	18,238
	62	manual therap?.mp.	353
	63	exp manipulations,musculoskeletal/	14,613
	64	or/59–63	66,144
	65	58 and 64	1,284
	66	limit 65 to English language	1,183
	67	limit 66 to yr= "1999–2009"	1,001
68	limit 67 to abstracts	930	
69	limit 68 to "all adult (19 plus years)"	699	

SMT, spinal manipulation therapy.

at baseline and each follow-up point. For harms, the following data were abstracted: 1) type of adverse event, 2) number of adverse events occurring in the intervention group, and 3) number of adverse events occurring in the control group(s).

Risk of bias

To assess the possibility of bias in the results of the included RCTs, methodological quality was assessed according to a tool developed by the CBRG [7]. The tool includes 12 criteria that assess different aspects of bias, and each must be scored as yes/no/unsure; RCTs scoring 6 or higher and without serious flaws were deemed to be of higher methodological quality [7]. Two reviewers assessed the risk of bias in the included studies independently. Conflicts between reviewers were discussed until consensus was achieved. The clinical relevance of RCTs was also assessed descriptively according to whether the study protocols reflected common clinical practice for the application of SMT for acute LBP.

Synthesis of results

Results related to pain, function, global effect, health-care utilization, and other outcomes were synthesized separately according to whether the experimental group that received SMT (or MOB) was superior, equal, or inferior to the control group, as determined by between-group statistical significance ($p < .05$) reported in the studies at each follow-up point. Results were summarized by duration of follow-up, with less than 4 weeks considered short term, 1 to 6 months considered intermediate term, and more than 6 months considered long term. Pain and functional outcomes were converted to a 0 to 100 scale, and percent improvement from baseline was calculated for each follow-up point. If multiple studies reported results for pain or function at similar follow-up points within each category of duration (eg, 1–2, 3–4 weeks), the mean and standard deviation (SD) for improvement from baseline were calculated for the experimental groups and control groups. If

a study reported results for multiple, similar follow-ups (eg, 1 and 2 weeks), only results for the longest duration within that timeframe were included in the synthesis. If studies reported multiple outcome measures for pain (eg, visual analog scale [VAS] and McGill Pain Questionnaire) or function (eg, Roland-Morris Disability Questionnaire [RMDQ] and Oswestry Disability Index [ODI]), results from all outcome measures reported were included in the synthesis. Results for outcomes other than pain or function were synthesized descriptively.

Risk of bias across studies

The risk of bias across studies was assessed using the outcome-reporting bias item of the CBRG tool.

Results

Search

The MEDLINE search resulted in 699 citations, of which eight were deemed potentially relevant [26–33], and 11 were of uncertain relevance [34–44]. After screening full-text articles for those 19 studies, only six were deemed eligible [26,28,29,31–33]. Reasons for excluding full-text articles included duplicate reports (n=8) [34–38,40–42], less than 20 participants per study group (n=1) [27], not being able to distinguish separate effects of multimodal intervention (n=1) [30], mixed neck and back pain (n=1) [44], no patient-reported outcomes (n=1) [39], and no acute LBP (n=1) [43] (Figure). An additional eight eligible studies [45–52] were identified from two previous SRs on similar topics [23,53]. A total of 14 studies were, therefore, included in this review [26,28,29,31–33,45–52]; only one study was published in a journal not indexed in MEDLINE [52]. These studies were published between 1974 and 2006, including one in the 1970s [47], five in the 1980s [46,48,49,51,52], three in the 1990s [26,45,50], and five in the 2000s [28,29,31–33]. These studies originated in five countries, including Australia [29,46], Canada [48], Italy [33,52], United Kingdom [32,47,50,51], and the United States [26,28,31,45,49]. Study participants were recruited from primary care settings (n=6), outpatient medical centers (n=3), PT centers (n=2), employees of a company (n=1), or unclear settings (n=2). The full study descriptions can be found in Table 2.

Indication

Acute LBP was defined using both a minimum duration (n=4), ranging from 1 to 4 weeks, and a maximum duration (n=5), ranging from 3 weeks to 6 months. All studies enrolled participants with less than 12 weeks of symptoms, consistent with parameters set by the CBRG [7]. Only one study specified that participants were required to have LBP amenable to SMT to enroll [48]. The number of

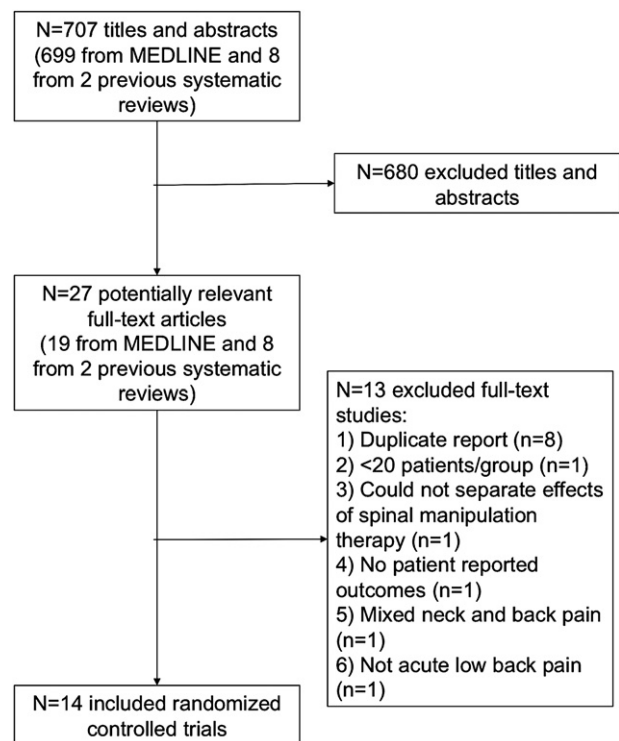


Figure. Study flow for the systematic review.

exclusion criteria reported ranged from 2 to 15, and the most common was severe disease (n=13), followed by nerve root compression/neurological symptoms (n=11), pregnancy (n=8), prior lumbar surgery (n=6), systemic inflammation (n=5), active litigation/worker's compensation (n=5), current treatment for LBP (n=5), mild severity (n=5), prior SMT (n=4), and psychological illness (n=3).

Experimental group

The experimental group received some form of SMT, including high-velocity or low-amplitude (HVLA; ie, manual thrusts pushing the spinal joints slightly beyond their passive range of motion [19]) (n=6) [26,28,33,45,49,50]; rotational (ie, an HVLA technique involving rotating the patient's thigh and leg [19]) (n=3) [47,48,51]; HVLA or MOB (ie, manual force to the spinal joints not involving a thrust or pushing them beyond their passive range of motion [19]) (n=2) [29,32]; instrument (n=1) [31]; MOB (n=1) [46]; or unspecified (n=1) [52]. There were two experimental groups that received the intervention of interest (eg, SMT) in two of the included studies [29,32]. The number of study treatments in the experimental groups ranged from 1 to 20 sessions delivered over 1 to 12 weeks, with most studies providing 5 to 10 sessions [26,28,31,32,45–47,49] over 2 to 4 weeks [28,29,31,33,45,46,51,52]. A DC (n=5) or PT (n=5) most frequently administered SMT, although some studies used a DO (n=2) or MD (n=2); it was unclear who the provider was in one study (n=1). The number of participants enrolled in the

experimental groups at baseline ranged from 21 to 165, with a mean of 63.1 and an SD (\pm) of 38.1; overall, a total of 1,009 participants received SMT across these 14 studies.

Control group

Studies most frequently had one control group ($n=10$), though some had two ($n=3$) or even four ($n=1$) control groups against which SMT was compared. The most common intervention given to the control groups was physical modalities (eg, ultrasound, transcutaneous electrical nerve stimulation, heat, ice) ($n=7$), followed by medication (eg, NSAIDs, muscle relaxants, acetaminophen) ($n=5$); education ($n=6$); exercise (eg, strengthening, aerobic, stretching) ($n=5$); MOB ($n=3$); and sham SMT ($n=2$). Other interventions as controls to SMT included lumbar supports, sham physical modalities (eg, detuned diathermy), placebo medication, and bed rest. The number of treatment sessions and duration of treatment in the experimental groups generally mirrored those in the experimental groups (eg, 5–10 sessions over 2–4 weeks). The most common type of provider in the control groups was PT ($n=8$), followed by MD ($n=5$), DC ($n=2$), and others ($n=1$). The total number of participants enrolled in control groups was higher than in experimental groups at 1,018, ranging from 23 to 133, with a mean of 53.6 ± 31.6 .

Methodological quality

The methodological quality results can be found in Table 3. The number of criteria met by RCTs varied from 3 to 11, with a mean of 6.6 ± 2.4 . Nine RCTs met six or more items [26,28,29,31–33,45,47,49], but two had high dropouts [31,32]. There were seven RCTs of higher methodological quality that met 8.1 ± 2.0 criteria [26,28,29,33,45,47,49] and seven RCTs of lower methodological quality that met 5.1 ± 1.8 criteria [31,32,46,48, 50–52]. The quality criterion most commonly fulfilled was no selective outcome reporting ($n=14$), followed by groups similar at baseline ($n=13$), having similar timing of outcome assessment ($n=12$), blinding of outcome assessor ($n=10$), acceptable dropout ($n=10$), adequate randomization ($n=7$), intention-to-treat analysis ($n=7$), treatment allocation concealment ($n=5$), patient blinded ($n=5$), similar cointerventions ($n=5$), and acceptable compliance ($n=5$).

Pain

The results for the pain outcomes can be found in Table 4. Six RCTs reported pain outcomes using the VAS [26,31–33] or numerical rating scale [45,46]; one study reported pain relief (%) without raw data [47]. Baseline pain scores in the experimental groups had a mean of 51.8 ± 4.1 ; baseline scores were similar in the control groups (48.4 ± 6.6). Five studies [31,33,45–47] reported pain reduction after 1 to 2 weeks of $38\pm 13\%$ in the experimental groups and $34\pm 19\%$ in control groups; this

difference was statistically significant in two studies [31,33]. Four studies [31,33,45,46] reported pain reduction after 3 to 4 weeks of $66\pm 17\%$ in the experimental groups and $50\pm 22\%$ in control groups; this difference was statistically significant in one study [45]. Four studies [26,32,33,45] reported pain reduction after 2 to 3 months of $57\pm 13\%$ in the experimental groups and $46\pm 10\%$ in control groups; this difference was statistically significant in one study [45].

Two studies [32,33] reported pain reduction after 6 months of $47\pm 19\%$ in the experimental groups and $46\pm 1\%$ in control groups; these differences were not statistically significant. Two studies [32,45] reported pain reduction after 1 year of $51\pm 16\%$ in the experimental groups and $55\pm 9\%$ in control groups; these differences were not statistically significant. One study [45] reported pain reduction after 2 years of $71\pm 0.0\%$ in the experimental group and $60\pm 10\%$ in the control groups; this difference was not statistically significant. Other outcomes related to pain included LBP recurrence [32,45], which was $63.5\pm 19.1\%$ in experimental groups and $58.3\pm 9.7\%$ in control groups after 1 year and $70\pm 0.0\%$ in both groups after 2 years, and participants recovered from symptoms [29,33,51], whose values were $40.5\pm 31.5\%$ in the experimental groups and $37.8\pm 31.3\%$ in the control groups after 2 to 4 weeks; $26.0\pm 2.8\%$ and $6.0\pm 0.0\%$, respectively, after 3 to 6 months (this difference was statistically significant); and $46.5\pm 2.1\%$ and $32.5\pm 6.4\%$, respectively, after 1 year.

Function

The functional outcome results can be found in Table 5. Nine RCTs reported functional outcomes using the RMDQ [26,29,32,45,49], ODI [26,28,31], Short-Form 36 (SF-36) physical function [32,33], or other outcome measures [29,50]; one reported only the statistical significance of differences without raw data [29]. Some studies reported multiple functional outcomes [26,29,32], and others reported functional outcome results for multiple subgroups [49,50]. Baseline RMDQ scores from five experimental groups had a mean of 43.3 and an SD of 8.1; baseline scores were similar in seven control groups (mean \pm SD = 43.5 ± 8.6). Baseline ODI scores from three experimental groups had a mean of 60.7 ± 18.5 ; scores were similar in four control groups (56.0 ± 17.4). Five studies [28,31,45,49,50] reported functional improvement in the experimental groups of $53\pm 15\%$ after 1 to 2 weeks and $44\pm 22\%$ in the control groups; this difference was statistically significant in one study [28]. Four studies [28,31,45,50] reported functional improvement after 3 to 4 weeks of $55\pm 7\%$ in the experimental groups and $55\pm 21\%$ in control groups; this difference was statistically significant in one study [28]. Three studies [26,32,45] reported functional improvement after 2 to 3 months of $51\pm 21\%$ in the experimental groups and $58\pm 23\%$ in the

Table 2
Study descriptions

Author, year [reference], study population	Inclusion criteria LBP duration (mean) Age range	Exclusion criteria	SMT group	Control group 1	Control group 2
			Intervention No. sessions Duration Provider Participants	Intervention No. sessions Duration Provider Participants	Intervention No. sessions Duration Provider Participants
Andersson et al., 1999 [26], patients from primary care HMO	LBP 3 wk–6 mo Age: 20–59 y	Active litigation/WC Alcohol/drug abuse Diabetic neuropathy Nerve root compression Neurovascular disease No manipulable lesion Pregnant Psychiatric disease Recent MI Scoliosis Severe disease SMT in past 3 wk Systemic inflammatory disease	HVLA, MOB, education 8 sessions 12 wk DO n=83	Active PT, corset, diathermy, education, heat/cold, medications, TENS, US 8 sessions 12 wk MD N=72	—
Cherkin et al., 1998 [45], patients from primary care HMO	LBP >7 d Age: 20–64 y	Active litigation/WC Coagulation disorder Corticosteroids Current treatment for LBP Prior SMT Lumbar surgery Mild pain severity Osteoporosis Pregnant Sciatica Severe disease Severe neurological signs Spondylolisthesis Systemic/visceral pain Vertebral fracture/dislocation	HVLA, HEP, education Up to 9 visits 4 wk DC n=122	McKenzie: supervised exercise, MOB, HEP, education, lumbar cushion Up to 9 visits 4 wk PT n=133	Education Unclear n=66
Childs et al., 2004 [28], patients from outpatient PT centers	LBP Median: 27 d Age: 18–60 y	ODI<30% Lumbar surgery Pregnant Red flags Nerve root compression	HVLA, core stabilization, aerobic exercise 5 sessions 4 wk PT n=70	Core stabilization, aerobic exercise 5 sessions 4 wk PT n=61	—

Farrell and Twomey, 1982 [46], unclear	LBP with pain on movement or SLR ≤3 wk Age: 20–65 y Pain-free 6 mo before current episode	Altered sensation Current treatment for LBP Lumbar surgery Lower extremity weakness Pregnant Signs of cauda equina Systemic disease Thoracolumbar fracture	MOB Mean: 3.5 sessions (up to 9 visits) 3 wk PT n=24	Diathermy, isometric trunk exercise, HEP, education Mean: 5.8 sessions (up to 9 visits) 3 wk PT n=24	—
Glover et al., 1974 [47], employees of an engineering company	LBP <7 d (results for >7 d excluded) Age: range 19–64 y	Bilateral pain and hyperesthesia Contraindications to SMT Current treatment for LBP Neurological involvement	Rotational SMT (1 treatment)+ detuned diathermy (4 sessions) 5 d Unclear n=21	Detuned diathermy 5 sessions 5 d PT n=23	—
Godfrey et al., 1984 [48], patients from primary care	Mechanical noninflammatory LBP <2 wk Age: 18–68 y Limited lumbar ROM Manipulable condition	Severe disease Gross spinal deformity	Rotational SMT, massage, electrical stimulation Unclear (up to 5 visits) Unclear MD or DC n=48	Electrical stimulation, minimal massage Unclear (up to 5 visits) Unclear Kinesiologist n=42	—
Hadler et al., 1987 [49], patients from primary care	LBP <1 mo Age: 18–40 y Pain-free 6 mo before current episode	Active WC/disability claims Cauda equina syndrome Overt weakness Previous SMT Systemic inflammatory disease Work-related LBP	High-velocity, long-lever SMT, acetaminophen 1 treatment N/A MD n=26	Rotational MOB, acetaminophen 1 treatment N/A MD n=28	—
Hancock et al., 2007 [29], patients from primary care	Moderate LBP as defined by SF-36 <6 wk	Contraindications to treatment Known or suspected pathology Nerve root compromise Current NSAIDs or SMT Lumbar surgery: <6 mo	HVLA/MOB 12 sessions 4 wk Acetaminophen 1 g, 4×/d PT (SMT) MD (other) n=59 —	Diclonefac 2×/d 4 wk Placebo-detuned pulsed US Acetaminophen 1 g, 4×/d MD/PT n=60 Control group 3: placebo medication, detuned pulsed US, acetaminophen 1 g, 4×/d 4 wk MD/PT n=60	SMT+control group]1 4 wk PT/MD n=60 —

(continued)

Table 2 (continued)

Author, year [reference], study population	Inclusion criteria LBP duration (mean) Age range	Exclusion criteria	SMT group	Control group 1	Control group 2
			Intervention No. sessions Duration Provider Participants	Intervention No. sessions Duration Provider Participants	Intervention No. sessions Duration Provider Participants
Hoiriis et al., 2004 [31], unclear	LBP 2–6 wk Age: 21–59 y	Cervical complaint Disc herniation Malignancy Neuropathy Personal injury litigation Pregnant women Spinal fracture Spinal stenosis Lumbar surgery Spondylitis Vascular disease	HVLA instrument–assisted SMT 7 sessions 2 wk Placebo medication (acetaminophen) DC n=50	Muscle relaxants, placebo medication, sham SMT 7 sessions 2 wk MD DC for sham SMT N=53	Placebo medication, acetaminophen, sham SMT MD DC for sham SMT N=53
Hurely et al., 2004 [32], patients from hospital-based PT centers	LBP 4–12 wk Age: 18–65 y Pain-free 6 mo before current episode	Cauda equina syndrome Concurrent condition Contraindications to treatment Lumbar surgery Nerve root compression Non-English Pregnant Psychiatric illness PT for LBP in past 12 mo Recent MVA RMD<4 Systemic disease	HVLA, MOB, education 4–10 sessions 8 wk PT n=80	Interferential current therapy, education 4–10 sessions 8 wk PT n=80	Experimental group+control group, education PT n=80
MacDonald and Bell, 1990 [50], patients from general medical practice	LBP <4 wk Age: 16–70 y	Current treatment for LBP Lumbosacral neurological deficit Osteomalacia Osteoporosis Pregnant Skeletal metastasis or infection Spondylolisthesis Systemic inflammatory disease Visceral pathology	LVLA/HVLA SMT, unspecified exercise, education 2×/wk (unclear) Unclear DO n=33	Education Exercise Unclear Unclear Unclear n=30	—

Mathews et al., 1987 [51], patients from an outpatient medical center	LBP <3 mo Age: 18–60 y	Abnormalities from examination Imaging or laboratory findings	Rotational or thrust SMT, analgesic medication, education, corset Unclear 2 wk PT n=165	Infrared heat Analgesic medication Corset Education 3×/wk (unclear) Unclear PT n=126	—
Postacchini et al., 1988 [52], patients from an outpatient hospital center	LBP <4 wk Age: 17–58 y	Litigation Pregnant or nursing women Psychiatric disturbance Serious general disease Spinal neoplasm or infection	Manipulation unspecified 13 sessions 4 wk DC n=35	NSAIDs Unclear 10–14 d MD n=34 Control group 3: bed rest 15–24 h/d 6–8 d MD n=29	Massage, electrical stimulation, heat/diathermy 14–21 sessions 3 wk PT n=31 Control group 4: placebo topical gel 14–28 sessions (2×/d) 1–2 wk PT n=30
Santilli et al., 2006 [33], patients from outpatient medical rehabilitation centers	LBP≥5/10 with leg pain≥5/10 <10 d Age: 18–65 y MRI evidence of lumbar disc protrusion in segments involved	BMI>30 Diabetic neuropathy Herniated disc History of chronic LBP Leg length difference>1.5 cm Lumbar scoliosis>20° Surgical lesion Osteopenia Previous SMT Severe osteoporosis Spinal surgery Spondylolisthesis	HVLA Up to 20 sessions 30 d DC n=53	Sham SMT Up to 20 sessions 30 d DC n=49	—

LBP, low back pain; HMO, health maintenance organization; WC, worker's compensation; MI, myocardial infarction; SMT, spinal manipulation therapy; HVLA, high-velocity, low-amplitude SMT; DO, Doctor of Osteopathy; PT, physical therapy (or therapist); TENS, transcutaneous electrical nerve stimulation; US, ultrasound; MD, Doctor of Medicine; HEP, home exercise program; MOB, mobilization/nonthrust manual therapy; ODI, Oswestry Disability Index; SLR, straight leg raise; ROM, range of motion; DC, Doctor of Chiropractic/chiropractor; LVLA, low velocity low amplitude; NSAIDs, nonsteroidal anti-inflammatory drugs; MVA, motor vehicle accident; BMI, body mass index; MRI, magnetic resonance imaging.

control groups; these differences were not statistically significant.

Two studies [28,32] reported functional improvement after 6 months of 44±22% in the experimental groups and 38±21% in the control groups; this difference was statistically significant in one study [28]. Two studies [32,45] reported functional improvement after 1 year of 43±23% in the experimental groups and 49±25% in the control groups; this difference was statistically significant in one study [32]. One study [45] reported functional improvement after 2 years of 75±0% in the experimental group and 69±9% in the control groups; this difference was not statistically significant. Other functional outcomes reported included need for bed rest [45], which was 8.0±0% in the experimental group and 10.0±1.4% in control groups after 1 year; reduced activity because of LBP [45], which was 33±0% in the experimental group and 36±1% in control groups after 1 year; marked or moderate improvement in a functional scale of 10 activities of daily living [48], which was 29% in the experimental group and 30% in the control group after 2 weeks.

Global effect

The global effect results can be found in Table 6. Five RCTs reported global effect using a variety of scales (eg, global impression of severity; global rating of care; composite score combining pain, stiffness, and tenderness) [29,31,45,48,52]. Results for global effect were statistically significant in favor of the experimental groups in two of five RCTs after 1 to 2 weeks [29,31,45,48], in two of three RCTs after 3 to 4 weeks [29,45,52], and one of two RCTs after 2 to 3 months [29,52]; no differences were noted beyond 6 months of follow-up [52].

Health-care utilization

The health-care utilization results can be found in Table 7. Six RCTs reported on health-care utilization for LBP, including analgesic medication use [28,31–33,51] and other health-care use [28,45]. For analgesic medication use, there were no statistically significant differences between groups after 2 weeks in three RCTs [31,33,51] nor after 2 months in one RCT [32]. Results after 6 months favored the experimental group in one RCT [28], though no differences were noted in another RCT after 1 year [32]. For other health-care use, results favored the experimental group after 6 months in one RCT [28]; no differences were noted in one RCT after 1 year [45].

Other outcomes

In addition to pain, function, global effect, and health-care utilization, other outcomes were also measured and reported in these RCTs, and their results can be found in Table 8. These outcomes included lumbosacral range of motion (eg, degrees of flexion, extension, and rotation, or fingertip-to-floor distance) [26,46,48]; mental health (eg, SF-36 mental composite score, modified Zung Questionnaire) [31,32]; lost work time because of LBP [28,32,45]; and utility (eg, EuroQol-5D) [32]. Results for lumbosacral range of motion were not statistically significant between groups after 1, 2, 3 weeks, or 3 months [26,46,48]. Results for mental health were no different between groups after 2, 4 weeks or 2 or 6 months [31–33] but were statistically significant in favor of the control group after 1 year [32]. Results for work loss because of LBP were statistically significant in favor of the experimental group after 6 months [28], though no differences were noted between groups after 1 year [32,45]. Results for utility were not

Table 3
Methodological quality

Author, year [reference]	1	2	3	4	5	6	7	8	9	10	11	12	Total	Final
Andersson et al., 1999 [26]	x	x			x	x	x	x	x				7	High
Cherkin et al., 1998 [45]					x	x	x	x	x	x		x	7	High
Childs et al., 2004 [28]	x	x			x		x	x	x			x	7	High
Farrell and Twomey, 1982 [46]					x	x		x	x			x	5	Low
Glover et al., 1974 [47]	x				x	x		x	x			x	6	High
Godfrey et al., 1984 [48]			x		x	x		x	x				5	Low
Hadler et al., 1987 [49]			x		x	x		x	x	x	x	x	8	High
Hancock et al., 2007 [29]	x	x	x		x	x	x	x	x	x	x	x	11	High
Hoiriis et al., 2004 [31]	x		x		x		x	x	x		x	x	8	Low
Hurley et al., 2004 [32]	x	x					x	x	x		x	x	7	Low
MacDonald and Bell, 1990 [50]						x		x				x	3	Low
Mathews et al., 1987 [51]								x	x	x		x	4	Low
Postacchini et al., 1988 [52]						x		x	x			x	4	Low
Santilli et al., 2006 [33]	x	x	x		x	x	x	x	x	x	x	x	11	High
Total	7	5	5	0	10	10	7	14	13	5	5	12		

Criteria: 1. Was the method of randomization adequate? 2. Was the treatment allocation concealed? 3. Was the patient blinded to the intervention? 4. Was the care provider blinded to the intervention? 5. Was the outcome assessor blinded to the intervention? 6. Was the dropout rate described and acceptable? 7. Were all randomized participants analyzed in the group to which they were allocated? 8. Are reports of the study free of suggestion of selective outcome reporting? 9. Were the groups similar at baseline regarding the most important prognostic indicators? 10. Were cointerventions avoided or similar? 11. Was the compliance acceptable in all groups? 12. Was the timing of the outcome assessment similar in all groups?.

Table 4
Pain outcome results

Author, year [reference]	Outcome measure range	Time point	SMT	Control 1	Control 2	Control 3	p Value	
Andersson et al., 1999 [26]	VAS (0–100)	Baseline	49	45	—	—	—	
		3 mo	17	18.7	—	—	NS	
Cherkin et al., 1998 [45]	NRS (0–12)	Baseline	5.5	5.3	6	—	—	
		1 wk	3.8	4	3.7	—	NS	
		1 mo	1.9	3.1	2.3	—	.007 (SMT>control 2)	
		3 mo	2	3.2	2.7	—	.02 (SMT>control 2)	
		1 y	1.8	2.7	2.1	—	NS	
		2 y	1.6	2.5	2	—	NS	
	LBP recurrence (% subjects)	1 y	50	50	50	—	NS	
		2 y	70	70	70	—	NS	
Farrell and Twomey, 1982 [46]	NRS (0–10)	Baseline	4.9	5.3	—	—	NS	
		1 wk	3.7	4.5	—	—	NS	
		3 wk	0.3	0.3	—	—	NS	
		Days to reach symptom-free condition	—	15	20	—	—	<.001 (SMT>control 1)
Glover et al., 1974 [47]	Pain relief (%)	Immediate	37	23	—	—	<.05 (SMT>control 1)	
		3 d	63	56	—	—	NS	
		1 wk	89	79	—	—	NS	
Hancock et al., 2007 [29]	NRS (0–10) (% subjects recovered)	3 wk	47	40	50	48	NS	
Hoiriis et al., 2004 [31]	VAS (0–10)	Baseline	4.52	4.24	3.95	—	—	
		2 wk	4.52	3.84	3.89	—	.03 (SMT>control 2)	
		1 mo	2.44	3.18	2.73	—	NS	
Hurley et al., 2004 [32]	VAS (0–100)	Baseline	52.08	52.06	49.84	—	—	
		2 mo	32.2	30.68	25.15	—	NS	
		6 mo	35.13	27.51	29.94	—	NS	
		1 y	33.88	25.56	24.14	—	NS	
	LBP recurrence (% subjects)	1 y	77	69	64	—	NS	
		MPQ	Baseline	16	17	17	—	—
			2 mo	11	11	10	—	NS
			6 mo	11	10	11	—	NS
1 y			10	9	8	—	NS	
Mathews et al., 1987 [51]	NRS (% recovered)	Without positive SLR	2 wk	62	70	—	—	NS
		1 y	48	28	—	—	NS	
	With positive SLR	2 wk	80	67	—	—	<.05 (SMT>control 1)	
		1 y	45	37	—	—	NS	

(continued)

Table 4 (continued)

Author, year [reference]	Outcome measure range	Time point	SMT	Control 1	Control 2	Control 3	p Value
Santilli et al., 2006 [33]	VAS (0–10)	Baseline	6	6	—	—	—
	Pain reduction (% subjects)	2 wk	86	61	—	—	<.01 (SMT>control 1)
		1 mo	94	85	—	—	NS
		6 wk	100	92	—	—	NS
		3 mo	98	90	—	—	NS
		6 mo	98	94	—	—	NS
		2 wk	0	0	—	—	NS
	Free of LBP (% subjects)	1 mo	6	0	—	—	NS
		6 wk	17	6	—	—	NS
		3 mo	24	6	—	—	<.05 (SMT>control 1)
		6 mo	28	6	—	—	<.005 (SMT>control 1)
		2 wk	13	4	—	—	NS
		1 mo	23	12	—	—	NS
	Free of leg pain (% subjects)	6 wk	41	16	—	—	<.01 (SMT>control 1)
		3 mo	55	12	—	—	<.0001 (SMT>control 1)
6 mo		55	20	—	—	<.0001 (SMT>control 1)	

NS, not significant (p≥.05); NRS, numerical rating scale; VAS, visual analog scale; VRS, verbal rating scale; PDI, Pain Disability Index; MPQ, McGill Pain Questionnaire; SLR, straight leg raise. Follow-up time points: time from randomization. >/< sign indicates that results for SMT group were statistically significantly superior/inferior to control group listed.

statistically significant between groups after 2 or 6 months or 1 year [32].

Subgroups

One RCT reported pain outcomes separately for subgroups that had either a positive or a negative straight leg raise (SLR) [51]. Results suggest that a greater proportion had recovered after 2 weeks in those with a positive SLR, though there were no apparent differences after 1 year [51]. Two RCTs reported functional outcomes separately for subgroups that had LBP for less than 2 weeks and for 2 to 4 weeks [49,50]. Results suggest that a greater improvement in RMDQ was noted in those with LBP of 2 to 4 weeks’ duration after 3 days [49]; no further improvements were observed in this subgroup after 12 days, whereas those with LBP duration of less than 2 weeks noted additional improvement [49,50]. One RCT reported global effect outcomes separately for subgroups with or without leg pain [52]. Results suggest that the experimental group was more superior to the control groups in those with leg pain after 3 weeks but not after 2 or 6 months [52].

Summary

Overall results for pain and functional outcomes are summarized in Tables 9 and 10, respectively.

Harms

Data on harms are presented in Table 11. None of the included studies reported harms specifically related to SMT.

Discussion

Improvements in pain and function

Spinal manipulation therapy appears to be effective for pain reduction in the short, intermediate, and long term. Only 1 to 2 weeks after initiating care with SMT, pain reduction was substantial (62%), though it was almost as large for the control groups against which it was compared. Pain reduction tended to peak within 3 to 4 weeks of beginning SMT (80%) and tapered slightly after 2 to 3 months (67%) and 6 months (65% SMT) but remained higher than that achieved after 1 to 2 weeks. Pain reduction continued to taper after 1 year (51%) and 2 years (66%). One-third of the studies that reported pain outcomes demonstrated a greater pain reduction for SMT than that for the control groups at one or more time points [31,33,45], whereas two-thirds showed no difference between SMT and control groups [26,29,32,46,47,51]. No studies reported that SMT was inferior to other treatments in providing pain reduction at any time point. Of the studies that reported function and disability outcomes, most (seven out of nine) reported no difference compared with various control interventions [26,31,33,45,48–50]. One study demonstrated

Table 5
Functional outcome results

Author, year [reference]	Outcome measure	Time point	SMT	Control 1	Control 2	p Value	
Andersson et al., 1999 [26]	RMDQ (0–24)	Baseline	7	7	—	—	
		12 wk	2	1	—	NS	
	ODI (0–50)	Baseline	25	23.1	—	—	
		12 wk	11.4	10.2	—	NS	
Cherkin et al., 1998 [45]	RMDQ (0–24)	Baseline	12.1	11.7	12	—	
		1 wk	7	7.6	7	NS	
		4 wk	3.7	4.9	5	NS	
		12 wk	3.1	4.3	4	NS	
		1 y	3	4.8	5	NS	
		2 y	3	4.6	5	NS	
		Needed bed rest (%)	1 y	8	11	9	—
Childs et al., 2004 [28]	ODI (0–50)	Baseline	41.40	40.9	—	—	
		1 wk	21.50	33.75	—	<.001 (SMT>control 1)	
		4 wk	16.50	25.75	—	<.001 (SMT>control 1)	
		6 mo	13.50	24.25	—	<.001 (SMT>control 1)	
Godfrey et al., 1984 [48]	VRS (functional status for 10 ADLs) (% with moderate or marked improvement)	2 wk	29	30	—	NS	
Hadler et al., 1987 [49]	RMDQ (0–24)	LBP duration: <2 wk	Baseline	10.50	12.70	—	—
		12 d	2.10	2.00	—	NS	
		LBP duration: 2–4 wk	Baseline	10.50	10.40	—	—
Hoiriis et al., 2004 [31]	ODI (0–50)	Baseline	25	23	25	—	
		2 wk	17	17	19	NS	
		4 wk	12	16	16	NS	
Hurley et al., 2004 [32]	RMDQ (0–24)	Baseline	10.7	9.04	10.41	—	
		8 wk	6.17	5.48	5.76	NS	
		6 mo	6.04	5.10	5.79	NS	
		1 y	5.99	4.14	3.91	NS	
	SF-36 PF (0–100)	Baseline	50.64	55.65	51.46	—	
		8 wk	65.90	66.27	65.77	NS	
		6 mo	63.24	65.75	65.84	NS	
1 y	60.00	67.36	72.86	.03 (SMT<control 2)			
MacDonald and Bell, 1990 [50]	Disability index (0–12)	LBP duration: ≤2 wk	Baseline	7.8	7.9	—	—
		1 wk	4.84	4.65	—	NS	
		2 wk	3.68	2.43	—	NS	
	LBP duration: 2–4 wk	3 wk	2.72	1.23	—	NS	
		Baseline	6.5	5.9	—	—	
		1 wk	3.92	4.81	—	NS	
		2 wk	2.58	3.01	—	NS	
3 wk	2.25	1.70	—	NS			
Santilli et al., 2006 [33]	SF-36 PF (0–100)	Baseline	ND	ND	—	—	
		Unclear	67	61	—	NS	

RMDQ, Roland-Morris Disability Questionnaire; ODI, Oswestry Disability Index; VRS, verbal rating scale; ADLs, activities of daily living; LBP, low back pain; NS, not significant ($p > .05$); ND, no data; SF-36 PF, Short-Form 36, physical functioning subscale; SMT, spinal manipulation therapy.

Follow-up time points: time from randomization. >/< sign indicates that results for SMT group were statistically significantly superior/inferior to control group listed.

a greater improvement for SMT at two time points [28], and one study demonstrated a greater improvement in control compared with SMT at one time point [32].

Relative efficacy

Results from most studies indicate that SMT was either superior or equivalent to many commonly used interventions, including physical modalities, education, exercise, and

medication. In cases where SMT was equivalent to the control group, both groups improved. Lack of superiority for any particular approach is likely related to many conservative interventions having equally favorable results in the initial stages of LBP. This suggests that a patient with acute LBP (or a spine clinician involved in their care) can reasonably choose the most appealing of these management options based on availability, personal preference, expectation of improvement, or other factors beyond simply efficacy.

Table 6
Global effect outcome results

Author, year [reference]	Outcome measure	Time point	SMT	Control 1	Control 2	Control 3	Control 4	p Value	
Cherkin et al., 1998 [45]	Global rating of care (VRS, 5-point, % subjects with “very good” or “excellent” ratings)	1 wk	75	75	30	—	—	<.001 (SMT>control 2)	
		4 wk	75	75	30	—	—	<.001 (SMT>control 2)	
Godfrey et al., 1984 [48]	5-Point composite scale for pain, stiffness, tenderness (% subjects with moderate or marked improvement)	2 wk	74	74	—	—	—	NS	
Hancock et al., 2007 [29]	Global perceived effect (VRS)	1 wk	ND	ND	ND	ND	—	NS	
		2 wk	ND	ND	ND	ND	—	NS	
		4 wk	ND	ND	ND	ND	—	NS	
		12 wk	ND	ND	ND	ND	—	NS	
Hoiriis et al., 2004 [31]	Global impression of severity (0–31)	Baseline	13	11	13	—	—	—	
		2 wk	8	9	10	—	—	<.05 (SMT<control 2)	
Postacchini et al., 1988 [52]	Composite score (5–32) (NRS, functional status questionnaire, spinal mobility, abdominal muscle strength), change from baseline	LBP without leg pain	3 wk	8	3	5	5	2	<.05 (SMT>control 4)
			2 mo	10	11	8	8	7	NS
			6 mo	12	14	10	7	11	NS
		LBP with leg pain	3 wk	6	5	4	4	2	<.001 (SMT>control 2, 3, 4)
			2 mo	9	9	6	6	5	<.05 (SMT>control 2, 3, 4)
			6 mo	12	11	10	10	10	NS

VRS, verbal rating scale; SMT, spinal manipulation therapy; ND, no data; NS, not significant ($p>.05$); LBP, low back pain; NRS, numerical rating scale. >/< sign indicates that results for SMT group were statistically significantly superior/inferior to control groups listed.

Table 7
Health-care utilization results

Author, year [reference]	Outcome measure	Time point	SMT	Control 1	Control 2	p Value
Childs et al., 2004 [28]	Medication usage in past week (% subjects)	6 mo	37	60	—	<.05 (SMT>control 1)
	Current health-care utilization (% subjects)	6 mo	12	43	—	<.05 (SMT>control 1)
Cherkin et al., 1998 [45]	Sought care (% subjects)	2 y	29	20	24	NS
Hoiriis et al., 2004 [31]	Analgesic medication use (no. tablets)	2 wk	20	19	17	NS
Hurley et al., 2004 [32]	Analgesic medication usage (% subjects)	8 wk	56	45	48	NS
		1 y	46	42	32	NS
Mathews et al., 1987 [51]	Analgesic use (mean no. tablets consumed)					NS
	LBP without positive SLR	2 wk	4	3	—	NS
	LBP with positive SLR	2 wk	6	7	—	NS
Santilli et al., 2006 [33]	NSAID use (no. days)	2 wk	2	4	—	NS
	NSAID use (no. prescriptions)	2 wk	3	5	—	NS

NSAID, nonsteroidal anti-inflammatory drug; SLR, straight leg raise; LBP, low back pain; NS, not significant ($p > .05$).
>/< sign indicates that results for SMT group were statistically significantly superior/inferior to control group listed.

Treatment of acute low back pain

This review is unable to address a different research question that may also be of interest, that is, is any intervention at all necessary for acute LBP? The prognosis of acute LBP is generally viewed as favorable, with or without treatment. One could, therefore, suggest that the efficacy of SMT relative to other commonly used interventions is less important than that compared with no treatment at all. However, this question can only be addressed by RCTs in which SMT is compared with a pure no-treatment control group, which did not occur in the 14 RCTs included.

No-treatment control group

Although conducting an RCT of SMT compared with a no-treatment control group for acute LBP could be of scientific or economic interest, it may pose certain challenges. For example, it may be difficult to justify randomizing participants to a no-treatment control group when several commonly used interventions, including SMT, appear to be relatively safe, effective, inexpensive, and widely available. Even if an ethics review board approved such a study design, it may be challenging to recruit participants. At minimum, brief education of participants may be required as to why a no-treatment approach is appropriate, in effect, changing the no-treatment control group into a brief-education control group. Once recruited, monitoring and compliance of participants assigned to a no-treatment control group could also be problematic as they may resort to self-prescribed nonstudy interventions (eg, over-the-counter analgesics) for pain relief. This issue may warrant further discussion among clinicians, researchers, and ethicists, but cannot be addressed from this review of currently available RCTs.

Previous systematic reviews on this topic

The present review uncovered five new RCTs [28,29,31–33] that were conducted after publication of two previous SRs on the same topic [23,53]. The present review focused exclusively on acute LBP, whereas the two previous reviews included acute, subacute, and chronic LBP. Nevertheless, our results appear to be generally consistent with those of the two previous SRs. It is important to note, however, that interpretation of the results and conclusions drawn from them are different among the SRs. For example, the present review concludes that SMT is equally effective as other commonly used conservative approaches for acute LBP. On the other hand, a previous SR interpreted similar evidence and concluded that SMT had no statistically or clinically significant advantage over general medical care, analgesic medication, physical therapy, exercises, or back school [23]. Although both conclusions are similar, their wording may influence how their findings will be perceived by those who do not read the full study report.

Systematic versus narrative reviews

There are many different ways to approach a review article. A narrative review simply proposes one or more hypotheses and cites studies supporting those points. On the other hand, an SR approaches the process in an organized and transparent manner that removes much of the bias that can be introduced in a narrative review. When conducted appropriately, SRs are considered to be an important tool in evidence-based medicine. The main steps required in an SR are to define a research question; devise a comprehensive and transparent search strategy to uncover relevant studies; specify study eligibility criteria; screen results independently by two reviewers to avoid bias in selecting studies; evaluate methodological quality; summarize results for similar studies; and interpret findings for those who do

Table 8
Results from additional outcomes

Author, year [reference]	Outcome measure	Time point	SMT	Control 1	Control 2	p Value	
Andersson et al., 1999 [26]	Lumbar ROM (degree) Flexion	Baseline	32	33	—	—	
		12 wk	36	37	—	NS	
	Extension	Baseline	7	7	—	—	
		12 wk	8	9	—	NS	
	SLR (degree) Supine	Baseline	76	75	—	—	
		12 wk	79	77	—	NS	
	Sitting	Baseline	76	75	—	—	
		12 wk	82	82	—	NS	
	Cherkin et al., 1998 [45]	Missed work (% subjects)	1 y	7	13	17	NS
	Childs et al., 2004 [28]	Lost work time in past 6 wk (% subjects)	6 mo	10	25	—	<.05 (SMT> control 1)
Farrell and Twomey, 1982 [46]	Lumbar ROM (index: 0–3) Flexion	Baseline	0.7	0.75	—	—	
		Immediate	0.95	1	—	NS	
		3 wk	1.2	1.35	—	NS	
	Extension	Baseline	0.7	0.6	—	—	
		Immediate	1	0.75	—	NS	
		3 wk	1.25	1	—	NS	
	Left rotation	Baseline	1.6	1.6	—	—	
		Immediate	1.75	1.8	—	NS	
		3 wk	2.1	2.1	—	NS	
	Right rotation	Baseline	1.6	1.8	—	—	
		Immediate	2	1.9	—	—	
		3 wk	2	2	—	—	
	SLR (degree) left	Baseline	77	70	—	—	
		Immediate	85	75	—	NS	
		3 wk	85	80	—	NS	
	SLR (degree) right	Baseline	75	70	—	—	
		Immediate	81	76	—	—	
		3 wk	84	80	—	NS	
	Godfrey et al., 1984 [48]	Spinal mobility (fingertip-floor-cm)	Baseline	ND	ND	—	—
			2 wk	7	7	—	NS
Hoiriis et al., 2004 [31]	Depression: MZQ	Baseline	18	15	17	—	
		2 wk	12	12	14	NS	
		4 wk	12	12	12	NS	
Hurley et al., 2004 [32]	SF-36 MCS (0–100)	Baseline	64	66	65	—	
		8 wk	68	68	71	NS	
		6 mo	71	69	72	NS	
		1 y	69	67	75	.02 (control 2> control 1)	
Hurley et al., 2004 [32]	EQ-5D	Baseline	0.5	0.5	0.5	—	
		8 wk	0.7	0.7	0.7	NS	
		6 mo	0.7	0.7	0.7	NS	
		1 y	0.7	0.7	0.8	NS	
Hurley et al., 2004 [32]	Work absenteeism <30 d (% subjects)	1 y	21	22	18	NS	
Santilli et al., 2006 [33]	SF-36 MH (0–100)	Baseline					
		Note: unclear which time point is shown in Table 4	74	70	—	NS	

ROM, range of motion; NS, not significant ($p > .05$); SLR, straight leg raise; MZQ, Modified Zung Questionnaire; ND, no data; SF-36 MCS, Short-Form 36 mental component summary; EQ-5D, EuroQol-5D; SF-36 MH, Short-Form 36 mental health subscale.

Follow-up time points: time from randomization. >/< sign indicates that results for SMT group were statistically significantly superior/inferior to control group listed.

not have the time, expertise, or willingness to do so. Embedded within each of these steps are decisions that authors must make that can impact their findings. Readers should be aware of these potential limitations.

Duplicate reports

Numerous duplicate reports were uncovered in the search. Many of these reports were related to the same

Table 9
Summary of evidence for improvement in pain

Reference	SMT group	Results	Control groups	Follow-up
Short term				
[24]	7 sessions of instrument SMT by DC+placebo medication	Superior to	– Muscle relaxants+sham SMT – Acetaminophen+sham SMT	2 wk
[26]	Up to 20 sessions of HVLA SMT by DC	Superior to	Up to 20 sessions sham SMT by DC	2 wk
[38]	Up to 8 visits with HVLA+HEP+education by PT	Superior to	– Up to 8 visits with McKenzie supervised exercise+MOB+HEP+education+lumbar cushion by PT – Education	4 wk
[40]	1 session rotation of SMT+4 sessions of detuned diathermy	Equal to	5 sessions of detuned diathermy	1 wk
[38]	Up to 8 visits with HVLA+HEP+education by PT	Equal to	– 8 visits with McKenzie supervised exercise+MOB+HEP+education+lumbar cushion by PT – Education	1 wk
[39]	Mean 3.5 sessions of MOB by PT	Equal to	Mean 5.9 sessions of diathermy+isometric trunk exercise+HEP+education by PT	1 wk 3 wk
[24]	7 sessions of instrument SMT by DC+placebo medication	Equal to	– Muscle relaxants+sham SMT – Acetaminophen+sham SMT	4 wk
[26]	Up to 20 sessions of HVLA SMT by DC	Equal to	Up to 20 sessions of sham SMT by DC	4 wk
Intermediate term				
[38]	Up to 8 visits with HVLA+HEP+education by PT	Superior to	– Up to 8 visits with McKenzie supervised exercise+MOB+HEP+education+lumbar cushion by PT – Education	3 mo
[25]	4–10 sessions of HVLA+MOB+education by PT	Equal to	– 4–10 sessions of interferential+education by PT – 4–10 sessions of HVLA+MOB+interferential+education by PT	2 mo
[19]	8 sessions of HVLA+MOB by DO	Equal to	8 sessions of corset+diathermy+education+heat/cold+medications+TENS+US by MD	3 mo
[26]	Up to 20 sessions of HVLA SMT by DC	Equal to	Up to 20 sessions of sham SMT by DC	3 mo 6 mo
[25]	4–10 sessions of HVLA+MOB+education by PT	Equal to	– 4–10 sessions of interferential+education by PT – 4–10 sessions of HVLA+MOB+interferential+education by PT	6 mo
Long term				
[25]	4–10 sessions of HVLA+MOB+education by PT	Equal to	– 4–10 sessions of interferential+education by PT – 4–10 sessions of HVLA+MOB+interferential+education	1 y
[38]	Up to 8 visits with HVLA+HEP+education by PT	Equal to	– Up to 8 visits with McKenzie supervised exercise+MOB+HEP+education+lumbar cushion by PT – Education	1 y 2 y

SMT, spinal manipulation therapy; DC, Doctor of Chiropractic/chiropractor; HVLA, high-velocity, low-amplitude SMT; HEP, home exercise program; MOB, mobilization/nonthrust manual therapy; PT, physical therapy (or therapist); DO, Doctor of Osteopathy.

Table 10
Summary of evidence for improvement in function

Reference	SMT group	Comparison	Control groups	Follow-up
Short term				
[21]	5 sessions of HVLA SMT by PT, core stabilization, and aerobic exercise	Superior to	5 sessions of core stabilization and aerobic exercise	1 wk 4 wk
[38]	Up to 8 visits with HVLA+HEP+education by PT over 4 wk	Equal to	– Up to 8 visits with McKenzie supervised exercise +MOB+HEP+education+lumbar cushion by PT – Education	1 wk 4 wk
[42]	1 session of high-velocity, long-lever SMT by MD	Equal to	1 session of rotational MOB by MD	2 wk
[43]	LVLA and HVLA SMT with unspecified exercise and education twice/week by a DO	Equal to	– Education – Exercise	2 wk 3 wk
[24]	7 sessions of instrument SMT by DC+placebo medication	Equal to	– Muscle relaxants+sham SMT – Acetaminophen+sham SMT	2 wk 4 wk
Intermediate term				
[21]	5 sessions of HVLA SMT by PT, core stabilization, and aerobic exercise	Superior to	5 sessions of core stabilization and aerobic exercise	6 mo
[25]	4–10 sessions of HVLA+MOB+education by PT	Equal to	– 4–10 sessions of interferential+education by PT – 4–10 sessions of HVLA+MOB+interferential +education by PT	2 mo 6 mo
Long term				
[38]	Up to 8 visits with HVLA+HEP+education by PT	Equal to	– Up to 8 visits McKenzie supervised exercise +MOB+HEP+education+lumbar cushion by PT – Education	1 y 2 y
[25]	4–10 sessions of HVLA+MOB+education by PT	Inferior to	Education by a PT	1 y

HVLA, high-velocity, low-amplitude SMT; SMT, spinal manipulation therapy; PT, physical therapy (or therapist); HEP, home exercise program; MOB, mobilization/nonthrust manual therapy; MD, Doctor of Medicine; LVLA, low velocity low amplitude; DO, Doctor of Osteopathy; DC, Doctor of Chiropractic/chiropractor.

cohort of participants but reported new analyses that attempted to explain observed differences by examining various hypotheses, including gender [36], confidence [37], satisfaction [40], and lumbar mobility [35]. Although secondary analyses can provide greater insight when interpreting results, duplicate reports can also artificially inflate the amount of evidence supporting an intervention if readers

are not aware whether they are referring to the same patient population [54–56].

Eligibility criteria

Many of the RCTs appear to have been designed pragmatically rather than using standardized methodology. For

Table 11
Harms

Author, year [reference]	Harms	Harm description	SMT group	Control 1	Control 2
Andersson et al., 1999 [26]	No	—	—	—	—
Cherkin et al., 1998 [45]	Yes	Important AE related to treatment	0	0	—
Childs et al., 2004 [28]	No	—	—	—	—
Farrell and Twomey, 1982 [46]	No	—	—	—	—
Glover et al., 1974 [47]	No	—	—	—	—
Godfrey et al., 1984 [48]	No	—	—	—	—
Hadler et al., 1987 [49]	No	—	—	—	—
Hancock et al., 2007 [29]	Yes	AE related to SMT, AE related to drug	0	11	11
Hoiriis et al., 2004 [31]	No	—	—	—	—
Hurley et al., 2004 [32]*	Yes	AE related to treatment	0	0	0
MacDonald and Bell, 1990 [50]	No	—	—	—	—
Mathews et al., 1987 [51]	Yes	Harm, increased pain, surgery	0	0	—
Postacchini et al., 1988 [52]	No	—	—	—	—
Santilli et al., 2006 [33]	Yes	AE unspecified	0	0	—

AE, adverse events; SMT, spinal manipulation therapy.

* One patient died in the treatment group, but it was reported as being unrelated to SMT.

example, acute LBP is a fairly simple, universal concept typically defined as duration of symptoms of less than 12 weeks [7]. However, many RCTs have defined acute LBP in differing ways that preclude combining their results in SRs or meta-analyses. When designing future RCTs, investigators should consider how data from their study might be combined with data from other studies.

Providers

It has been estimated that 94% of SMT is administered by DCs [57]. However, only 38% (5 out of 13) of the studies which reported provider type involved DCs as providers of SMT. Potential explanations for this observation include insufficient funding of RCTs outside medical research universities, inadequate research training or infrastructure for DCs to conduct RCTs, or a perception that efficacy of SMT for acute LBP has been sufficiently answered and is no longer of primary research interest. The involvement of PTs as authors or providers of SMT was greater than that one might expect, as they were involved in 38% (5 out of 13) of the studies, including three of the most recent RCTs [28,29,32]. It is unknown if results from SMT administered by different providers are interchangeable in terms of efficacy. Nonetheless, it is interesting to note that SMT was administered by DCs in all of the studies that reported greater pain reduction in the SMT group over control groups at one or more time points [31,33,45].

Frequency and duration of spinal manipulation therapy

For acute LBP, it is common practice to recommend two to three sessions per week for the first few weeks and then to gradually decrease the frequency of treatments during subsequent weeks. In the reviewed studies, the total number of SMT sessions ranged from 1 [47,49] to 20 sessions over 30 days [33]. Data on SMT frequency and duration were ambiguous in some of the reviewed studies; hence, the extent to which these variables affected outcomes is uncertain. However, there is no evidence to suggest that 20 treatment sessions offer clear advantages over 5 to 10 treatment sessions.

Cointerventions

Cointerventions, including passive physical modalities, massage, assisted stretching, exercises, and medications, were often administered concurrently with SMT. Investigators who design RCTs that use multiple cointerventions likely do so to reflect how SMT is used in clinical practice. However, this practice draws on anecdotal evidence and other factors as patients attempt to find symptomatic relief. Administering numerous interventions in RCTs without appropriate control groups (eg, placebo) obscures the unique contribution of specific therapies, including those of interest to investigators (ie, SMT). It may even increase the possibility that no difference will be found among the various treatments. The end result is that such studies are typically

not useful in the clinical decision-making process. Monitoring the use of cointerventions would likely require a participant diary that could be verified through claim records. This item is challenging to assess when the control group intervention is a cointervention in the experimental group (eg, analgesics). In such cases, control group use should not be comparable among study arms. Studies with protocols requiring multiple sessions should report compliance to help determine if it affects outcome. This would also allow subgroup analyses of dose and frequency effects.

Spinal manipulation therapy techniques

Many different SMT techniques are used for LBP by a variety of providers. However, most of the studies we reviewed did not include sufficient details of the technique used. One study did directly compare two common techniques (HVLA SMT and rotational MOB), but only one treatment session of SMT was carried out in this study [49]. Therefore, we were not able to draw conclusions about the relative efficacy of different SMT techniques.

Methodological quality

We found that most of the new CBRG criteria were useful in assessing methodological quality. However, it was difficult to evaluate the new CBRG criterion regarding selective outcome reporting, which was assumed to be absent unless outcomes were specified in the objectives but not reported. Presumably, the authors' intent on concealing unfavorable results would not mention those outcomes at all rather than selectively mention in portions of the manuscript that could create doubts among readers. Furthermore, the relevance of blinding for physical interventions, such as SMT, is questionable. Providers cannot readily be blinded to a skilled manual technique they deliver. Participants cannot easily be blinded unless a sham SMT is devised, which may itself have therapeutic effect. When the primary outcomes are self-reported, blinding the outcome assessor is also less relevant. Nevertheless, these CBRG criteria are widely used.

Funding

The source of funding is an important methodological consideration because of the potential for funding bias [58,59]. The source of funding for the included studies is presented in Table 12. All of the included studies reported a funding source, which was either a not-for-profit agency (n=11) or a government organization (n=5). Three of the included studies also reported an in-kind donation or the use of equipment for the RCT from private industry, indicating that the results of this review are likely not influenced by funding bias.

Harms

Spinal manipulation therapy appears to be relatively safe, as no harms were attributed to SMT in the five studies

Table 12
Funding organization details

Author, year [reference]	Government	Industry	Nonprofit
Andersson et al., 1999 [26]			American Osteopathic Association, USA
Cherkin et al., 1998 [45]	Agency for Health Care Policy and Research, USA		
Childs et al., 2004 [28]	Wilford Hall Medical Center Commander's Intramural Research Funding Program, USA		Foundation for Physical Therapy, USA
Farrell and Twomey, 1982 [46]			Western Australian Manipulative Therapy Association, Australia Nuffield Foundation, UK
Glover et al., 1974 [47]			
Godfrey et al., 1984 [48]	National Institute of Neurological, Communicative Disorders and Stroke, USA		
Hadler et al., 1987 [49]			Robert Wood Johnson Foundation, USA
Hancock et al., 2007 [29]	National Health and Medical Research Council, Australia	Alphapharm (in-kind donation)	
Hoiriis et al., 2004 [31]			Life University, USA
Hurley et al., 2004 [32]*		TensCare Ltd, UK (loaned the interferential therapy units)	University of Ulster and UK Society of Orthopedic Medicine, UK Manipulation Association of Chartered Physiotherapists, UK
MacDonald and Bell, 1990 [50]		Rehabilitation Products Ltd (loaned the manipulation couches)	Osteopathic Trust Ltd, UK
Mathews et al., 1987 [51]	Department of Health and Social Security, UK		Special Trustees St. Thomas Hospital, UK
Postacchini et al., 1988 [52]			Centro Studi di Patologia Vertebrale Roma, Italy
Santilli et al., 2006 [33]			*Centro Studi di Patologia Vertebrale Roma, Italy; Universit a di Roma; and Clinica Neurologica, Ospedale "San Gerardo" Monza, and Istituto, Italy

* This study reported that two of the three institutions listed provided funding for the trial but did not indicate which ones.

that reported harms data. Because RCTs are typically not powered to estimate the risk of harms, the literature on this topic was also briefly reviewed to provide additional information about the known or potential harms of SMT. After reviewing this literature, it appears that harms associated with SMT can be divided into relatively common, minor, temporary, and self-limiting harms (eg, side effects), or very rare, more serious adverse events (SAEs).

Minor, temporary, and self-limiting harms

The minor, temporary, and self-limiting harms that have been reported after lumbar SMT include local discomfort, stiffness, radiating pain, and fatigue; these symptoms are typically reported to last between several hours and a few days [8,60]. These minor, temporary, and self-limiting harms have been reported by 30% to 50% of those receiving lumbar SMT and have also been reported more frequently in females [61].

Very rare serious adverse events

In contrast, very rare SAEs have only been reported in the literature through case reports or case series. The main

types of SAEs associated with lumbar SMT are lumbar disc injury, cauda equina syndrome, spinal cord ischemia or infarct, vertebral fracture, and epidural hematoma [62–70]. These very rare SAEs are reported so infrequently that few risk factors have yet been identified, though anticoagulation therapy may be associated with epidural hematoma. In addition, the frequency of very rare SAEs is difficult to estimate with any precision, as this requires estimating both a very small numerator (ie, reported SAEs) and a very large denominator (ie, total number of lumbar SMT in a given period). One review reported that the rate of disc herniation or cauda equina syndrome after lumbar SMT was 1 per 3.7 million procedures; the confidence interval around this estimate is unknown but likely to be wide [71].

Conclusion

Based on the RCTs reviewed, SMT appears to be effective for pain reduction in the short, intermediate, and long terms. One-third of the studies included in this SR demonstrated more pain reduction with SMT than for control groups at one or more time points, whereas two-thirds

showed no difference between SMT and the control groups. No study found SMT to be inferior to other treatments in regard to pain reduction at any time. There is no evidence to suggest that a higher number of treatment sessions with SMT was superior to the commonly used 5 to 10 treatment sessions. With the currently available evidence, the choice of SMT versus other treatment approaches for acute LBP cannot be made on the basis of relative efficacy alone. That decision must, therefore, be based on patient preference, treatment availability, treatment cost, or other factors.

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References

- [1] Waxman R, Tennant A, Helliwell P. A prospective follow-up study of low back pain in the community. *Spine* 2000;25:2085–90.
- [2] Cassidy JD, Cote P, Carroll LJ, Kristman V. Incidence and course of low back pain episodes in the general population. *Spine* 2005;30:2817–23.
- [3] Loney PL, Stratford PW. The prevalence of low back pain in adults: a methodological review of the literature. *Phys Ther* 1999;79:384–96.
- [4] Walker BF. The prevalence of low back pain: a systematic review of the literature from 1966 to 1998. *J Spinal Disord* 2000;13:205–17.
- [5] Linton SJ, Ryberg M. Do epidemiological results replicate? The prevalence and health-economic consequences of neck and back pain in the general population. *Eur J Pain* 2000;4:347–54.
- [6] Dionne CE, Dunn KM, Croft PR, et al. A consensus approach toward the standardization of back pain definitions for use in prevalence studies. *Spine* 2008;33:95–103.
- [7] Furlan AD, Pennick V, Bombardier C, van TM. 2009 updated method guidelines for systematic reviews in the Cochrane Back Review Group. *Spine* 2009;34:1929–41.
- [8] Andersson GB, Svensson HO, Oden A. The intensity of work recovery in low back pain. *Spine* 1983;8:880–4.
- [9] Atroshi I, Andersson IH, Gummesson C, et al. Primary care patients with musculoskeletal pain. Value of health-status and sense-of-coherence measures in predicting long-term work disability. *Scand J Rheumatol* 2002;31:239–44.
- [10] Roland M, Morris R. A study of the natural history of low-back pain. Part II: development of guidelines for trials of treatment in primary care. *Spine* 1983;8:145–50.
- [11] Stanton TR, Henschke N, Maher CG, et al. After an episode of acute low back pain, recurrence is unpredictable and not as common as previously thought. *Spine* 2008;33:2923–8.
- [12] Kovacs FM, Abaira V, Zamora J, Fernandez C. Spanish Back Pain Research N. The transition from acute to subacute and chronic low back pain: a study based on determinants of quality of life and prediction of chronic disability. *Spine* 2005;30:1786–92.
- [13] Manek NJ, MacGregor AJ. Epidemiology of back disorders: prevalence, risk factors, and prognosis. *Curr Opin Rheumatol* 2005;17:134–40.
- [14] Dagenais S, Caro J, Haldeman S. A systematic review of low back pain cost of illness studies in the United States and internationally. *Spine J* 2008;8:8–20.
- [15] Chou R, Qaseem A, Snow V, et al. Diagnosis and treatment of low back pain: a joint clinical practice guideline from the American College of Physicians and the American Pain Society. *Ann Intern Med* 2007;147:478–91.
- [16] van Tulder MW, Becker A, Bekkering T, et al. European guidelines for the management of acute nonspecific low back pain in primary care. *Eur Spine J* 2006;15(Suppl 2):S169–91.
- [17] Dagenais S, Tricco AC, Haldeman S. Synthesis of recommendations for the assessment and management of low back pain from recent clinical practice guidelines. *Spine J* 2010;10:514–29.
- [18] Haldeman S, Dagenais S. A supermarket approach to the evidence-informed management of chronic low back pain. *Spine J* 2008;8:1–7.
- [19] Bronfort G, Haas M, Evans R, et al. Evidence-informed management of chronic low back pain with spinal manipulation and mobilization. *Spine J* 2008;8:213–25.
- [20] Wiese G, Challender A. History of spinal manipulation. In: Haldeman S, Dagenais S, Budgell B, eds. *Principles and practice of chiropractic*. 3rd ed. New York, NY: McGraw-Hill, 2005.
- [21] Shekelle PG, Adams AH, Chassin MR, et al. Spinal manipulation for low-back pain. *Ann Intern Med* 1992;117:590–8.
- [22] Stone PW. Popping the (PICO) question in research and evidence-based practice. *Appl Nurs Res* 2002;15:197–8.
- [23] Assendelft WJ, Morton SC, Yu EI, et al. Spinal manipulative therapy for low back pain. *Cochrane Database Syst Rev* 2004;CD000447.
- [24] Bronfort G, Evans RL, Maiers M, Anderson AV. Spinal manipulation, epidural injections, and self-care for sciatica: a pilot study for a randomized clinical trial. *J Manipulative Physiol Ther* 2004;27:503–8.
- [25] van Tulder M, Furlan A, Bombardier C, Bouter L. Updated method guidelines for systematic reviews in the Cochrane Collaboration Back Review Group. *Spine* 2003;28:1290–9.
- [26] Andersson GB, Lucente T, Davis AM, et al. A comparison of osteopathic spinal manipulation with standard care for patients with low back pain. *N Engl J Med* 1999;341:1426–31.
- [27] Bronfort G, Evans RL, Anderson AV, et al. Nonoperative treatments for sciatica: a pilot study for a randomized clinical trial. *J Manipulative Physiol Ther* 2000;23:536–44.
- [28] Childs JD, Fritz JM, Flynn TW, et al. A clinical prediction rule to identify patients with low back pain most likely to benefit from spinal manipulation: a validation study. *Ann Intern Med* 2004;141:920–8.
- [29] Hancock MJ, Maher CG, Latimer J, et al. Assessment of diclofenac or spinal manipulative therapy, or both, in addition to recommended first-line treatment for acute low back pain: a randomised controlled trial. *Lancet* 2007;370:1638–43.
- [30] Hay EM, Mullis R, Lewis M, et al. Comparison of physical treatments versus a brief pain-management programme for back pain in primary care: a randomised clinical trial in physiotherapy practice. *Lancet* 2005;365:2024–30.
- [31] Hoiriis KT, Pflieger B, McDuffie FC, et al. A randomized clinical trial comparing chiropractic adjustments to muscle relaxants for subacute low back pain. *J Manipulative Physiol Ther* 2004;27:388–98.
- [32] Hurley DA, McDonough SM, Dempster M, et al. A randomized clinical trial of manipulative therapy and interferential therapy for acute low back pain. *Spine* 2004;29:2207–16.
- [33] Santilli V, Beghi E, Finucci S. Chiropractic manipulation in the treatment of acute back pain and sciatica with disc protrusion: a randomized double-blind clinical trial of active and simulated spinal manipulations. *Spine J* 2006;6:131–7.
- [34] Flynn TW, Childs JD, Fritz JM. The audible pop from high-velocity thrust manipulation and outcome in individuals with low back pain. *J Manipulative Physiol Ther* 2006;29:40–5.
- [35] Fritz JM, Whitman JM, Childs JD. Lumbar spine segmental mobility assessment: an examination of validity for determining intervention

- strategies in patients with low back pain. *Arch Phys Med Rehabil* 2005;86:1745–52.
- [36] George SZ, Fritz JM, Childs JD, Brennan GP. Sex differences in predictors of outcome in selected physical therapy interventions for acute low back pain. *J Orthop Sports Phys Ther* 2006;36:354–63.
- [37] Goldstein MS, Morgenstern H, Hurwitz EL, Yu F. The impact of treatment confidence on pain and related disability among patients with low-back pain: results from the University of California, Los Angeles, low-back pain study. *Spine J* 2002;2:391–9; discussion 399–401.
- [38] Hurwitz EL, Morgenstern H, Chiao C. Effects of recreational physical activity and back exercises on low back pain and psychological distress: findings from the UCLA Low Back Pain Study. *Am J Public Health* 2005;95:1817–24.
- [39] Hurwitz EL, Morgenstern H, Vassilaki M, Chiang L-M. Adverse reactions to chiropractic treatment and their effects on satisfaction and clinical outcomes among patients enrolled in the UCLA Neck Pain Study. *J Manipulative Physiol Ther* 2004;27:16–25.
- [40] Hurwitz EL, Morgenstern H, Yu F. Satisfaction as a predictor of clinical outcomes among chiropractic and medical patients enrolled in the UCLA Low Back Pain Study. *Spine* 2005;30:2121–8.
- [41] Kominski GF, Heslin KC, Morgenstern H, et al. Economic evaluation of four treatments for low-back pain: results from a randomized controlled trial. *Med Care* 2005;43:428–35.
- [42] Seferlis T, Lindholm L, Nemeth G. Cost-minimisation analysis of three conservative treatment programmes in 180 patients sick-listed for acute low-back pain. *Scand J Prim Health Care* 2000;18:53–7.
- [43] Shearar KA, Colloca CJ, White HL. A randomized clinical trial of manual versus mechanical force manipulation in the treatment of sacroiliac joint syndrome. *J Manipulative Physiol Ther* 2005;28:493–501.
- [44] Skillgate E, Vingard E, Alfredsson L. Naprapathic manual therapy or evidence-based care for back and neck pain: a randomized, controlled trial. *Clin J Pain* 2007;23:431–9.
- [45] Cherkin DC, Deyo RA, Battie M, et al. A comparison of physical therapy, chiropractic manipulation, and provision of an educational booklet for the treatment of patients with low back pain. *N Engl J Med* 1998;339:1021–9.
- [46] Farrell JP, Twomey LT. Acute low back pain. Comparison of two conservative treatment approaches. *Med J Aust* 1982;1:160–4.
- [47] Glover JR, Morris JG, Khosla T. Back pain: a randomized clinical trial of rotational manipulation of the trunk. *Br J Ind Med* 1974;31:59–64.
- [48] Godfrey CM, Morgan PP, Schatzker J. A randomized trial of manipulation for low-back pain in a medical setting. *Spine* 1984;9:301–4.
- [49] Hadler NM, Curtis P, Gillings DB, Stinnett S. A benefit of spinal manipulation as adjunctive therapy for acute low-back pain: a stratified controlled trial. *Spine* 1987;12:702–6.
- [50] MacDonald RS, Bell CM. An open controlled assessment of osteopathic manipulation in nonspecific low-back pain. *Spine* 1990;15:364–70.
- [51] Mathews JA, Mills SB, Jenkins VM, et al. Back pain and sciatica: controlled trials of manipulation, traction, sclerosant and epidural injections. *Br J Rheumatol* 1987;26:416–23.
- [52] Postacchini F, Facchini M, Palieri P. Efficacy of various forms of conservative treatment in low back pain. *Neuro Orthop* 1988;6:28–35.
- [53] Bronfort G, Haas M, Evans RL, Bouter LM. Efficacy of spinal manipulation and mobilization for low back pain and neck pain: a systematic review and best evidence synthesis. *Spine J* 2004;4:335–56.
- [54] Gotzsche PC. Multiple publication of reports of drug trials. *Eur J Clin Pharmacol* 1989;36:429–32.
- [55] Tramer MR, Reynolds DJ, Moore RA, McQuay HJ. Impact of covert duplicate publication on meta-analysis: a case study. *BMJ* 1997;315:635–40.
- [56] von Elm E, Poggia G, Walder B, Tramer MR. Different patterns of duplicate publication: an analysis of articles used in systematic reviews. *JAMA* 2004;291:974–80.
- [57] Shekelle PG, Adams AH, Chassin MR, et al. The appropriateness of spinal manipulation for low back pain: indications and ratings by a multi-disciplinary expert panel. Santa Monica, CA: RAND, 1991. Report No.: R-4025/2-CCR/FCER.
- [58] Lexchin J, Bero LA, Djulbegovic B, Clark O. Pharmaceutical industry sponsorship and research outcome and quality: systematic review. *BMJ* 2003;326:1167–70.
- [59] Bekelman JE, Li Y, Gross CP. Scope and impact of financial conflicts of interest in biomedical research: a systematic review. *JAMA* 2003;289:454–65.
- [60] Senstad O, Leboeuf-Yde C, Borchgrevink C. Frequency and characteristics of side effects of spinal manipulative therapy. *Spine (Phila, PA, 1976)* 1997;22:435–40.
- [61] Barrett AJ, Breen AC. Adverse effects of spinal manipulation. *J R Soc Med* 2000;93:258–9.
- [62] Gallinaro P, Cartesegna M. Three cases of lumbar disc rupture and one of cauda equina associated with spinal manipulation (chiropraxis). *Lancet* 1983;1:411.
- [63] Oppenheim JS, Spitzer DE, Segal DH. Nonvascular complications following spinal manipulation. *Spine J* 2005;5:660–6.
- [64] Dan NG, Saccasan PA. Serious complications of lumbar spinal manipulation. *Med J Aust* 1983;2:672–3.
- [65] Haldeman S, Rubinstein SM. Cauda equina syndrome in patients undergoing manipulation of the lumbar spine. *Spine* 1992;17:1469–73.
- [66] Haldeman S, Rubinstein SM. Compression fractures in patients undergoing spinal manipulative therapy. *J Manipulative Physiol Ther* 1992;15:450–4.
- [67] Morandi X, Riffaud L, Houedakor J, et al. Caudal spinal cord ischemia after lumbar vertebral manipulation. *Joint Bone Spine* 2004;71:334–7.
- [68] Balblanc JC, Pretot C, Ziegler F. Vascular complication involving the conus medullaris or cauda equina after vertebral manipulation for an L4-L5 disk herniation. *Rev Rhum Engl Ed* 1998;65:279–82.
- [69] Whedon JM, Quebada PB, Roberts DW, Radwan TA. Spinal epidural hematoma after spinal manipulative therapy in a patient undergoing anticoagulant therapy: a case report. *J Manipulative Physiol Ther* 2006;29:582–5.
- [70] Solheim O, Jorgensen JV, Nygaard OP. Lumbar epidural hematoma after chiropractic manipulation for lower-back pain: case report. *Neurosurgery* 2007;61:E170–1.
- [71] Oliphant D. Safety of spinal manipulation in the treatment of lumbar disk herniations: a systematic review and risk assessment. *J Manipulative Physiol Ther* 2004;27:197–210.