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REVIEW ARTICLE

Surgery or physical activity in the management of sciatica: a systematic review and meta-analysis

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Abstract
Purpose Previous reviews have compared surgical to non-surgical management of sciatica, but have overlooked the specific comparison between surgery and physical activity-based interventions.
Methods Systematic review using MEDLINE, CINAHL, Embase and PEDro databases was conducted. Randomised controlled trials comparing surgery to physical activity, where patients were experiencing the three most common causes of sciatica—disc herniation, spondylolisthesis and spinal stenosis. Two independent reviewers extracted pain and disability data (converted to a common 0–100 scale) and assessed methodological quality using the PEDro scale. The size of the effects was estimated for each outcome at three different time points, with a random effects model adopted and the GRADE approach used in summary conclusions.
Results Twelve trials were included. In the short term, surgery provided better outcomes than physical activity for disc herniation: disability [WMD −9.00 (95 % CI −13.73, −4.27)], leg pain [WMD −16.01 (95 % CI −23.00, −9.02)] and back pain [WMD −12.44 (95 % CI −17.76, −7.09)]; for spondylolisthesis: disability [WMD −14.60 (95 % CI −17.12, −12.08)], leg pain [WMD −35.00 (95 % CI −39.66, −30.34)] and back pain [WMD −20.00 (95 % CI −24.66, −15.34)] and spinal stenosis: disability [WMD −11.39 (95 % CI −17.31, −5.46)], leg pain [WMD, −27.17 (95 % CI −35.87, −18.46)] and back pain [WMD −20.80 (95 % CI −25.15, −16.44)]. Long-term and greater than 2-year post-randomisation results favoured surgery for spondylolisthesis and stenosis, although the size of the effects reduced with time. For disc herniation, no significant effect was shown for leg and back pain comparing surgery to physical activity.
Conclusion There are indications that surgery is superior to physical activity-based interventions in reducing pain and disability for disc herniation at short-term follow-up only; but high-quality evidence in this field is lacking (GRADE). For spondylolisthesis and spinal stenosis, surgery is superior to physical activity up to greater than 2 years follow-up. Results should guide clinicians and patients when facing the difficult decision of having surgery or engaging in active care interventions.
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Keywords Sciatica · Surgery · Physical activity · Systematic review · Meta-analysis

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Introduction

Sciatica is a complaint believed to arise from a disorder related to the spinal nerve or nerve root [1]. It is characterised by radiating pain in one or more lumbar or sacral dermatomes and is often accompanied by sensory and motor changes. While less common than low back pain [2], patients with sciatica experience more severe symptoms [3]. Estimates for the annual prevalence of sciatica vary greatly, ranging from 2.2 to 34 %, most likely due to differences in the definition of sciatica [4]. Sciatica is usually attributed to herniated intervertebral discs leading to nerve root compromise, but can also have other causes such as lumbar spinal stenosis, spondylolisthesis, tumours or cysts [5]. Furthermore, other conditions can mimic sciatica, including sacroiliac joint [6], myofascial [7] and degenerative hip joint pain [8].

Whilst there is limited knowledge on the prognosis for sciatica, [9] many will improve within weeks to months yet approximately one-third of patients will develop persistent symptoms for at least 12 months [2]. Most patients are treated non-surgically in the first 6–8 weeks, [10] through analgesics or various physical therapies. Staying active and avoiding bed rest have also been recommended for sciatica [10]. Previous systematic reviews have investigated the efficacy of conservative treatments for sciatica and have either found little evidence of one type of conservative treatment being superior to another, [10] insufficient evidence to confidently recommend any analgesic medicine [11] or corticosteroid injections for pain relief [1]. No previous review has specifically assessed the effectiveness of physical activity prescription for sciatica—e.g. advice to stay active or undertake a structured exercise programme [12].

Surgery for sciatica is also a treatment option but only recommended if symptoms persist following a trial of conservative treatment [13]. The primary rationale is that surgery will relieve nerve root irritation or compression due to a herniated disc [14] with microdiscectomy being the most commonly used surgical technique. Recent evidence from a systematic review, [14] which compared surgery to conservative treatment, found that early surgery provided better short-term relief, although no significant between-group differences were observed after 1–2 years. However, conservative care typically included a combination of passive [15] and active approaches. Because previous systematic reviews have failed to specifically compare surgery to physical activity, we currently do not know whether surgery is superior to interventions based on physical activity either delivered by a qualified practitioner or when patients are encouraged to be physically active. Given that physical activity is a promising intervention in treating and preventing a variety of health conditions, [16] including low back pain [17], it could potentially have a positive effect in the management of sciatica. The objective of this review is to evaluate the available evidence comparing surgery to physical activity (exercises or advice to stay active) in the management of sciatica.

Methods

Data sources and searches

The MEDLINE, CINAHL, Embase and PEDro databases were searched independently by two authors (MF, IRS) from the earliest record to 15 May 2013, identifying randomised controlled trials comparing surgery to physical activity-based interventions. Search terms included sciatica, synonyms of sciatica, randomised controlled trials and surgery (Supplementary Table 1). Studies were identified when surgery was compared to physical activity-based interventions. Reference lists of included studies, conference proceedings, unpublished reports and clinical trials registries were also searched, with no language or geographic restrictions.

Study selection

Eligible studies were confined to randomised controlled trials that compared surgery versus physical activity in the management of sciatica. Eligible trials needed to enrol patients experiencing sciatica or a synonym for sciatica, including lumbosacral radicular syndrome, nerve root compromise, radiculopathy, nerve root pain and nerve root entrapment. Studies with acute, subacute and chronic sciatica were included. Trials enrolling patients with spinal stenosis or spondylolisthesis were also eligible if the patients specifically experienced sciatica. Trials including patients who previously had spinal surgery or serious spinal pathology such as cancer, fracture, infection, cauda equina syndrome or progressive neurologic deficit that required urgent surgery were excluded from this review. Studies that included surgery versus passive therapies such as prescribed medication or epidural corticosteroid injections were also excluded.

All types of surgical procedures conducted in patients with sciatica, irrespective of diagnosis, were eligible to be included. Studies were eligible if physical activity was investigated as a separate intervention or if they were integrated into non-surgical care packages. Physical activity included any form of planned, structured and repetitive exercise [12] supervised by a health professional, as well as advice to stay active/engage in physical activity.

Trials were considered eligible if they reported pain and/or disability outcomes.

Data extraction and quality assessment

Two reviewers (MF, IRS) independently assessed trials' methodological quality, using the PEDro scale [18–20]. A PEDro score of 7 or greater was considered 'high quality', those with a score of 5 or 6 were considered 'moderate quality' and those with a score of 4 or less 'poor quality' [21]. Scoring disagreements were resolved by consensus. Methodological quality was not an inclusion criterion. Two reviewers (MF, IRS) also independently extracted outcome data using a standardised data extraction form. When there was insufficient information in trial reports, authors were contacted or data imputed using methods recommended in the Cochrane Handbook for Systematic Reviews of Interventions [22] (Supplementary Table 2).

The GRADE (Grading of Recommendations Assessment, Development and Evaluation) approach was used by two independent reviewers (MF, IRS) to evaluate the overall quality of evidence and the strength of the recommendation [23], as advocated by the Cochrane Back Review Group [24]. The overall quality of evidence was initially regarded as "High" but downgraded by 1 level for each of three factors encountered: limitations in the design (>25 % of patients from studies with low-quality methods—PEDro score <7 points); inconsistency of results ($I^2 > 50$ %); imprecision (<400 patients in total for each outcome). Publication bias was not assessed with a funnel plot as too few studies were included in the meta-analyses. Indirectness was also not considered for this review due to the presence of a specific population, relevant outcome measures and direct comparisons.

The following defined the quality of evidence [25]: high quality—further research is unlikely to change our confidence in the estimate of effect; moderate quality—further research is likely to have an important impact on our confidence in the estimate of effect and might change the estimate; low quality—further research is likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate and very low quality—we are uncertain about the estimate.

Data synthesis and analysis

For the initial analysis, disc herniation, spondylolisthesis and stenosis trials were grouped together and pooled according to (1) outcome (pain and disability) and (2) time points (short term, long term and beyond). Trials were then pooled separately by diagnostic subgroup for short- and long-term and beyond follow-up points. Pooling was carried out with Comprehensive Meta-Analysis software, version 2.2.064 (Biostat, Englewood, NJ) and calculated using a random effects model. Weighted mean difference (WMD) with 95 % confidence intervals were calculated as the difference in means between groups. Heterogeneity was evaluated by the I^2 Statistic, with $I^2 > 30$ %, $I^2 > 50$ % and $I^2 > 75$ % indicating moderate, substantial and considerable heterogeneity [22].

Outcome data were extracted for short-term (>2 weeks but ≤3 months) and long-term (≥12 months but ≤24 months) follow-up evaluations. Additional outcome data were extracted if available beyond 24 months. Pain intensity scales and disability scores were converted to a common scale from 0 (no pain/disability) to 100 (worst possible pain/disability). The conversion of data to a common scale has been utilised in previous systematic reviews [1, 11], which have evaluated pain and disability outcome measures. Proposed thresholds for clinically meaningful within-person reductions in pain and disability have been previously reported to range between 10 and 30 points on a scale of 0 to 100 [26, 27]. We considered a mean difference of at least 10 points to be clinically significant. When more than one outcome measure was used to assess intensity of pain or disability, the primary outcome measure for the trial was utilised. Pain and disability outcome measures used to calculate pooled effects are summarised in Supplementary Table 2.

Results

Supplementary Figure 1 illustrates the flow of trials retrieved throughout this review. Database searches identified 5768 potential studies of interest. Citations were screened by title and abstract and a total of 179 articles were retrieved for evaluation in full text. A total of 17 published papers were included in this review, [13, 28–43] with a number of published reports on the same trial identified. One report was excluded due to identical data [44] and others were included as they provided results for different time points [37–40, 43]. In six trials, patients were diagnosed with lumbar disc herniation, in two trials with spondylolisthesis and in four trials patients had lumbar spinal stenosis. Three studies provided insufficient data for outcome measures and were excluded from the meta-analysis [28, 29, 33].

The following surgical procedures were included in the trials: microdiscectomy, [13, 32, 42] open discectomy [33, 36] and fluoroscopic-guided percutaneous disc decompression [29] for disc herniation. Decompressive laminectomy [34] and posterior-lateral fusion [31] were used for spondylolisthesis, while partial or total laminectomy, medial facetectomy, discectomy, osteophyte removal, hypertrophic ligament removal or fusion [28, 30, 35, 41] were employed for spinal stenosis. Interventions based on physical activity included encouragement to stay active and resume physical activity, [13, 28, 29, 32] isometric exercises, [32, 33] supervised exercise programme by a physiotherapist, [29, 31] home-based structured exercise (flexibility, strength, conditioning and stabilisation), [28, 30, 34–36, 41, 42] and advice on ergonomics and exercise principles [30]. Table 1 shows the characteristics of the included trials.

The methodological quality assessment using the PEDro scale (scored out of 10) revealed a mean score of 5.7 (SD = 0.9). Three studies were considered 'high quality', [13, 30, 37] thirteen studies considered 'moderate quality' [28, 31–36, 38–43] and one study considered 'poor quality' [29]. Details are reported in Supplementary Table 3. In brief, the most apparent weakness was absence of participant and therapist blinding. Duration of symptoms varied amongst studies, with one trial investigating participants with acute symptoms, [33] three trials with subacute symptoms [13, 32, 36] and five trials with chronic symptoms [28, 30, 31, 34, 35]. In three trials, duration was not specified [29, 41, 42].

Individual trial effect sizes are summarised in Supplementary Table 2. All trials used a combination of clinical assessment and imaging to define sciatica, while one study used imaging for the surgical group only [31]. Pooling of data was possible for disability outcomes, leg pain and back pain intensity at short- and long-term and greater than 2-year follow-up points.

Analysis

The results for the initial meta-analysis of all studies (i.e. disc herniation, spondylolisthesis and stenosis trials pooled together) comparing the effects of surgery versus physical activity showed considerable statistical heterogeneity ($I^2 = 91$ %). The effects are therefore discussed separately by diagnosis.

Sciatica associated with disc herniation

The results for the meta-analysis for the short-term follow-up show there is 'low-quality evidence' according to the GRADE approach (Table 2), that surgery has a small positive effect on reducing disability outcomes compared physical activity (four studies, $I^2 = 55$ %, WMD −9.00 (95 % CI −13.73, −4.27)], 'low-quality evidence' that surgery has a positive effect for leg pain intensity compared to physical activity (four studies, $I^2 = 71$ %, WMD −16.01 (95 % CI −23.00, −9.02)] and 'moderate quality evidence' that surgery has a positive effect for back pain intensity compared to physical activity [three studies, $I^2 = 12$ %, WMD, −12.44 (95 % CI−17.76, −7.09)] (Fig. 1a). Long-term follow-up results show 'moderate quality evidence' that surgery has a small positive effect on reducing disability outcomes compared to physical activity (four studies, $I^2 = 47$ %, WMD −4.31 (95 % CI −8.46, −0.15)], 'low-quality evidence' that surgery has no significant effect for leg pain intensity compared to physical activity (four studies, $I^2 = 78$ %, WMD −6.38 (95 % CI −13.21, 0.44)] and 'very low-quality evidence' that surgery has no significant effect for back pain intensity compared to physical activity [three studies, $I^2 = 72$ %, WMD −6.31 (95 % CI −17.44, 4.81)] (Fig. 1b). Analysis of greater than two-year follow-up showed 'moderate quality evidence' that surgery has no significant effect on reducing disability outcomes compared to physical activity (four studies, $I^2 = 25$ %, WMD −2.74 (95 % CI −6.06, 0.59)], 'low-quality evidence' that surgery has no significant effect for leg pain intensity compared to physical activity (four studies, $I^2 = 55$ %, WMD −3.97 (95 % CI −9.12, 1.19)] and 'low-quality evidence' that surgery has no significant effect for back pain intensity compared to physical activity [three studies, $I^2 = 21$ %, WMD −4.94 (95 % CI −10.64, 0.77)] (Fig. 1c). The size of the effect ranged from 2 to 16 points on a 0–100 scale for disc herniation.

Sciatica associated with spondylolisthesis

The results for the meta-analysis for the short-term follow-up show 'moderate quality evidence' that surgery has a positive effect on reducing disability outcomes compared to physical activity [one study, WMD −14.60 (95 % CI −17.12, −12.08)], 'moderate quality evidence' that surgery has a positive effect for leg pain intensity compared to physical activity [one study, WMD −35.00 (95 % CI −39.66, −30.34)] and 'moderate quality evidence' that surgery has a positive effect for back pain intensity compared to physical activity [one study, WMD −20.00 (95 % CI −24.66, −15.34)] (Fig. 2a). Long-term follow-up results show 'moderate quality evidence' that surgery has a positive effect on reducing disability outcomes compared to physical activity [two studies, $I^2 = 0$ %, WMD −17.77 (95 % CI −20.59, −14.96)], 'moderate quality evidence' that surgery has a positive effect on leg pain intensity compared to physical activity [one study, WMD −28.40, (95 % CI −33.05, −23.74)] and 'moderate quality evidence' that surgery has a positive effect on back pain intensity compared to physical activity [one study, WMD −21.67, (95 % CI −26.33, −17.01)] (Fig. 2b). Analysis of greater than 2-year follow-up showed 'moderate quality evidence' that surgery has a positive effect on reducing disability outcomes compared to physical activity [two studies, $I^2 = 0$ %, WMD −16.55 (95 % CI −19.54,

Table 1 Characteristics of the included studies

Study	Patient characteristics and sample size	Participants (inclusion criteria)	Interventions	Primary outcomes (measures) and time points
Disc herniation				
Osterman [32]	$N = 56$ (surgery group = 28, physical activity group = 28) % Female = 39 % (surgery group = 46 %, physical activity group = 32 %) Mean age (range) = 37.5 (20–50); surgery group = 37, physical activity group = 38	Below knee radicular pain of 6–12 wks CT evidence of intervertebral disc extrusion or sequester, one of: positive SLR test <70°, muscle weakness, altered DTR or dermatomal sensory change	Surgery group: microdiscectomy (within 2 wks) Physical activity group: early physical activity within pain limits initially encouraged, isometric muscle exercises. All received active physiotherapeutic instructions	Leg pain intensity (VAS); 6 wk, 3 mo, 6 mo, 1 and 2 yr
Peul [13, 37], Lequin [43]	$N = 283$ (surgery group = 141, physical activity group = 142) % Female: 34 % (surgery group = 37 %, physical activity group = 32 %) Mean age (range) = 42.6(18–65); surgery group = 41.7, physical activity group = 43.4	Radiologically confirmed disc herniation, lumbosacral radicular syndrome diagnosed by neurologist, dermatomal pattern of pain, correlation with MRI findings	Surgery group: microdiscectomy (within 2 wks) Physical activity group: resume daily activity with medical practitioner care and education of natural history of disc herniation, NSAIDs prescription as required	RMDQ, leg pain intensity (VAS), global perceived recovery (self-rating); 2, 4, 8, 12, 26, 38 and 52, 104 and 260 wks
Weinstein [35, 36]	$N = 501$ (surgery group = 232, physical activity group = 240) % Female: 41 % (surgery group = 44 %, physical activity group = 39 %) Mean age (range) = 42; surgery group = 41.7; physical activity group = 43	Diagnosis of IVD herniation by physician, radicular pain below the knee/anterior upper thigh, SLR positive 30°–70°, positive femoral NR test or corresponding neurological deficit, CT and MRI confirmed IVD herniation	Surgery group: standard open discectomy Physical activity group: individualised active physical therapy (flexibility, strength, conditioning, stabilisation) as home exercise, education and counselling with NSAIDs, opioid analgesics, epidural injections if tolerated	SF-36 bodily pain and physical function scales, ODI; 6 wks, 3 mo, 6 mo, 1, 2, 3 and 4 yr
Weber [33]	$N = 126$ (surgery group = 60, physical activity group = 66) % Female = 46 % (surgery group = 47 %, physical activity group = 45 %) Mean age (range): 41 (25–55); surgery group = 40.0; physical activity group = 41.7	Clinical signs and symptoms of L5, S1 nerve root lesion, corresponding with radiculography for at least 14 days	Surgery group: lumbar discectomy Physical activity group: moderate isometrics exercises, Back School instructions, Physiotherapy and analgesic medication, wide belts/crutches, strict to partial bed rest	Questionnaire; 3, 6, 9 mo, 2, 3 yr Doctors perception: work capacity, presence/absence of pain, need for analgesics, participation in leisure activities, spinal mobility, neurological test, tenderness; 1, 4 and 10 yr

Table 1 continued

Study	Patient characteristics and sample size	Participants (inclusion criteria)	Interventions	Primary outcomes (measures) and time points
Erginousakis [29]	$N = 62$ (surgery group = 31, physical activity group = 31) % Female = 42 % (surgery group 1 = 39 %, physical activity group = 45 %) Mean age (range): 37; surgery group = 38, physical activity group = 36	Small/medium sized disc herniation on MRI Leg pain with/without back pain Leg pain > back pain Clinical signs of radiculopathy Lancinating, burning, stabbing, electrical sensation of pain, <30° positive SLR test	Surgery group: percutaneous disk decompression fluoroscopic guide Physical activity group: 6 wks of education/counselling: "remain active", monitored, registered physiotherapy plus NSAIDs, muscle relaxants	Pain intensity (NVS), Pain influence on activity and mobility impairment; 3, 12 and 24 mo
Greenfield [42]	$N = 88$ (surgery group = 44, physical activity group = 44) % Female = 43 % (surgery group = 50 %, physical activity group = 36 %) Mean age (range): 39.8; surgery group = 40.1, physical activity group = 39.5	Low back pain and sciatica, MRI evidence of small/medium LDH	Surgery group: standard microdiscectomy Physical activity group: proactive exercise and education: "Back School book", low tech physical therapy	Pain intensity (VAS); ODI; disability days; 3, 6, 12, 18 and 24 mo
Spondylolisthesis				
Möller [31]	$N = 111$ (surgery group = 77, physical activity group = 34) % Female = 49 % (surgery group = 51 %, physical activity group = 44 %) Mean age (range): 39 (18–55); surgery group = 39, physical activity group = 37	Isthmic spondylolisthesis of any grade, at least 1 yr of low back pain or sciatica, restricted functional ability	Surgery group: posterior-lateral fusion with/without transpedicular fixation Physical activity group: exercise programme from specialist physiotherapist (supervised): strength/postural training of back and abs muscles and home exercise	Disability rating index (DRI), pain intensity (VAS), overall outcome (asked to patient); 1 and 2 yr
Weinstein [34, 39]	$N = 304$ (surgery group = 159, physical activity group = 145) % Female = 66 % (groups not specified) Mean age (range): 66 (groups not specified)	Neurogenic Claudication or radicular leg pain, lateral radiographs showing degenerative spondylolisthesis, stenosis on cross-sectional imaging	Surgery group: posterior decompressive laminectomy Physical activity group: individualised active physical therapy (flexibility, strength, conditioning, stabilisation) with exercise at home, education, counselling and NSAIDs, epidural injections if tolerated	SF-36 bodily pain and physical function scores, ODI; 6 wk, 3, 6, 12, 24, 36 and 48 mo

Table 1 continued

Study	Patient characteristics and sample size	Participants (inclusion criteria)	Interventions	Primary outcomes (measures) and time points
Stenosis				
Amundsen [28]	N = 31 (surgery group = 13, physical activity group 2 = 18) % Female = 48 % (group 1 = 31 %, group 2 = 61 %) Mean age (range): 59 (16–77); groups not specified	Sciatic pain with/without back pain, radiological signs of stenosis, compression of the clinically afflicted nerve root(s)	Surgery group: partial or total laminectomy, medial facetectomy, discectomy, osteophyte removal or hypertrophic ligament removal as required Physical activity group: encourage to walk/move as normal as possible (with orthosis), instruction and back school, no initial physiotherapy. Ambulation and stabilising exercises later with orthosis removal	Pain Intensity (VAS), claudication distance, level of daily activity, neurological deficits status, patient evaluation (excellent, fair, unchanged, worse); 6 mo, 12 mo, 4 and 10 yr
Weinstein [35, 40]	N = 278 (groups not specified) % Female = 38 % (groups not specified) Mean age (range): 65.5; groups not specified	Neurogenic Claudication or radicular leg symptoms, lumbar spine stenosis on cross-sectional imaging	Surgery group: posterior decompressive laminectomy Physical activity group: "usual care", active physical therapy (flexibility, strength, conditioning, stabilisation), with exercise at home, education, counselling and NSAIDs as tolerated	SF-36 bodily pain and physical function scores, Modified ODI; 6 wk, 3 mo, 6 mo, 1, 2, 3 and 4 yr
Malmivaara [30]	N = 94 (surgery group = 50, physical activity group = 44) %Female = 67 % (surgery group = 78 %, physical activity group = 55 %) Mean age (range): 62.5; surgery group = 63, physical activity group = 62	Back pain radiation to lower limbs or buttocks; fatigue or loss of sensation in the lower limbs aggravated by walking; spinal canal narrowing on imaging	Surgery group: segmental decompression undercutting facetectomy, fusion performed if risk of lumbar instability Physical activity group: physiotherapy referral only if required, individually structured exercises programme, education of nature of stenosis, principles of activation and physical training (trunk endurance), postures, ergonomics and NSAIDs	ODI, leg pain during walking (VAS), Low back pain during walking (VAS), self-reported/measured walking ability (m); 6, 12 and 24 mo

Table 1 continued

Study	Patient characteristics and sample size	Participants (inclusion criteria)	Interventions	Primary outcomes (measures) and time points
Mariconda [41]	*N* = 44 (surgery group = 22, physical activity group = 22) % Female = 68.2% (surgery group = 72.7 %, physical activity group = 63.6%) Mean age (range): 61 (41–75); surgery group = 62.59, physical activity group = 59.59	Mild to moderate leg pain; age >40 years; narrowing of the central portion of the spinal canal with an area of the dural sac measuring less than 130 mm^2 at one or more intervertebral levels	Surgery group: unilateral laminectomy with complete removal of ligamenta flava; lateral decompression Physical activity group: physiotherapy; appropriate exercise programme and lumbar orthosis	Beaujeon scoring system of functional assessment; 1, 2 yr and 47 mo (average)

Mean age is described in years

DTR deep tendon reflex, *IVD* intervertebral disk, *NRS* numerical rating scale, *NSAID* non-steroidal anti-inflammatory drug, *NVS* numerical verbal scale, *ODI* Oswestry Index, *RMDQ* Roland-Morris Disability Questionnaire, *SF-36* 36-Item Short-Form Health Survey, *SLR* straight leg raise, *DTR* deep tendon reflexes, *IVD* intervertebral disc, *NR* nerve root, *LDH* lumbar disc herniation, *CT* computed tomography, *MRI* magnetic resonance imaging, *VAS* visual analogue scale, *mo* month(s), *wk* week(s), *yr* year(s); *m* meters

−13.55)], 'moderate quality evidence' that surgery has a positive effect on leg pain intensity compared to physical activity [one study, WMD −25.00, (95 % CI −29.98, −20.02)] and 'moderate quality evidence' that surgery has a positive effect on back pain intensity compared to physical activity [one study, WMD −16.67, (95 % CI −21.65, −11.69)] and (Fig. 2c). The size of the effect ranged from 15 to 35 points on a 0–100 scale for spondylolisthesis.

Sciatica associated with spinal stenosis

The results for the meta-analysis for the short-term follow-up show 'low-quality evidence' that surgery has a positive effect on reducing disability outcomes compared to physical activity [two studies, $I^2 = 68$ %, WMD −11.39 (95 % CI −17.31, −5.46)], 'moderate quality evidence' that surgery has a positive effect on leg pain intensity compared to physical activity [two studies, $I^2 = 46$ %, WMD, −27.17 (95 % CI −35.87, −18.46)] and 'moderate quality evidence' that surgery had a positive effect on back pain intensity compared to physical activity [two studies, $I^2 = 0$ %, WMD −20.80 (95 % CI −25.15, −16.44)] (Fig. 3a). Long-term follow-up results show 'moderate quality evidence' that surgery had a positive effect on reducing disability outcomes compared to physical activity [two studies, $I^2 = 0$ %, WMD −12.32 (95 % CI −15.03, −9.62)], 'moderate quality evidence' that surgery has a positive effect on leg pain intensity compared to physical activity [three studies, $I^2 = 0$ %, WMD −19.39, (95 % CI −23.73, −15.05)] and 'moderate quality evidence' that surgery has a positive effect on back pain intensity compared to physical activity [three studies, $I^2 = 0$ %, WMD −17.80 (95 % CI −22.09, −13.51)] (Fig. 3b). Analysis of greater than 2-year follow-up showed 'moderate quality evidence' that surgery had a positive effect on reducing disability outcomes compared to physical activity [two studies, $I^2 = 0$ %, WMD −10.64 (95 % CI −13.50, −7.78)], 'moderate quality evidence' that surgery has a positive effect on leg pain intensity compared to physical activity (three studies, $I^2 = 0$ %, WMD −17.73 (95 % CI −22.24, −13.21)] and 'moderate quality evidence' that surgery has a positive effect on back pain intensity compared to physical activity (three studies, $I^2 = 26$ %, WMD −17.99 (95 % CI −24.58, −11.40)] (Fig. 3c). The size of the effect ranged from 11 to 27 points on a 0–100 scale for spinal stenosis.

Discussion

Our systematic review showed that surgery provides better outcomes over physical activity at short-term follow-up only for disc herniation and clinically significant outcomes

Table 2 Summary of outcomes and quality of outcome assessment (GRADE)

Studies (references) by outcome	Quality assessment			Patient, *n*		Effect[a]	Quality	Importance
	Risk of bias	Inconsistency	Imprecision	Surgery group	Physical activity group	WMD (95 % CI)[c]		
Short-term								
Disability (0–100 scale)								
Disc Herniation Short-term follow-up four studies [13, 32, 36, 44]	Serious limitation (−1)[d]	Serious inconsistency (−1)[e]	No serious imprecision[f]	408	417	−9.00 (−13.73 to −4.27)	Low	Important[b]
Spondylolisthesis Short-term follow-up one study [34]	Serious limitation (−1)[d]	No serious inconsistency[e]	No serious imprecision[f]	385	320	−14.60 (−17.12 to −12.08)	Moderate	Important[b]
Stenosis Short-term follow-up two studies [30, 35]	Serious limitation (−1)[d]	Serious inconsistency (−1)[e]	No serious imprecision[f]	422	354	−11.39 (−17.31 to −5.46)	Low	Important[b]
Leg pain (0–100 scale)								
Disc Herniation Short-term follow-up four studies [13, 32, 36, 42]	Serious limitation (−1)[d]	Serious inconsistency (−1)[e]	No serious imprecision[f]	408	417	−16.01 (−23.00 to −9.02)	Low	Important[b]
Spondylolisthesis Short-term follow-up one study [34]	Serious limitation (−1)[d]	No serious inconsistency[e]	No serious imprecision[f]	385	320	−35.00 (−39.66 to − 30.34)	Moderate	Important[b]
Stenosis Short-term follow-up two studies [30, 35]	Serious limitation (−1)[d]	No serious inconsistency[e]	No serious imprecision[f]	422	354	−27.17 (−35.87 to −18.46)	Moderate	Important[b]
Back pain (0–100 scale)								
Disc Herniation Short-term follow-up three studies [13, 32, 42]	Serious limitation (−1)[d]	No serious inconsistency[e]	No serious imprecision[f]	210	206	−12.44 (−17.76 to −7.09)	Moderate	Important[b]
Spondylolisthesis Short-term follow-up one study [34]	Serious limitation (−1)[d]	No serious inconsistency[e]	No serious imprecision[f]	385	320	−20.00 (−24.66 to −15.34)	Moderate	Important[b]
Stenosis Short-term follow-up two studies [30, 35]	Serious limitation (−1)[d]	No serious inconsistency[e]	No serious imprecision[f]	422	354	−20.80 (−25.15 to −16.44)	Moderate	Important[b]
Long-term								
Disability (0–100 scale)								
Disc Herniation Long-term follow-up four studies [13, 32, 36, 42]	Serious limitation (−1)[d]	No serious inconsistency[e]	No serious imprecision[f]	402	411	−4.31 (−8.46 to −0.15)	Moderate	Important[b]
Spondylolisthesis Long-term follow-up two studies [31, 34]	Serious limitation (−1)[d]	No serious inconsistency[e]	No serious imprecision[f]	357	261	−17.77 (−20.59 to −14.96)	Moderate	Important[b]

Table 2 continued

Studies (references) by outcome	Quality assessment			Patient, *n*		Effect[a]	Quality	Importance
	Risk of bias	Inconsistency	Imprecision	Surgery group	Physical activity group	WMD (95 % CI)[c]		
Stenosis Long-term follow-up two studies [30, 35]	Serious limitation (−1)[d]	No serious inconsistency[e]	No serious imprecision[f]	350	271	−12.32 (−15.03 to −9.62)	Moderate	Important[b]
Leg pain (0–100 scale)								
Disc Herniation Long-term follow-up four studies [13, 32, 36, 42]	Serious limitation (−1)[d]	Serious inconsistency (−1)[e]	No serious imprecision[f]	402	411	−6.38 (−13.21 to −0.44)	Low	Important[b]
Spondylolisthesis Long-term follow-up one study [34]	Serious limitation (−1)[d]	No serious inconsistency[e]	No serious imprecision[f]	286	234	−28.40 (−33.05 to −23.74)	Moderate	Important[b]
Stenosis Long-term follow-up three studies [30, 35, 41]	Serious limitation (−1)[d]	No serious inconsistency[e]	No serious imprecision[f]	372	293	−19.39 (−23.73 to −15.05)	Moderate	Important[b]
Back pain (0–100 scale)								
Disc Herniation Long-term follow-up three studies [13, 32, 42]	Serious limitation (−1)[d]	Serious inconsistency (−1)[e]	Serious imprecision (−1)[f]	200	198	−6.31 (−17.44 to 4.81)	Very low	Important[b]
Spondylolisthesis Long-term follow-up one study [34]	Serious limitation (−1)[d]	No serious inconsistency[e]	No serious imprecision[f]	286	234	−21.67 (−26.33 to −17.01)	Moderate	Important[b]
Stenosis Long-term follow-up three studies [30, 35, 41]	Serious limitation (−1)[d]	No serious inconsistency[e]	No serious imprecision[f]	372	293	−17.80 (−22.09 to −13.51)	Moderate	Important[b]
Greater than 2 years follow-up								
Disability (0–100 scale)								
Disc Herniation 2 years follow-up four studies [32, 36, 37, 42]	Serious limitation (−1)[d]	No serious inconsistency[e]	No serious imprecision[f]	383	379	−2.74 (−6.06 to 0.59)	Moderate	Important[b]
Spondylolisthesis 2 years follow-up two studies [31, 34]	Serious limitation (−1)[d]	No serious inconsistency[e]	No serious imprecision[f]	399	218	−16.55 (−19.54 to −13.55)	Moderate	Important[b]
Stenosis 2 years follow-up two studies [30, 35]	Serious limitation (−1)[d]	No serious inconsistency[e]	No serious imprecision[f]	382	238	−10.64 (−13.50 to −7.78)	Moderate	Important[b]
Leg pain (0–100 scale)								
Disc herniation 2 years follow-up three studies [32, 37, 42]	Serious limitation (−1)[d]	Serious inconsistency (−1)[e]	No serious imprecision[f]	383	379	−3.97 (−9.12 to 1.19)	Low	Important[b]

Table 2 continued

Studies (references) by outcome	Quality assessment			Patient, *n*		Effect[a]	Quality	Importance
	Risk of bias	Inconsistency	Imprecision	Surgery group	Physical activity group	WMD (95 % CI)[c]		
Spondylolisthesis 2 years follow-up one study [34]	Serious limitation (−1)[d]	No serious inconsistency[e]	No serious imprecision[f]	324	187	−25.00 (−29.98 to −20.02)	Moderate	Important[b]
Stenosis 2 years follow-up three studies [30, 35, 41]	Serious limitation (−1)[d]	No serious inconsistency[e]	No serious imprecision[f]	403	258	−17.73 (−22.24 to −13.21)	Moderate	Important[b]
Back pain (0–100 scale)								
Disc herniation 2 years follow-up three studies [32, 37, 42]	Serious limitation (−1)[d]	No serious inconsistency[e]	Serious imprecision (−1)[f]	197	192	−4.94 (−10.64 to 0.77)	Low	Important[b]
Spondylolisthesis 2 years follow-up one study [34]	Serious limitation (−1)[d]	No serious inconsistency[e]	No serious imprecision[f]	329	187	−16.67 (−21.65 to −11.69)	Moderate	Important[b]
Stenosis 2 years follow-up three studies [30, 35, 41]	Serious limitation (−1)[d]	No serious inconsistency[e]	No serious imprecision[f]	403	258	−17.99 (−24.58 to −11.40)	Moderate	Important[b]

WMD weighted mean difference

[a] Negative values favour surgery group

[b] Patient-relevant outcome measures

[c] The WMD of the surgery group compared with the physical activity group

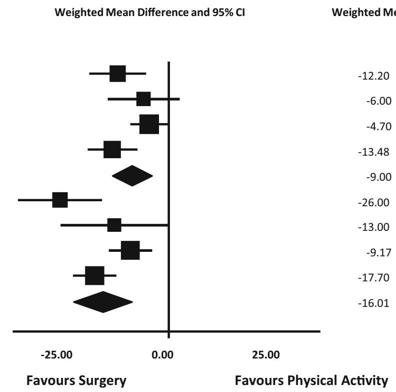
[d] More than 25 % of participants from studies with low methodological quality (Physiotherapy Evidence Database score <7 points)

[e] $I^2 > 50$ %

[f] Fewer than 400 combined participants for each outcome

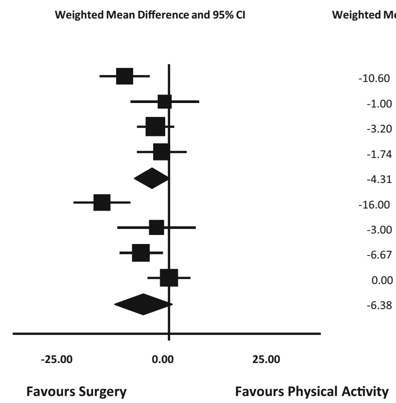
A Short term Disc Herniation

Outcome	Study name	Surgery Mean	Surgery (SD)	Surgery Total	Physical Activity Mean	Physical Activity (SD)	Physical Activity Total	Relative weight %	Weighted Mean Difference (95% CI)
Disability	Greenfield et al, 2003	25.20	16.00	44	37.40	16.00	39	23.31	-12.20 (-19.10 to -5.30)
	Osterman et al, 2006	16.00	16.00	26	22.00	16.00	26	18.04	-6.00 (-14.70 to 2.70)
	Weinstein et al, 2006	-26.00	23.92	198	-21.30	23.24	211	32.26	-4.70 (-9.27 to -0.13)
	Peul et al, 2007	26.52	25.74	140	40.00	25.83	141	26.39	-13.48 (-19.51 to -7.45)
Pooled effect: I² = 55%									-9.00 (-13.73 to -4.27)
Leg pain intensity	Greenfield et al, 2003	26.00	20.00	44	52.00	27.00	39	21.07	-26.00 (-36.15 to -15.85)
	Osterman et al, 2006	12.00	20.00	26	25.00	27.00	26	16.52	-13.00 (-25.92 to -0.08)
	Weinstein et al, 2006	-37.50	26.96	198	-28.33	27.25	211	31.21	-9.17 (-14.43 to -3.91)
	Peul et al, 2007	10.20	22.48	140	27.90	22.56	141	31.19	-17.70 (-22.97 to -12.43)
Pooled effect: I² = 71%									-16.01 (-23.00 to -9.02)



B Long term Disc Herniation

Outcome	Study name	Surgery Mean	Surgery (SD)	Surgery Total	Physical Activity Mean	Physical Activity (SD)	Physical Activity Total	Relative weight %	Weighted Mean Difference (95% CI)
Disability	Greenfield et al, 2003	17.90	13.00	39	28.50	14.00	37	25.03	-10.60 (-16.67 to -4.53)
	Osterman et al, 2006	10.00	13.00	21	11.00	14.00	20	17.19	-1.00 (-9.26 to 7.26)
	Weinstein et al, 2006	-30.60	24.16	202	-27.40	23.35	213	32.57	-3.20 (-7.77 to 1.37)
	Peul et al, 2007	14.35	25.74	140	16.09	25.83	141	25.21	-1.74 (-7.77 to 4.29)
Pooled effect: I ² = 47%									-4.31 (-8.46 to -0.15)
Leg pain intensity	Greenfield et al, 2003	23.00	11.00	39	39.00	19.00	37	24.61	-16.00 (-22.94 to -9.06)
	Osterman et al, 2006	6.00	11.00	21	9.00	19.00	20	20.21	-3.00 (-12.45 to 6.45)
	Weinstein et al, 2006	-42.92	27.25	202	-36.25	27.37	213	27.60	-6.67 (-11.93 to -1.41)
	Peul et al, 2007	11.00	22.48	140	11.00	22.56	141	27.58	0.00 (-5.27 to 5.27)
Pooled effect: I ² = 78%									-6.38 (-13.21 to 0.44)



C ≥2 years Disc Herniation

Outcome	Study name	Surgery Mean	Surgery (SD)	Surgery Total	Physical Activity Mean	Physical Activity (SD)	Physical Activity Total	Relative weight %	Weighted Mean Difference (95% CI)
Disability	Greenfield 2003	16.40	9.00	41	22.10	16.00	38	25.55	-5.70 (-11.37 to -0.03)
	Osterman 2006	6.00	9.00	26	11.00	16.00	24	17.88	-5.00 (-12.12 to 2.12)
	Weinstein 2006	-31.40	23.18	186	-28.70	23.25	187	33.18	-2.70 (-7.41 to 2.01)
	Peul 08	13.48	24.74	130	11.30	24.74	130	23.39	2.18 (-3.83 to 8.19)
Pooled effect I² = 25%									-2.74 (-6.06 to 0.59)
Leg pain intensity	Greenfield 2003	19.00	11.00	41	24.00	24.00	38	21.59	-5.00 (-13.13 to 3.13)
	Osterman 2006	6.00	11.00	26	15.00	24.00	24	16.48	-9.00 (-19.22 to 1.22)
	Weinstein 2006	-42.08	27.28	186	-35.42	26.80	187	30.53	-6.66 (-12.15 to -1.17)
	Peul 08	11.00	21.66	130	9.00	21.66	130	31.40	2.00 (-3.27 to 7.27)
Pooled effect I² = 55%									-3.97 (-9.12 to 1.19)

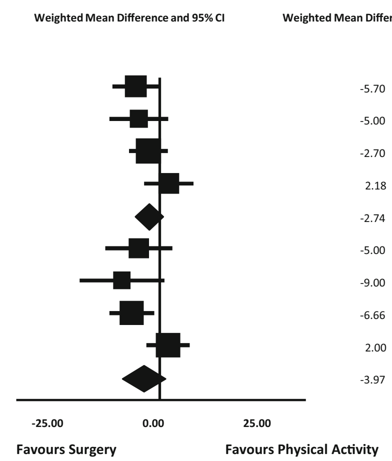


Fig. 1 **a–c** Short-term, long-term and greater than 2-year follow-up. Weighted mean difference for disability and leg pain—disc herniation

for spondylolisthesis and spinal stenosis at short-term, long-term and greater than 2-year follow-up for sciatica. However, there is a lack of high-quality evidence in this field, creating some uncertainly in these results and it is important to note that the benefits of surgery over physical activity reduced, particularly for disc herniation, over time.

In the context of previous related systematic reviews, our findings are in general agreement that surgery for disc herniation provides faster short-term relief over non-surgical management for sciatica throughout the first 3 months, [14, 45, 46] 6 months [47] and 1-year follow-up [10], although no differences were found after 1 and 2 years in one review [14]. Regarding spinal stenosis, our results are also in general agreement with several reviews, that surgery is superior to non-surgical therapy through 1 to 2 years [45]. Two reviews also found similar improvement in pain, function and quality of life for short- and long-term outcomes [48, 49] and for pain and disability at 2-year follow-up, although non-significant findings were identified at 6 and 12 months [50]. Previous related meta-analyses on

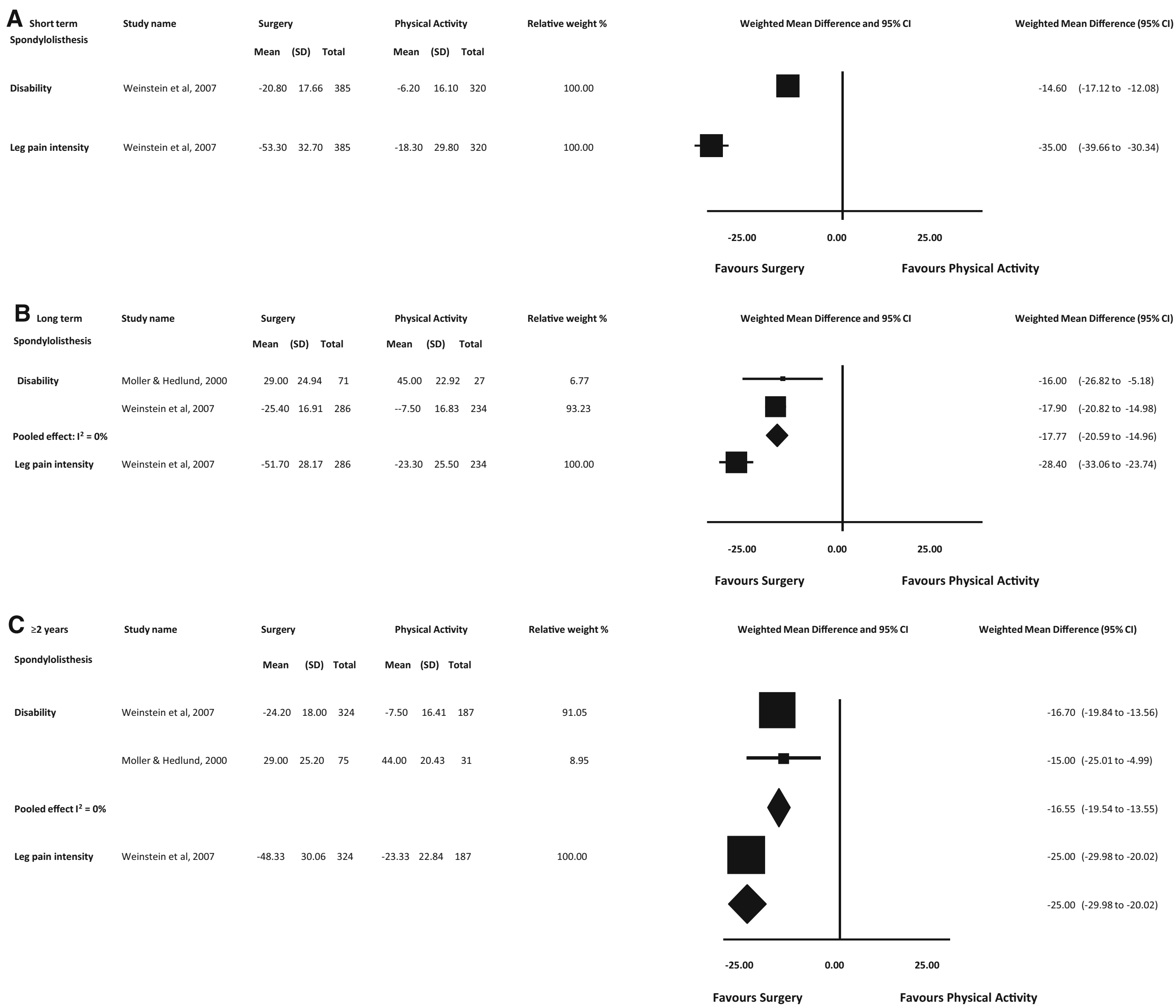


Fig. 2 **a–c** Short-term, long-term and greater than 2-year follow-up. Weighted mean difference for disability and leg pain—spondylolisthesis

treatments for sciatica reported similar effect sizes favouring surgery but were limited to either disability [46, 49–51] or bodily pain [49] over a two-year period and their recommendations were generally made without considering the size of the treatment effect.

Although our review showed statistically significant differences between surgery and physical activity-based interventions (particularly for spondylolisthesis and spinal stenosis), it is important to consider our findings in light of clinically meaningful effects. There is currently a paucity of evidence on what constitutes the smallest worthwhile effect of interventions for sciatica, particularly based on patients' opinions [52]. The size of the treatment effects in our review were relatively modest and ranged from 2 to 16 points for disc herniation, 15 to 35 for spondylolisthesis and 11 to 27 for spinal stenosis on a 0 to 100 scale favouring surgery. Because the size of the treatment effects identified in this review is not substantial, clinicians should consider the risks and costs associated with spinal surgery when making recommendations about treatment options for sciatica [27]. Complications from surgery are common and may result in repeat surgery, with reoperation rates being as high 8 % within two years from index procedure [35] and 23 % within 10 years [53]. Repeat surgery is also associated with lower effectiveness and greater complications as compared with initial surgery [54]. Furthermore, the older population may be at higher risks of developing major medical complications from surgical procedures including acute myocardial infarction, pulmonary embolism and stroke, along with poor wound healing, infection and mortality [55], hence the risks and benefits must be

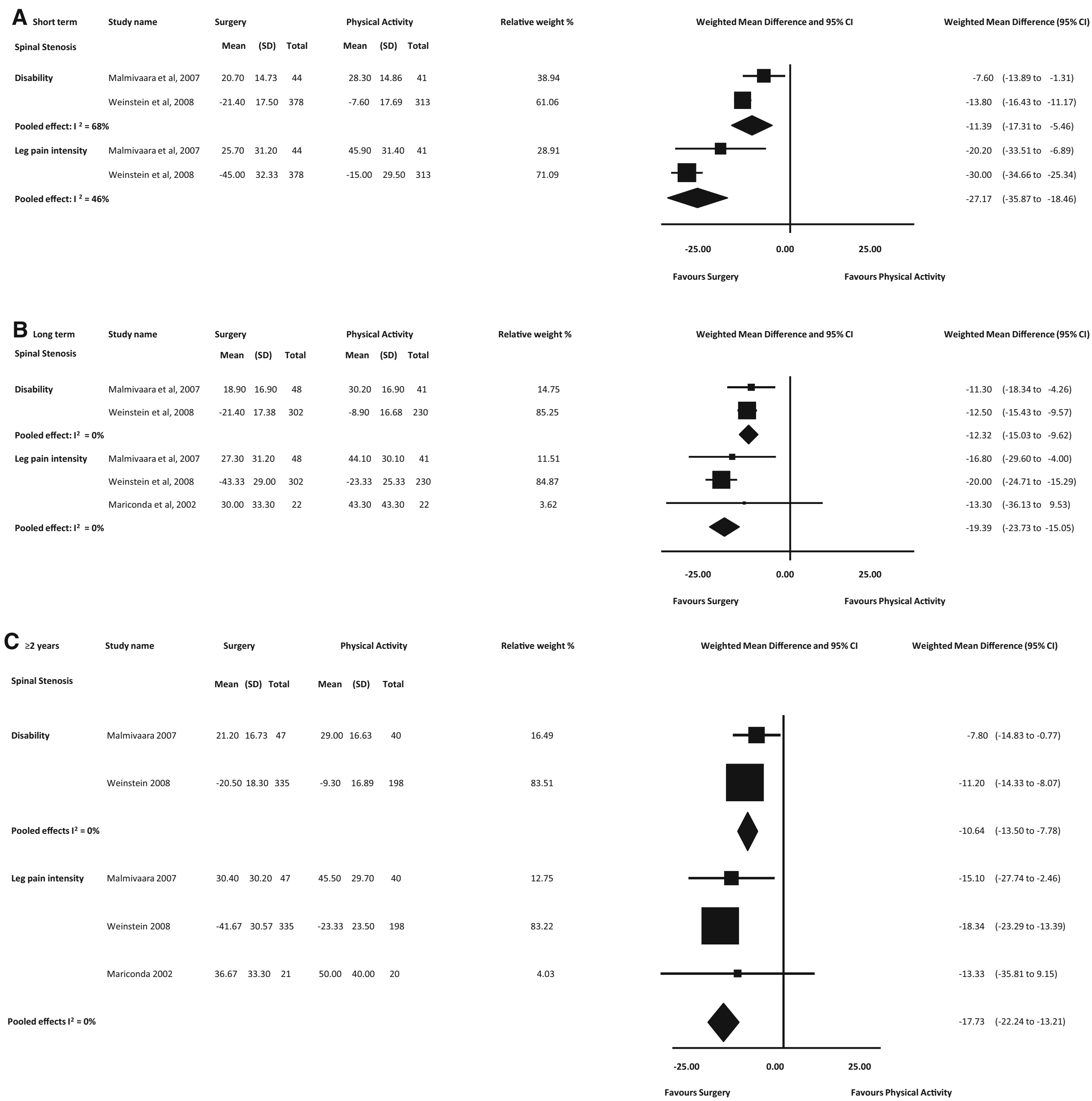


Fig. 3 **a**–**c** Short-term, long-term and greater than 2-year follow-up. Weighted mean difference for disability and mean difference for leg pain—spinal stenosis

carefully weighed regarding the choice of surgical procedures and surgical candidates [55].

Clinicians, patients and policy makers must also take into consideration the costs associated with surgery [56], when discussing treatment options for sciatica. The total costs of spinal surgery are defined as the sum of direct (e.g. medical bills) and indirect costs (e.g. costs associated with patients' time away from work), which reached an estimated $1 billion in 2003 in the United States [56]. A recent systematic review showed spinal surgery to be a cost-effective treatment for sciatica, with cost-effectiveness increasing over time despite the different surgical interventions and spinal diagnoses [56]. Specifically, the Spine Patient Outcomes Research Trial (SPORT) showed progressively improved cost-effectiveness ratios over a 2- to 4-year period, with the mean cost per quality-adjusted life year (QALY) gained reducing from $34,355 to $20,600 for disc herniation, $77,600 to $59,400 for spinal stenosis and

$115,600 to $64,300 for degenerative spondylolisthesis [57]. In comparison to non-surgical care, surgery appears to be cost effective despite the initial higher (surgical procedure) costs, [37] although fewer recurrences, less permanent disability benefits and absenteeism [58] resulted in the total cost for surgery being lower than non-surgical treatments [59]. Surgery for sciatica still appears to rank below the $100,000 per QALY limit that is considered 'costly' for widely accepted medical interventions [60].

Our results need to be viewed in the context of some study limitations. There was between-trial heterogeneity in this review and while the reasons for this are not clear, we suggest that the use of different interventions, outcome measures and methodologies including the type of anatomical diagnosis for sciatica, are potential sources of heterogeneity. Despite the inclusion criteria requiring participants to experience sciatica or a synonym of sciatica, it is possible some patients may have presented with concurrent neurogenic claudication, particularly in the spinal stenosis and spondylolisthesis subgroups. In addition, physical activity was a common denominator of all studies, but the duration, intensity, frequency and type of exercise were not clearly defined in included trials. Also, only a small number of studies were identified in this review and there was a lack of high-quality evidence as defined by the GRADE approach. Despite these limitations, our review does have a number of strengths, including recommendations based on the treatment effect size, utilising the GRADE approach to rate the overall quality of evidence, a pre-registered protocol and used a comprehensive search strategy, including the identification of unpublished trials.

This meta-analysis provides an estimate of the treatment effects in the management of sciatica symptoms. A shared decision-making process, by way of information sharing, knowledge and good relationships in making the difficult decision regarding the best management approach for sciatica is encouraged between patients and practitioners [61]. Patients should be advised that the treatment effects appear to be moderate initially, with greater symptom relief and initial improvement associated with surgery. While surgical outcomes continue to be clinically significant for spondylolisthesis and spinal stenosis at greater than 2-year follow-up, they are not for disc herniation by the long-term follow-up. Whereas decisions regarding management depend on symptom severity, tolerance and treatment preferences, other factors such as the use of medication, lifestyle habits and patients' expectations with treatments should be considered by practitioners when selecting the most likely candidates to benefit from surgery [62–64]. Findings from this review along with guideline recommendations [65–67] should allow a shared decision-making approach between health care practitioners and patients regarding management choices.

What is already known on this topic?

- Patients with sciatica have a worse prognosis than those with low back pain only.
- Surgery and conservative care based on recommending physical activity are commonly used in the management of sciatica.
- Surgery appears to provide short-term relief for patients with sciatica compared to overall conservative interventions.

What this study adds

- Surgery provides better outcomes than physical activity-based interventions for disability, leg pain and back pain at short term only for disc herniation.
- The treatment outcomes for surgery are consistently superior to physical activity-based interventions for disability, leg pain and back pain at short-term, but less so after long-term and greater than 2-year post-treatment follow-up for spondylolisthesis and spinal stenosis.
- The relatively consistent but moderately small size of the effects of surgery over physical activity-based interventions (particularly for spondylolisthesis and spinal stenosis) should guide clinicians and patients when facing the difficult decision of having surgery or engaging in active care interventions.

Compliance with ethical standards

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