Rehabilitation after lumbar disc surgery (Review)

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[Intervention review]

Rehabilitation after lumbar disc surgery

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ABSTRACT

Background

Several rehabilitation programs are available for individuals after lumbar disc surgery.

Objectives

To evaluate the effects of active rehabilitation for adults after first-time lumbar disc surgery.

Search strategy

We searched CENTRAL (*The Cochrane Library* 2007, Issue 2) and MEDLINE, EMBASE, CINAHL and PsycINFO to May 2007.

Selection criteria

We only included randomised controlled trials (RCTs).

Data collection and analysis

Pairs of review authors independently assessed studies for eligibility and risk of bias. A meta-analysis was performed with clinically homogeneous studies. The GRADE approach was used to determine the quality of evidence.

Main results

Fourteen studies were included, seven of which had a low risk of bias. Most programs were only assessed in one study. Statistical pooling was only completed for three comparisons in which exercises were started four to six weeks post-surgery: exercise programs versus no treatment, high versus low intensity exercise programs, and supervised versus home exercises.

There is low quality evidence (three RCTS, N = 156) that exercises are more effective than no treatment for pain at short-term follow-up (WMD -11.13; 95% CI -18.44 to -3.82) and moderate evidence (two RCTs, N = 136) that they are more effective for functional

status on short-term follow-up (WMD -6.50; 95% CI -9.26 to -3.74). None of the studies reported that exercises increased the re-operation rate.

There is low quality evidence (two RCTs, N =103) that high intensity are slightly more effective than low intensity exercise programs for pain in the short term (WMD -10.67; 95% CI -17.04 to -4.30) and moderate evidence (two RCTs, N = 103) that they are more effective for functional status in the short term (SMD -0.77; 95% CI -1.17 to -0.36).

There is low quality evidence (three RCTS, N = 95) that there were no significant differences between supervised and home exercises for short-term pain relief (SMD -1.12; 95% CI -2.77 to 0.53) or functional status (three RCTs, N = 88; SMD -1.18; 95% CI -2.63 to 0.26).

Authors' conclusions

Exercise programs starting four to six weeks post-surgery seem to lead to a faster decrease in pain and disability than no treatment. High intensity exercise programs seem to lead to a faster decrease in pain and disability than low intensity programs. There were no significant differences between supervised and home exercises for pain relief, disability, or global perceived effect. There is no evidence that active programs increase the re-operation rate after first-time lumbar surgery.

PLAIN LANGUAGE SUMMARY

Rehabilitation after lumbar disc surgery

A prolapsed lumbar disc (also called a 'slipped' or 'herniated' disc) is thought to be the most common cause of sciatica (pain or numbness spreading over the buttocks or legs caused by a 'pinched' or compressed nerve in the lower back). Many patients are treated effectively by a combination of non-surgical measures such as medication or physiotherapy. However, patients with persistent symptoms often have surgery. While 60% to 90% of patients will improve after surgery, some will continue to have symptoms. It is estimated that 3% to 12% of patients who have disc surgery will develop another prolapsed disc and most of these patients will have surgery again.

Active treatment programs, such as physiotherapy, in which the patient is an active participant, and advice to return to normal activities, including work, as soon as possible after surgery are common approaches.

This updated review evaluated the effectiveness of various active treatment programs for patients who had lumbar disc surgery for the first time. The review authors included 14 randomised controlled trials with 1927 participants between the ages of 18 and 65 years. Most commonly, treatment started four to six weeks after surgery, but this ranged from two days to 12 months. There was also considerable variation in the content, duration and intensity of the treatments. Most of the treatments were only assessed in one trial and their results are presented in the full review.

For programs that started four to six to six weeks after surgery, the review authors were able to pool the results for three comparisons:

- Patients who participated in exercise programs reported a slightly less short-term pain and disability than those who received no treatment.

- Patients who participated in high intensity programs reported slightly less short-term pain and disability than those in low intensity programs.

- Those in supervised exercise programs reported little or no difference in pain and disability than those in home exercise programs.

None of the included studies reported that active programs increased the rate of repeated surgery, nor did the evidence suggest that patients should restrict their activities after lumbar disc surgery. However, limitations in the methods of half of the trials suggest the results should be read with caution.

The evidence does not tell us whether all patients should be treated after surgery or only those who still have symptoms four to six weeks later.

BACKGROUND

The lumbosacral radicular syndrome (LRS) is characterized by radiating pain over an area of the buttocks or legs served by one or more lumbosacral nerve roots combined with phenomena associated with nerve root tension or neurological deficit. The prevailing view is that the condition is most commonly caused by a lumbar disc prolapse, however, other pathologies may also cause LRS. It is estimated that there are between 60,000 and 75,000 new cases of LRS in the Netherlands each year (HCN 1999), for which the direct and indirect costs are estimated at 1.6 billion US$ per annum (van Tulder 1995). Many patients with LRS are treated conservatively, but surgery is a common option in patients with persistent symptoms. In the Netherlands, with a population of about 16 million people, it is estimated that 10,000 to 11,000 operations are performed each year because of the LRS (HCN 1999) but surgery rates vary across countries. An international comparison showed that the rate of back surgery in the United States was at least 40% higher than in any other country and was more than five times those in England and Scotland (Cherkin 1994). But even within one country (i.e. the U.S.), considerable regional variations are reported (Weinstein 2006). The reported success rate of lumbar disc surgery varies from 60% to 90% (Korres 1992; Findlay 1998; Loupasis 1999; Yorimitsu 2001). Differences between these studies with regard to inclusion criteria, indications for surgery and operationalization of success, may account for the wide range in success rate. Still, these figures show that in 10% to 40% of the patients the results of surgery are unsatisfactory and patients still have symptoms. These persisting symptoms mainly consist of pain, motor deficits, a decreased functional status, not being able to return to work, or any combination. In 3% to 12% of patients who undergo disc-surgery for the first time, a recurrent herniated lumbar disc occurs for which almost all patient undergo a re-operation (CBO 2008)

Further treatment is often recommended after lumbar disc surgery (e.g. physiotherapy, rehabilitation programs), but there are persistent controversies about many issues. Should all patients receive

further treatment, or only those patients who still suffer from persisting symptoms after surgery? The necessity and duration of activity restrictions after lumbar disc surgery is still controversial. Although several active rehabilitation programs, physical fitness programs or instruction protocols for patients to return to work after lumbar disc surgery have been suggested, there are still fears that these interventions may cause re-injury, re-herniation, or instability (Manniche 1995; Carragee 1996; Manniche 1996). Unfortunately, little is known about the effectiveness of these treatments. In this updated review, we systematically evaluated the effectiveness of active treatments that are used in rehabilitation after first-time lumbar disc surgery.

OBJECTIVES

To determine if active rehabilitation after lumbar disc surgery is more effective than no treatment, and to describe which type of active rehabilitation is most effective.

First, we clustered treatments according to the start of treatment:

1. Active rehabilitation that starts immediately post-surgery,

2. Active rehabilitation that starts four to six weeks post-surgery,

3. Active rehabilitation that starts more than 12 months post-surgery.

For every cluster the following comparisons were investigated:

A. Active rehabilitation versus no treatment, placebo or waiting list control,

B. Active rehabilitation versus other kind of active rehabilitation,

C. Specific intervention in addition to active rehabilitation versus active rehabilitation alone.

METHODS

Criteria for considering studies for this review

Types of studies

Randomized controlled trials (RCTs) were included and non-randomised controlled trials (CCTs) or quasi RCTs were excluded.

Types of participants

Subjects who had first-time lumbar disc surgery because of a lumbar disc prolapse and aged between 18 and 65 years were included. All types of surgical techniques for lumbar disc herniation (e.g. standard discectomy, microdiscectomy, laser discectomy and chemonucleolysis) were included.

Types of interventions

Trials with one or more types of active rehabilitation programs aiming at functional restoration (improvement in functional status and return to work) were included. Examples of treatments that were considered are (supervised) exercise therapy, functional restoration programs or rehabilitation-oriented approaches in insurance medicine. Treatments solely aimed at pain relief (e.g. medication) or improvement of physical outcomes such as strength or flexibility were excluded.

Types of outcome measures

Trials were included if they used at least one of the four primary outcome measures that we considered to be important, that is pain (e.g. VAS), a global measure of improvement (overall improvement, proportion of patients recovered, subjective improvement of symptoms), back-pain specific functional status (e.g. Roland-Morris Disability Questionnaire, Oswestry Disability Index), and return-to-work (return-to-work status, days off work). Outcomes of physical examination (e.g. spinal range of motion, straight-leg raise range of motion or muscle strength), behavioural outcomes (e.g. anxiety, depression, pain behaviour) and generic functional status (SF-36, Nottingham Health Profile, Sickness Impact Profile) were considered as secondary outcomes. Other outcomes such as medication use and side-effects were also considered.

Search methods for identification of studies

All relevant trials meeting our inclusion criteria were identified by:
A) A search of CENTRAL (The Cochrane Library 2007, Issue 2),
B) A computer aided search of the MEDLINE (from 1966 to May 2007), EMBASE (from 1988 to May 2007), CINAHL (2000 to May 2007) and PsycINFO (from 1984 to May 2007) databases using the search strategy recommended by the Editorial Board of the Cochrane Back Review Group (van Tulder 2003). Specific search terms for low-back pain, lumbar disc surgery and post surgery treatment were added. No language restriction was used. The complete search strategies are outlined in Appendix 1; Appendix 2; Appendix 3; Appendix 4.
C) Screening of references given in relevant reviews and identified trials.
D) Screening of personal bibliographies and communication with experts in the field.

Data collection and analysis

Study selection

Pairs of review authors independently selected the studies to be included in this systematic review by applying the selection criteria to the studies that were retrieved by the literature search. Consensus was used to resolve disagreements concerning selection

and inclusion of studies and a third review author was consulted if disagreements persisted.

Risk of bias assessment

The criteria recommended in the updated method guidelines for systematic reviews in the Cochrane Back Review Group were used (van Tulder 2003; Table 1). Pairs of review authors independently assessed the risk of bias of included studies (RO assessed all studies, except the study on which he is the first author; RO was not involved in any decision regarding this trial). We decided not to blind studies for authors, institution or journal because the review authors who assessed the risk of bias were familiar with the literature. A consensus method was used to resolve disagreements and a third review author was consulted if disagreements persisted. If the article did not contain enough information to assess all the risks of bias (i.e. if one or more criteria were scored "unclear"), the review authors contacted the study authors for additional information. The risk of bias assessment form was mailed to all study authors and they were also asked whether they agreed with the risk of bias assessment.

Table 1. Criteria for the Risk of Bias Assessment

Criteria for a judgment of yes for the sources of risk of bias

Adequate method of randomisation: A random (unpredictable) assignment sequence. Examples of adequate methods are computer-generated random numbers table and use of sealed opaque envelopes. Methods of allocation using date of birth, date of admission, hospital numbers, or alternation should not be regarded as appropriate

Adequate concealment of randomisation: Assignment generated by an independent person not responsible for determining the eligibility of the patients. This person has no information about the persons included in the trial and has no influence on the assignment sequence or on the decision about eligibility of the patient.

Blinding of patients: The review author determines if enough information about the blinding is given in order to score a "yes." If blinding of patients was not feasible, we assessed this item to be positive if the credibility of applied treatments was evaluated and treatments were equally credible and acceptable to patients

Blinding of care providers: The review author determines if enough information about the blinding is given in order to score a "yes."

Blinding of outcome assessment: The review author determines if enough information about the blinding is given in order to score a "yes."

Drop-out during intervention period (<10%) AND withdrawal during follow-up period (<20%): The number of participants who were included in the study but did not complete the observation period or were not included in the analysis must be described and reasons given. If the percentage of drop-outs during the intervention period does not exceed 10% AND withdrawal during follow-up does not exceed 20% and does not lead to substantial bias, a "yes" is scored.

Intention-to-treat analysis: All randomized patients are reported/analyzed in the group to which they were allocated by randomization for the most important moments of effect measurement (minus missing values), irrespective of noncompliance and co-interventions.

Table 1. Criteria for the Risk of Bias Assessment

(*Continued*)

Similarity of baseline characteristics: In order to receive a "yes," groups have to be similar at baseline regarding demographic factors,
Co-interventions avoided or equal: Co-interventions should either be avoided in the trial design or be similar between the index and control groups.

Compliance: The review author determines if the compliance to the interventions is acceptable, based on the reported intensity, duration, number and frequency of sessions for both the index intervention and control intervention(s).

Identical timing outcome assessment: Timing of outcome assessment should be identical for all intervention groups and for all important outcome assessments.

Data extraction

Pairs of review authors independently extracted data from the studies using a standardized form (RO extracted data from all studies, except from the study on which he is the first author). All pairs of review authors who extracted the data, first piloted the data extraction form by using two RCTs on back pain without surgery. The domains that were assessed for data extraction were characteristics of patients and interventions, and results on primary and secondary outcome measures.

Data analysis and the GRADE approach

If studies were clinically homogeneous regarding study population, types of treatment and reference treatments, and outcomes and measurement instruments, a meta-analysis was performed. If possible, we calculated the weighted mean difference (WMD) because this improves the interpretability of the results. If a WMD was not possible the standardised mean difference (SMD) was calculated. For the comparisons where studies were too heterogeneous, no meta analysis was performed. The Editorial Board of the Cochrane Back Review Group recommends presenting the overall quality of the evidence using the GRADE approach. The quality of the evidence on a specific outcome is based on the study design, the potential for bias, consistency of results, directness (generalizability), precision (sufficient data) and potential reporting bias for the results across all studies that measure that particular outcome. The overall quality is considered to be high when RCTs with a low risk of bias provide consistent, generalizable results for the outcome, and reduces by one level when one of the factors described above are not met (Furlan 2008). In the case of only one study measuring an outcome, we considered the data to be 'sparse' and subsequently labelled the evidence as 'low quality evidence'. To improve the readability of this review, a GRADE table was only completed when we completed a meta analysis. If only one study was present for a given comparison, the results are described in the text and in the *Characteristics of included studies* table.

RESULTS

Description of studies

See: Characteristics of included studies; Characteristics of excluded studies; Characteristics of ongoing studies.

In total, 14 studies were included in this updated systematic review. Two RCTs assessed the effectiveness of programs that started immediately after surgery: one RCT focused on neural mobilization (Scrimshaw 2001), and one RCT assessed the effectiveness of intensive exercises (Kjellby-Wendt 1998). The majority of trials focused on treatments that started four to six weeks post-surgery. Two trials (Yilmaz 2003; Filiz 2005) included three arms, one of which was a no treatment arm, yielding two comparisons per RCT. For three comparisons assessing the effectiveness of interventions starting four to six weeks post surgery, a meta-analysis could be performed: exercise program versus no treatment (comparison 2A); high intensity programs versus low intensity programs (comparison 2B.1); and supervised exercise program versus home exercises (comparison 2B.2). For all other types of interventions (or programs) that started four to six weeks post surgery, there was only one study per comparison. Finally, two studies assessed treatment regimens that started later than 12 months after the surgery.

Risk of bias in included studies

The risk of bias of the included studies was assessed by using the criteria recommended in the updated method guidelines by the Cochrane Back Review Group (van Tulder 2003). If blinding of patients was not feasible, we redefined the item: the item assessing the blinding of patients was scored positive if the credibility of applied treatments was evaluated and treatments were equally credible and acceptable to patients (see Table 1 for criteria). Each criterion was assessed as "positive", "negative" or "unclear". Studies with a low risk of bias were defined as RCTs that fulfilled five or more of the risk of bias criteria.

Effects of interventions

Study selection

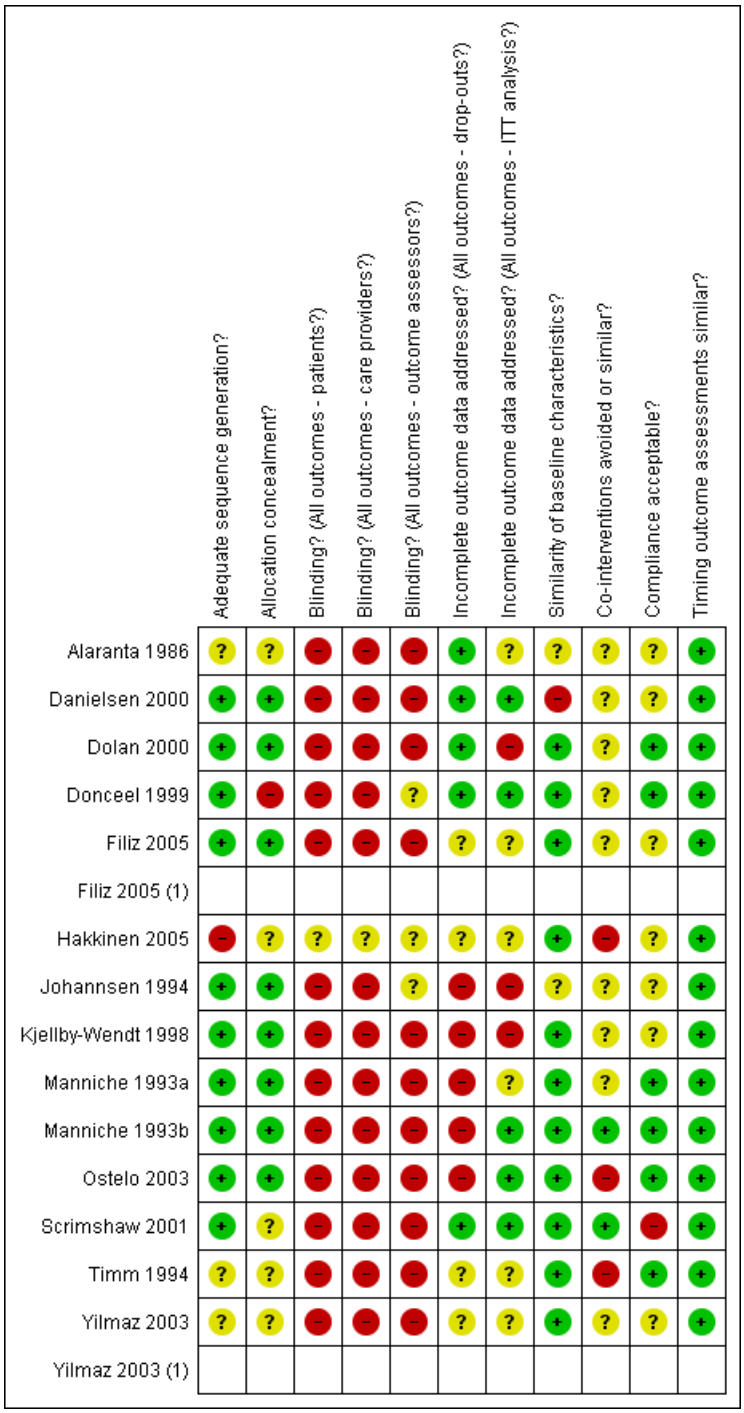
The search for the original review (until 2000) yielded 427 studies in MEDLINE, 414 in EMBASE and 135 in *The Cochrane li-*

brary. The first selection of this part of the search was based on keywords, title and abstract, resulting in the inclusion of 11 RCTs and 4 CCTs. After reading of the full text papers, two studies were excluded because one study evaluated intraoperative epidural corticosteroids (Lavyne 1992) and one evaluated the use of parenteral Ketorolac during wound closure (Le Roux 1999). Neither intervention matched our definition of active rehabilitation, yielding a total of nine RCTS and four CCTs for the original review. For this update, we searched the same databases plus CINAHL from 2000 until June 2007, but in line with the updated guidelines, only RCTs were included, yielding a total of 3059 hits. The first selection, based on title and abstract, resulted in 10 papers: five new RCTs, one long-term follow-up of an already included RCT (Kjellby-Wendt 1998) and one published protocol (Selkowitz 2006). Reference checking yielded another long-term follow-up of an already included RCT (Kjellby-Wendt 1998). After reading the full text papers, one RCT was excluded because this study was not an effectiveness study (Woischnek 2000). Four studies that were included in the original review were excluded because they were not randomised (Brennan 1994; Burke 1994; Kitteringham 1996; Rotthaupt 1997). Therefore, this updated systematic review includes a total of 14 randomised trials.

Risk of bias in included studies

Fifty percent of the included studies (seven out of 14) were assessed to have a low risk of bias. Care providers could not be blinded due to the nature of the interventions. Because blinding of patients is also often hampered (for similar reasons) we redefined this item (see method section). In addition, the credibility or acceptability of applied treatments was not evaluated in any study. In six studies, the randomisation (method AND concealment) was not described adequately and in eight studies, the compliance to the rehabilitation program was inadequate or not assessed. There was a general lack of published details concerning co-interventions: only two studies explicitly provided information on co-interventions. These methodological shortcomings in the conduct and reporting of studies suggest considerable potential for bias in half of the included trials (see Figure 1 for results of individual trials).

Figure 1. Summary of risks of bias



For overall judgement of quality of evidence, see GRADE tables (Figure 2; Figure 3; Figure 4).

Author(s): Raymond WJG Ostelo, Leonardo Oliveira Pena Costa, Christopher G. Maher, Henrica CW Vet de, Maurits W van Tulder
Date: 2008-07-11
Question: Should exercise (started 4-6 weeks post-surgery) vs no treatment be used in post-lumbar disc surgery ?
Settings: rehabilitation
Bibliography: Ostelo RWJG, Costa LOPena, Maher CG, Vet de HC, van Tulder MW. Rehabilitation after lumbar disc surgery. Cochrane Database of Systematic Reviews 2008, Issue 4.

Quality assessment							Summary of findings					Importance
							No of patients		Effect			
No of studies	Design	Limitations	Inconsistency	Indirectness	Imprecision	Other considerations	exercise (started 4-6 weeks post-surgery)	no treatment	Relative (95% CI)	Absolute	Quality	
Pain on VAS (post treatment) (measured with: VAS; 0 = no pain; range of scores: 0-100; Better indicated by less)												
5	randomised trial	serious[1]	serious[2]	no serious indirectness	no serious imprecision	none	77	45	-	MD -11.13 (-18.44 to -3.82)	⊕⊕OO LOW	
Functional status on Modified Oswestry (post treatment) (measured with: Modified Oswestry Index; 0 = no disability; range of scores: 0-50; Better indicated by less)												
4	randomised trial	serious[1]	no serious inconsistency	no serious indirectness	no serious imprecision	none	68	34	-	MD -6.5 (-9.26 to -3.74)	⊕⊕⊕O MODERATE	

[1] unsure of randomization, concealment, blinding of patients, care providers, or outcome assessors, intention-to-treat analysis, co-interventions, compliance, drop-outs
[2] statistical inconsistency

Author(s): Raymond WJG Ostelo, Leonardo Oliveira Pena Costa, Christopher G. Maher, Henrica CW Vet de, Maurits W van Tulder
Date: 2008-07-11
Question: Should high intensity exercise programs (started 4-6 weeks post-surgery) vs low intensity exercise programs be used in post-lumbar disc surgery ?
Settings: rehabilitation
Bibliography: Ostelo RWJG, Costa LOPena, Maher CG, Vet de HC, van Tulder MW. Rehabilitation after lumbar disc surgery. Cochrane Database of Systematic Reviews 2008, Issue 4.

Quality assessment							Summary of findings					Importance
							No of patients		Effect			
No of studies	Design	Limitations	Inconsistency	Indirectness	Imprecision	Other considerations	high intensity exercise programs (started 4-6 weeks post-surgery)	low intensity exercise programs	Relative (95% CI)	Absolute	Quality	
Pain (short term) (measured with: VAS; 0 = no pain; range of scores: 0-100; Better indicated by less)												
2	randomised trial	no serious limitations	serious[1]	no serious indirectness	serious[2]	none	59	44	-	MD -10.67 (-17.04 to -4.3)	⊕⊕OO LOW	
Function (short term) (measured with: Modified Oswestry Index; 0 = no disability; range of scores: 0-50; Better indicated by less)												
2	randomised trial	no serious limitations	no serious inconsistency	no serious indirectness	serious[2]	none	59	44	-	SMD -0.77 (-1.17 to -0.36)	⊕⊕⊕O MODERATE	

[1] statistical inconsistency
[2] sparse data

Author(s): Raymond WJG Ostelo, Leonardo Oliveira Pena Costa, Christopher G. Maher, Henrica CW Vet de, Maurits W van Tulder
Date: 2008-07-11
Question: Should supervised programs (started 4-6 weeks post-surgery) vs home exercises be used in post-lumbar disc surgery ?
Settings: rehabilitation
Bibliography: Ostelo RWJG, Costa LOPena, Maher CG, Vet de HC, van Tulder MW. Rehabilitation after lumbar disc surgery. Cochrane Database of Systematic Reviews 2008, Issue 4.

Quality assessment							Summary of findings					Importance
							No of patients		Effect		Quality	
No of studies	Design	Limitations	Inconsistency	Indirectness	Imprecision	Other considerations	supervised programs (started 4-6 weeks post-surgery)	home exercises	Relative (95% CI)	Absolute		
Functional status (short term) (measured with: Modified Oswestry Index; 0 = no disability; range of scores: 0-50; Better indicated by less)												
3	randomised trial	serious[1]	serious[2]	no serious indirectness	no serious imprecision	none	45	43	-	SMD -1.18 (-2.63 to 0.26)	⊕⊕OO LOW	
Pain (short term) (measured with: VAS; 0 = no pain; range of scores: 0-100; Better indicated by less)												
3	randomised trial	serious[1]	serious[2]	no serious indirectness	no serious imprecision	none	45	50	-	SMD -1.12 (-2.77 to 0.53)	⊕⊕OO LOW	

[1] uncertainty for all risk of bias criteria

[2] statistical inconsistency

Effectiveness of rehabilitation programs

1. Comparisons among rehabilitation programs that start immediately after surgery.

1 A. Treatment versus no treatment, placebo or waiting list control

No trials were identified.

1 B. Treatment versus other kinds of treatment

One small (N = 60) RCT with a high risk of bias (Kjellby-Wendt 1998) compared an intensive exercise program consisting of increasing daily activities, home training (mobilisation, trunk strengthening) and later mainly intensive muscle strengthening exercises and cardiovascular exercises with a control group that received no increasing daily activities, exercises only once a day and no promotion of cardiovascular exercises. The results showed that there were no statistically significant differences for pain, global perceived effect and sick leave outcomes. Only secondary analyses (leg pain on a VAS in a subgroup of patients with sciatica, and some clinical outcome measures) showed some small differences in favour of the intensive exercise program. However, these were post-hoc analyses that do not allow firm conclusions. At the five to seven-year follow-up, there were no relevant differences in the number of patients that had leg pain (VAS) or back pain (VAS), or days of sick leave. There was one re-operation (3.4%) in the intervention group and two re-operations (6.5%) in the reference group. There is a low quality evidence illustrating that there is no difference in the long-term for global perceived effect, pain or return-to-work between an intensive exercise program and a less active program.

1 C. Specific intervention in addition to a treatment program versus treatment alone

One small RCT with a low risk of bias (Scrimshaw 2001) (N = 59) evaluated the effectiveness of adding neural mobilisation to standard postoperative care consisting of isometric and dynamic exercises (progress as tolerated). The aim of the neural mobilisation was to maintain interplane mobility of the neural structures by stimulating gliding surfaces, and consisted mainly of repeated through-range straight leg raises. The published RCT reports on 81 patients, but only 59 patients received a standard laminectomy while the others underwent a fusion. For this review, we only analysed the 59 laminectomy patients (unpublished data). There is low quality evidence from one RCT (N = 59) that neural mobilisation is not effective as an adjunct to standard postoperative care on pain (mean difference - 6.8; 95% CI - 22.2 to 8.6 on a 0-100 VAS) and functional status (mean difference 4.5; 95% CI -7.2 to 16.2 on 0-100 Quebec Disability Scale) after six weeks follow-up. For these outcome measures, as well as for overall improvement, there were also no differences after 12 months. No data were presented on re-operation rates.

2. Comparisons among rehabilitation programs that start 4-6 weeks post surgery.

2 A. Exercise programs versus no treatment

One very small (N = 20) RCT with a low risk of bias (Dolan 2000) and two small (total N = 102) RCTs with a high risk of bias

(Yilmaz 2003; Filiz 2005) compared an exercise program with no treatment. Both Filiz 2005 and Yilmaz 2003 were three-armed RCTs with one no-treatment arm and two exercise arms, yielding two comparisons for each study. Outcome was only measured at the post-treatment follow-up. For treatments that start four to six weeks post-surgery, there is low quality evidence (three RCTs with five comparisons, N = 156) that exercise programs are more effective than no treatment on short-term follow-up for pain (WMD -11.13; 95% CI -18.44 to -3.82 on a 0-100 VAS), and moderate quality evidence (two RCTs with four comparisons, N = 136) in favour of exercise programs for functional status on short-term follow-up (WMD -6.50; 95% CI -9.26 to -3.74 on the 0 to50 Modified Oswestry). None of the included studies reported that these active programs increased the re-operative rate.

2 B. Treatment versus other kinds of treatment

2 B.1 High intensity exercise programs versus low intensity exercise programs

Two RCTs with a low risk of bias (total N = 159) (Manniche 1993a; Danielsen 2000) and one small (N = 42) RCT with a high risk of bias (Yilmaz 2003) compared intensive exercise programs with mild exercise programs. There are sparse data reporting no statistically significant differences on overall improvement at short-term follow-up (Manniche 1993a) and at six and 12-month follow-up (Danielsen 2000).

There is low quality evidence (two RCTs, N = 103) that high intensity exercise programs are slightly more effective for pain in the short term compared to low intensity exercise programs (WMD -10.67; 95% CI -17.04 to -4.30 on a 0-100 VAS), and moderate quality evidence (two RCTs, N = 103) in favour of high intensity exercise programs compared to low intensity exercise programs for functional status in the short term (SMD -0.77; 95% CI -1.17 to -0.36). Long-term follow-up results for both pain and functional status were contradictory. Results for sick leave, which could not be pooled, were also contradictory: Danielsen 2000 reported no significant differences in sick leave during the one-year follow-up (high intensity: mean 18.5 weeks (SD 14.3) versus 22.0 weeks (SD 18.6) for low intensity, while Filiz 2005 reported that patients in the high intensity programs returned to work quicker (mean after 56 days, SD 18.6) as compared to the low intensity program (mean after 75 days, SD 24.9). Danielsen 2000 reported one-year re-operative rates that were negligible.

2 B. 2 Supervised exercise program versus home exercises

Three small (total N = 142) RCTs with a high risk of bias (Johannsen 1994; Yilmaz 2003; Filiz 2005) compared supervised exercise programs to home exercise programs. There are sparse data from one trial (Johannsen 1994) showing no differences on global perceived effect (four-point scale) at both the post-treatment and the three-month follow-up. There is low quality evidence (three RCTs, N = 95) that there were no significant differences between supervised exercise program and home exercises on short-term pain relief (pooled SMD -1.12; 95% CI -2.77 to 0.53). There are sparse data from one trial (Johannsen 1994) that there were no differences between groups on long-term pain relief. For functional status, there is low quality evidence (three RCTs, N = 88) that there were no short-term differences between supervised exercise programs and home exercises (pooled SMD -1.18; 95% CI -2.63 to 0.26). For the long term, there are only sparse data (Johannsen 1994) reporting no significant differences between groups. One small (N = 40) trial (Johannsen 1994) reported re-operative rates that were negligible in both groups.

2 B. 3 Multidisciplinary rehabilitation program

Only one RCT with a high risk of bias (N = 212) (Alaranta 1986) compared a multidisciplinary rehabilitation program that consisted of sessions with a physical therapist, psychiatrist, occupational therapist, psychologist, social worker and an intensive back school with usual care. There is low quality evidence that at one-year follow-up, there were no statistically significant differences between groups for global perceived effect, sick leave or re-operative rates (3.7% in both groups).

2 B. 4 Rehabilitation in the occupational setting

One large (N = 710) RCT with a low risk of bias (Donceel 1999) compared a multidisciplinary rehabilitation-oriented approach intervention, coordinated by medical advisers of a social security sickness fund for a patient population with mandatory insurance, with usual care. Because there was only one RCT, there is low quality evidence that suggests that a rehabilitation-oriented approach by the medical advisers of social security is more effective than usual care on return-to-work at long-term follow-up.

2 B. 5 Behavioural treatment

One RCT with a low risk of bias (N = 105) compared a behavioural graded activity program with standard physiotherapy (Ostelo 2003). There was low quality evidence (one RCT only) that in the short term there was a clinically relevant and statistically significant difference of 19% in global perceived recovery in favour of the physiotherapy program, but there were no differences on the long term. There was also low quality evidence that there were no differences (short-term or long-term) in pain (VAS), functional status (RDQ) or return-to-work. This trial also included a cost effectiveness analysis that suggested that the behavioural program was associated with higher costs during the one-year follow-up.

2 B. 6 Stretching and strength training

One RCT with a high risk of bias (Hakkinen 2005) included 126 patients, two months after their first lumbar disc surgery if they were not pain free (VAS >10 mm). The intervention group received a 12-month home exercise program after one instruction session.

Patients were instructed to stretch and perform stabilization exercises and to perform strength training (instructed to perform two series of exercises twice a week). The control group received identical instructions, except for the strength training. There is low quality evidence that after 12 months there were no clinically relevant or statistically significant differences in pain (VAS) and disability (ODI).

2 C Specific intervention in addition to a treatment program versus treatment alone

No RCTs were identified.

3. Comparisons among rehabilitation programs that start more than 12 months post surgery.

3 A. Treatment versus no treatment, placebo or waiting list control

No RCTs were identified.

3 B. Treatment versus other kinds of treatment

One RCT with a high risk of bias (Timm 1994) compared physical agents with joint manipulations, high-tech exercise, low-tech exercise and no treatment in 250 workers after first-time surgery. There is low quality evidence that low-tech and high-tech exercise might be more effective in improving low-back functional status as compared to physical agents, joint manipulations or no treatment.

3 C. Specific intervention in addition to a treatment program versus treatment alone

One small (N = 62) RCT with a low risk of bias (Manniche 1993b) added hyperextension to an intensive exercise program. On short-term measurement, there was a statistically significant improvement in functional status, which was no longer present at long-term follow-up. There were no re-operations. There is low quality evidence that adding hyperextension to an intensive exercise program might not be more effective than intensive exercise alone on overall improvement or functional status outcomes.

DISCUSSION

Fourteen RCTs were included in this systematic review. The studies were heterogeneous with regard to timing, ranging from starting two days post-surgery up to more than 12 months post-surgery. The duration and intensity of the interventions also differed widely. Due to this clinical heterogeneity, statistical pooling of the results was considered appropriate in only three comparisons: exercise program versus no treatment (comparison 2A); high intensity programs versus low intensity programs (comparison 2B.1); and supervised exercise program versus home exercises (comparison 2B.2).

The effectiveness of many different rehabilitation programs has been assessed, but the majority in only one study. The results showed that adding neural mobilization to an exercise program was not effective for pain and functional disability in the short- and long-term. For treatments that started four to six weeks post-surgery, the pooled results suggest that exercise programs lead to a faster decrease in pain as compared to no treatment, and that high intensity programs, also starting four to six weeks post surgery, lead to a faster decrease in pain than low intensity programs. But these results should be interpreted cautiously as these are only supported by low quality evidence. However, the observation that exercise programs lead to a faster decrease in disability as compared to no treatment, and that high intensity programs, lead to a faster decrease in disability than low intensity programs is supported by moderate quality evidence. Mainly due to sparse data, the results with regard to long-term follow-up could not be pooled. None of the included studies reported that these active programs increase the re-operative rate. Because of these negligible rates, we concluded that it is not harmful to return to activity after lumbar disc surgery and consequently, that it is not necessary for patients to stay passive after lumbar disc surgery. This is in line with Carragee 1996, who concluded that lifting postoperative restrictions after limited discectomy led to shortened sick leave without increased complications.

Based on pooled results, we found some evidence suggesting that supervised training is not more effective than home-based training in the short-term. But again, these results should be interpreted cautiously (only low quality evidence). Moreover, the compliance, both of the home exercise programs and the supervised programs, is poorly reported in these studies, further hampering an adequate interpretation. Hakkinen 2005 assessed the adherence rates to home exercise programs that lasted 12 months. It was demonstrated that after two months, the adherence rates dropped to 50% to 60% of the target, dropping further to only 30% in the last six months. This seems to suggest that more intensive supervision needs to be in place for long-term rehabilitation, to maintain patients' motivation. One RCT with a low risk of bias (Donceel 1999) assessed an intervention of medical advisers of a social security sickness fund on a patient population with mandatory insurance. These medical advisors coordinated a multidisciplinary rehabilitation-oriented approach. The results of this study indicate that an intervention aimed at an active rehabilitation policy, encompassing gradual work resumption, information, early mobilization, and early contact with the medical adviser increased the probability of return-to-work for these patients. Although this is only one RCT in a specific setting (approaches like this are highly dependent on the social security system), these results look promising. The results are in agreement with the fact that patients

do not need to have their activities restricted and that aiming at an early re-activation is an effective approach (Carragee 1996). Furthermore this study highlights the need for more than just exercising if an intervention aims at early return to work. Further research is needed to assess whether these types of interventions are (cost-) effective.

Regarding bio-psychosocial aspects of post-surgery rehabilitation, it has been suggested that high-intensity programs confront patients with their fears and insecurities and that they learn that symptoms related to training are not necessarily dangerous (Manniche 1993b). In this updated review we included a RCT with a low risk of bias that assessed the effectiveness of a behavioural graded activity (BGA) program, that focused on bio-psychosocial aspects (Ostelo 2003). The results of this study indicate that there were no differences between the BGA program and standard physiotherapy. As of yet, there seems to be no convincing evidence to use bio-psychosocial-oriented approaches in the rehabilitation of patients after first-time disc surgery. Despite that, it could be hypothesized that, as both treatment arms in this RCT were active treatment programs, the results of this RCT also show that active programs do not increase the re-operative rate or that patients need to have their activities restricted after their first lumbar surgery.

In this systematic review, all surgical techniques were included a priori. Patients included in the studies had all received standard discectomy or microdiscectomy. A recent systematic Cochrane review showed that there were no significant differences in effectiveness between these two approaches (Gibson 2007a; Gibson 2007b). Therefore, it is unlikely that different surgical techniques have biased the results of this systematic review. Another important issue regarding surgery needs to be discussed. Although it was not the main focus of the current systematic review, it is important to know the indication for surgery, because indications might change over time, with potential consequences for rehabilitation. Unfortunately, the description of the indication for surgery in the included studies is scarce. In four RCTs (out of the 14), no description of the indication was given at all (only that there had been a surgery) and in seven RCTs, the only description was that patients were operated on because of a lumbar disc prolapse, without further information. In only three RCTs was it stated that the signs and neuromuscular symptoms and dysfunction should be elicited by a lumbar disc prolapse (or herniation) confirmed by an imaging technique. Future studies on rehabilitation should include more details on this issue in their design (see Table 2 for clinical relevance criteria, Table 3 for assessment results).

Table 2. Clinical relevance assessment questions

Based on the data provided, can you determine if the results will be clinically relevant?

1. Are the patients described in detail so that you can decide whether they are comparable to those that you see in your practice?
2. Are the interventions and treatment settings described well enough so that you can provide the same for your patients?
3. Were all clinically relevant outcomes measured and reported?
4. Is the size of the effect clinically important?
5. Are the likely treatment benefits worth the potential harms?

Table 3. Results of clinical relevance assessment

Study	Patients	Interventions	Relevant outcomes	Size of effect	Benefit & Harms
Alaranta 1986	N	N	Y	N	N
Danielsen 2000	Y	Y	Y	Y	Y
Dolan 2000	Y	Y	Y	Y	
Donceel 1999	Y	Y		Y	
Filiz 2005	Y	Y	Y	N	N

Table 3. Results of clinical relevance assessment

(*Continued*)

Hakinnen 2005	N	Y	Y	N	N
Johanssen 1994	Y	Y	Y	N	N
Kjellby-Wendt 1998	Y	Y	Y	N	N
Manniche 1993a	Y	Y	Y		
Manniche 1993b	Y	Y	Y		
Ostelo 2003	Y	Y	Y	N	N
Scrimshaw 2001	Y	Y	Y	N	N
Timm 1994	Y	Y	N		
Yilmaz 2003	Y	N	Y	Y	

This updated review differs in some aspects from the original review. In this update, only RCTs were included and in total five new studies were included. Therefore, it was now possible to pool the data in three comparisons. In addition, we used the GRADE approach in this update, as recommended by the Editorial Board of the Cochrane Back Review Group (CBRG), while in the original review the 'levels of evidence' approach was used. The GRADE approach gives an overall grade of the quality of the evidence, in which the study design, risk of bias, consistency of results, directness (to the population in question), and the precision of results across all studies that measure that particular outcome are taken into account. Pooling the data and applying the GRADE approach slightly changed the underpinning quality of evidence of the results compared to the original review. In the original review, based on the 'levels of evidence' we concluded that for treatments that start four to six weeks post-surgery there is strong evidence (level one) that high intensity programs are more effective on functional status. In this updated review this is underpinned with moderate grade of evidence. This change in strength of the evidence may seem somewhat inconsistent. But in our original review we clearly stated that although it was concluded, based on the 'levels of evidence' that the evidence was 'strong', this conclusion was based on only two studies with a low risk of bias. If results depend greatly on the system of summarizing the evidence, this means that the conclusions cannot be interpreted as absolutely convincing.

An important topic for future research is the identification of relevant subgroups. The goal of lumbar disc surgery is to relieve the leg pain of patients. Kjellby-Wendt 1998 presented a positive outcome for a subgroup with residual leg pain in favour of early active training. But numbers were too small and no firm conclusion could be drawn. This raises the question whether patients with residual leg pain should be treated differently than patients without residual leg pain. Another important topic for future trails relates to return-to-work or sick leave. Although various trials measured return-to-work or sick leave, the results of the current review should be interpreted with caution, with the exception of Donceel, because this study was specifically set up in an occupational setting to improve return-to-work. One difficulty when interpreting the return-to-work (or sick leave) results is that it is often unclear how many patients were employed (or not) at baseline and if that was comparable between groups. A second difficulty relates to the method of measuring return-to-work (or sick leave), which was rarely described. Future RCTs should include appropriate measures of return-to-work. Maybe even more importantly, full economic evaluations should be performed alongside these trials to assess the cost-effectiveness and cost-utility of rehabilitation programs following lumbar disc surgery.

Although we conclude that it is not harmful to return to activity after lumbar disc surgery and therefore it is not necessary for patients to stay passive after lumbar disc surgery, it is still unclear what exact components should be included in rehabilitation programs. High intensity programs seem to be more effective but they could also be more expensive. Therefore cost-effectiveness analysis should be performed in order to assess whether intensive rehabilitation programs, if started early after surgery, lead to a reduction in costs in terms of less healthcare utilization or earlier return to work. Future research should also focus on the implementation of rehabilitation programs in daily practice. Should all patients be treated post-surgery or is a minimal intervention with the message "return to an active lifestyle" sufficient, with only patients that still have symptoms four to six weeks post-surgery requiring reha-

bilitation programs? The cost-effectiveness of this approach needs to be investigated. In conclusion, more research is needed on the (cost-) effectiveness of rehabilitation after first-time disc surgery.

AUTHORS' CONCLUSIONS

Implications for practice

Exercise programs starting four to six weeks post-surgery seem to lead to a faster decrease in pain and functional disability when compared to no treatment, and high intensity programs lead to a faster decrease in pain and functional disability than low intensity programs. There is no evidence that these active programs increase the re-operation rate or that patients need to have their activities restricted after first-time lumbar surgery.

Implications for research

Future research should focus on determining the exact content of treatment programs and how they should be implemented in daily practice. Should all patients be treated post surgery or is a minimal intervention with the message "return to an active lifestyle" sufficient, and do only patients that still have symptoms four to six weeks post-surgery need to participate in rehabilitation programs? Future research should also focus on the identification of relevant subgroups and the role of psychosocial factors.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Alaranta 1986

Methods	Patients were randomised with stratification on sex and age (above 40 years) before the operation
Participants	212 patients after first time disc surgery because of lumbar prolapse: operation that was

Alaranta 1986

(*Continued*)

	usually carried out through an interlaminar trepanation and besides sequester all loose nucleus pulposus was removed
Interventions	Immediate postoperative care same in both groups: out of bed day after surgery, two one-hour health education lessons. (I) start four weeks after surgery (N = 106): multifactorial rehabilitation (physiatrist, physical and occupational therapist, psychologist, social worker) for two weeks, "Intensive Back School". Encouraging physical activities. (R) normal care: not described
Outcomes	All numbers:one year follow-up.Global perceived effect (five point scale) "Much better" or "Better: (I) 88%, (R) 83% not statically significant (NB: includes surgery!) Occupational handicap (WHO scales) and total sick leave during one year follow-up period no significant differences between groups. Re-operations: (I) 4/106, (R) 4/106: No difference
Notes	

Risk of bias

Item	**Authors' judgement**	**Description**
Adequate sequence generation?	Unclear	Unclear from text
Allocation concealment?	Unclear	B - Unclear
Blinding?	No	
Blinding?	No	
Blinding?	No	
Incomplete outcome data addressed?	Yes	
Incomplete outcome data addressed?	Unclear	Unclear from text
Similarity of baseline characteristics?	Unclear	Unclear from text
Co-interventions avoided or similar?	Unclear	Unclear from text
Compliance acceptable?	Unclear	Unclear from text
Timing outcome assessments similar?	Yes	

Danielsen 2000

Methods	Randomization "by random number table"
Participants	63 patients aged 22-58 (range), four weeks after operation for lumbar disc herniation (arcotomy in 36 patients, microsurgical in 27 patients, N = 3 at L3-L4, N = 34 at L4-L5, N=24 L5-S1))
Interventions	(I) Rehabilitation program (N = 39): From week four to 12, three times per week (40 minutes a session) exercise therapy; exclusively active, no manual intervention or physical therapist,

Danielsen 2000

(*Continued*)

	strengthen muscles (various apparatus) patient tailored. (R) (N = 24) week one through three: standard program, then follow-up consultation (info about clinical course and clinical examination) with physical therapist every two weeks for eight weeks, formula with mild home-exercise program, relaxing and resting the back and resume daily activities gradually, avoid any kind of heavy work at home
Outcomes	Pain intensity (VAS) absolute values (abs.) and mean improvement (MI), (95%CI) at six months (I) abs. 2.3 (1.5-3.1) (MI) 3.7 (2.7-4.7), (R) abs. 3.6 (2.5-4.7) (MI) 2.0 (0.7-3.3); for functional status (RDQ) (abs), MI and (95%CI) (I) abs. 5.1 (3.1-7.1) (MI) 8.9 (7.0-10.8), (R) abs. 6.2 (4.1-8.4) 5.4 (3.0-7.8). For pain 12 months: (I) abs.2.8 (1.9-3.7) (MI) 3.2 (2.1-4.3), (R) abs. 3.9 (2.6-5.7) (MI) 1.8 (0.5-3.1); (RDQ) (abs.) (MI) (95%CI) (I) abs. 5.3 (3.2-7.4) (MI) 8.7 (6.8-10.6), (R) abs. 6.3 (3.8-8.8) (MI): 5.3 (2.6-8.0). Absolute RDQ values minor advantage for (I): six and 12 months, on MI significantly larger scores for (I). Pain, both abs. And MI significant better for (I), 12 months no differences between groups. Significantly more patients in (I) participation in daily activities (sub-scale WONCA) at six months. At six and 12 months no significant differences, for overall health or sick leave. No significant changes for analysis with only complete follow-up.
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Yes	Randomization "by random number table"
Allocation concealment?	Yes	A - Adequate
Blinding?	No	
Blinding?	No	
Blinding?	No	
Incomplete outcome data addressed?	Yes	
Incomplete outcome data addressed?	Yes	
Similarity of baseline characteristics?	No	
Co-interventions avoided or similar?	Unclear	Unclear from text
Compliance acceptable?	Unclear	Unclear from text
Timing outcome assessments similar?	Yes	

Dolan 2000

Methods	"Blindly randomised"
Participants	20 patients aged between 18 to 60 (18 men, three women) with radiological evidence of disc

Dolan 2000

(*Continued*)

	prolapse associated with sciatica of less than 12 months duration. (N = 5 L4-L5), (N = 15 L5-S1) Type of surgery: Microdiscectomy, followed by a six weeks normal postoperative care by physical therapy: advice about exercise and return to normal activities.
Interventions	(I) (N = 9) received an exercise program by experienced physiotherapist, two one hour sessions per week for four weeks, (start six weeks after surgery); progress at own pace, general aerobic exercises, stretching exercises, extension exercises strength and endurance exercises (back and abdominal). (R) (N = 11) no further treatment.
Outcomes	Pain intensity (VAS) and (Pain Diary): significant reduction in both groups six weeks after surgery, but (I) showed further decrease (within group) compared to (R). Between groups (12 months) pain (diary): significantly less pain (P < 0.05) in favor of (I) and for pain (VAS) not significant (P = 0.08). Functional status (range 0-75, high scores: good status): improvement in both groups after surgery: mean (SD) (I) 54 (24), (R) 50 (25). On 12 months no between group analysis. Behavioral outcomes: little change post-surgery and during follow-up. ROM and muscle endurance: no differences
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Yes	"Blindly randomised"
Allocation concealment?	Yes	A - Adequate
Blinding?	No	
Blinding?	No	
Blinding?	No	
Incomplete outcome data addressed?	Yes	
Incomplete outcome data addressed?	No	
Similarity of baseline characteristics?	Yes	
Co-interventions avoided or similar?	Unclear	Unclear from text
Compliance acceptable?	Yes	
Timing outcome assessments similar?	Yes	

Donceel 1999

Methods	Randomization "by computer-generated random number"
Participants	710 patients (workers) that have mandatory insurance that introduced a benefit claim after open lumbar discectomy. Age between 15 to 64 and no longer than one year off work before surgery. Interventions start six weeks post-surgery

Interventions	(I) (N = 345) Rehabilitation-oriented approach (in insurance medicine) by medical adviser (MA). First visit six weeks post-surgery, functional evaluation, information on medicolegal aspects, rehabilitation, natural history and expected work incapacity period. Encourage and stimulate personal activities and early mobilization. MA asks treating physician for information regarding diagnosis and treatment, encourages rehabilitation measures, promote multi-disciplinary approach. (R) (N = 365) MA: usual care
Outcomes	On return to work at follow-up (52 weeks): (I) 89.9% (R) 81.9%. Statistically significant
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Yes	Randomization "by computer-generated random number"
Allocation concealment?	No	C - Inadequate
Blinding?	No	
Blinding?	No	
Blinding?	Unclear	Unclear from text
Incomplete outcome data addressed?	Yes	
Incomplete outcome data addressed?	Yes	
Similarity of baseline characteristics?	Yes	
Co-interventions avoided or similar?	Unclear	Unclear from text
Compliance acceptable?	Yes	
Timing outcome assessments similar?	Yes	

Filiz 2005

Methods	Randomized by opaque envelops prepared by independent person
Participants	60 patients (three arms) included one month after first time lumbar disc surgery. Aged between 20 and 50. Only short-term follow-up
Interventions	(I1, N = 20) intensive exercise program and back school education under supervision for eight weeks; three days a week with sessions of 1.5 hours each (I2, N = 20) Back education and McKenzie and Williams exercise in home program for eight weeks; advice to practice three days/week (C, N = 20) No treatment
Outcomes	RTW in days (I1) 56.07 (18.66) vs (I2) 75.0 (24.9) vs (C) 86.2 (27.1). Pain (post treatment score on VAS): (I1) 4.5 (1.6) vs (I2) 12.0 (3.7) vs (C) 13.3 (7.3). Functional status (post treatment scores on Modified Oswestry): (I1) 7.1 (4.9) vs (I2) 11.7 (C) 15.1 (8.6)
Notes	

Filiz 2005

(*Continued*)

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Yes	Randomized by opaque envelops prepared by independent person
Allocation concealment?	Yes	A - Adequate
Blinding?	No	
Blinding?	No	
Blinding?	No	
Incomplete outcome data addressed?	Unclear	Unclear from text
Incomplete outcome data addressed?	Unclear	Unclear from text
Similarity of baseline characteristics?	Yes	
Co-interventions avoided or similar?	Unclear	Unclear from text
Compliance acceptable?	Unclear	Unclear from text
Timing outcome assessments similar?	Yes	

Filiz 2005 (1)

Methods	see Filiz 2005
Participants	
Interventions	
Outcomes	
Notes	

Hakkinen 2005

Methods	"Randomly assigned"
Participants	126 patients included two months after their first lumbar disc surgery and not pain free (VAS > 10mm).
Interventions	(I) Home exercise program after one instruction session, for 12 months. Instructions for stretching and stabilization exercises, instructed to stretch three times AND strength training,

Hakkinen 2005

(*Continued*)

	instructed to perform two series of exercises twice a week. (R) Home exercise program after one instruction session, for 12 months. Instructions for stretching and stabilization exercises, instructed to stretch three times
Outcomes	At 12 months follow-up: Improvement in back pain (100 mm VAS): (I) 4 mm (IQR: -11 to 5) vs (R) 1 mm (IQR : -7 to 9); leg pain (100 mm VAS): (I) -2 (IQR: -7 to 7) vs (R) -2 (IQR: -7 to 3). Improvement in disability (ODI) (I): 3 mm (IQR: -6 to 1) vs (R): -2 (-5 to 1).
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	No	"Randomly assigned"
Allocation concealment?	Unclear	B - Unclear
Blinding?	Unclear	Unclear from text
Blinding?	Unclear	Unclear from text
Blinding?	Unclear	Unclear from text
Incomplete outcome data addressed?	Unclear	Unclear from text
Incomplete outcome data addressed?	Unclear	Unclear from text
Similarity of baseline characteristics?	Yes	
Co-interventions avoided or similar?	No	
Compliance acceptable?	Unclear	Unclear from text
Timing outcome assessments similar?	Yes	

Johannsen 1994

Methods	Randomized by minimization and stratified for sex, age (cut-off 40 years), +/- pre-operative hospitalisation, +/- post-operative complications
Participants	40 patients undergoing a first lumbar diskectomy (L4-L5) for classic nerve root compression symptoms without cauda equina and confirmatory imaging; at least 2 weeks of unsuccessful conservative therapy; aged between 18-65, employed were included. Excluded: specific other diseases spine or hip or system diseases. Interventions start within four to six weeks after surgery
Interventions	(I) (N = 20) supervised group training (max 10 patients) one hour, twice a week for three months. Session: 10 minutes warming up bicycle, dynamic exercises (endurance) for low and high back, buttock and abdominal muscles supervised by PT. (R) (N = 20) individual training at home with two hours instruction by PT plus written instructions. Same exercises as (I).

Johannsen 1994

(*Continued*)

Outcomes	Back pain (five-point scale): T_0, three, six months; median and 12.5 percentiles: (I): 4.1 (2.5 - 6.0), 2.8 (1.8 - 4.8), 2.8 (1.8 - 4.2), (R) 4.0 (2.0 - 5.9), 2.4 (1.7 - 4.2), 2.5 (1.8 - 5.8). Global Perceived Effect (four-point scale, 0 = good, 3 = bad): (I) 1,6 (0.8 - 2.5), 1.1 (0.7 - 1.9), 1.0 (0.6 - 1.5), (R) 1.4 (0.7 - 2.2), 1.2 (0.7 - 2.0), 1.3 (0.7 - 2.9). No differences except extension strength at three months for (R). ROM (sum-score in cm) (I): 12 (-3 - 26), 26 (19 - 41), 27 (8 - 37), (R) 16 (2 - 29), 23 (17 - 30), 26 (15 - 41). Disability (12-point scale with 12 = maximum disability) (I) 3 (0 - 4), 0 (0 - 2), 0 (0 - 3), (R) 2 (0 - 5), 0 (0 - 2), 0 (0 - 2) (NS). Isokentic trunk extension strength: (I) 36 (13 - 48), 45 (23 - 57), 50 (34 - 77), (R) 47 (12 - 59), 54 (35 - 69), 64 (45 - 73).
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Yes	Randomized by minimization and stratified for sex
Allocation concealment?	Yes	A - Adequate
Blinding?	No	
Blinding?	No	
Blinding?	Unclear	Unclear from text
Incomplete outcome data addressed?	No	
Incomplete outcome data addressed?	No	
Similarity of baseline characteristics?	Unclear	Unclear from text
Co-interventions avoided or similar?	Unclear	Unclear from text
Compliance acceptable?	Unclear	Unclear from text
Timing outcome assessments similar?	Yes	

Kjellby-Wendt 1998

Methods	Randomized according to a table of random numbers
Participants	60 patients (aged 16 to 70), microdiscectomy after not responding to conservative treatment. Patients with re-operation other surgery as microdiscectomy without microscope (e.g. laminectomy). Interventions start immediately after surgery
Interventions	(I) (N = 29) Total duration is 12 weeks, starting directly after surgery: out of bed from prone position, increase ADL & lumbar support (sitting). First six weeks home training (five to six times per day) with mobilization neural structures and low-back, increase trunk strength (functional positions), correct work posture, pain coping. Second six weeks (five to six times

Kjellby-Wendt 1998

(*Continued*)

	per day) mainly intensive muscle strength and flexion exercises and cardiovascular exercises (in total: four instruction sessions) (R) Total duration 12 weeks, starting direct after surgery out of bed from side position, no increase of ADL and no lumbar support (sitting). First six weeks abdominal exercises (once a day) lying position. Second six weeks more intensive strength exercises, mobilization spine. No promotion cardiovascular exercises (total: three instruction sessions)
Outcomes	At two years satisfaction (I) 88%, (R) 67%. Percent positive SLR (three weeks) (I) 0 (R) seven, significant difference On six, 12, 52 weeks no significant differences. Extension (52 weeks): (I) 30 (14.8) and (R) flexion (42 (11.5) significantly increased. (I) eight patients pain-free (R) (4), (six weeks) no differences on 12, 52, 104 weeks. Leg Pain intensity (VAS) (in patients with sciatica) at six,12, 52 weeks (mean, SD): (I) 1.0 (0.6), 1.5 (0.9) 2.7 (0.5), (R) 4.1 (2.9), 3.4 (2.2), 3.0 (1.9) statistically significant at six, 12 weeks, not at 52 weeks. At five to seven years follow-up (I) 52%, (R) 50% pain (leg); (I) 73% (R) 60% pain (back). Patients on sick leave at 12 weeks (I) 10 (R) 15 (NS). At 52 weeks (I) 120 (75) days (R) 153 (107) on sick leave. At two years (I) 88% (R) 67% satisfied with result. (I) 10=40% (R) 8 = 33% no pain. During two to five years after surgery no differences in days of sick leave (I) 146 (SD: 243 days) (C) 157 days (SD:203). On the five to seven years follow-up no differences in number of patients with leg pain (I) 16/30 (C) 15/30, or number of patients with back pain (I) 22/30, (C) 18/30
Notes	unpublished data were used

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Yes	Randomized according to a table of random numbers
Allocation concealment?	Yes	A - Adequate
Blinding?	No	
Blinding?	No	
Blinding?	No	
Incomplete outcome data addressed?	No	
Incomplete outcome data addressed?	No	
Similarity of baseline characteristics?	Yes	
Co-interventions avoided or similar?	Unclear	Unclear from text
Compliance acceptable?	Unclear	Unclear from text
Timing outcome assessments similar?	Yes	

Manniche 1993a

Methods	Randomized by drawing of lots
Participants	96 patient (49 men, 47 women) who had undergone first time discectomy for lumbar disc protrusion, aged 18 to 70. Interventions start five weeks after surgery
Interventions	Both groups: (in classes of two to six patients) in total 14 hours including five instruction & ergonomics sessions. (I) Intensive exercises: (start session hot packs & 5 heavy exercises: 1) leg lifting, 2) trunk lifting (one and two from 45O flexion to 0O), 3) abdominal exercise, 4) leg abduction 5) leg adduction (10 repetitions each). End of session: six minutes sub-maximal bicycle training & 5 stretching exercises. Six one-hour sessions, twice a week, next three weeks six 30-minute sessions in water (same principles, no limits to range of motion (including rotatory elements) Pain was no reason for stopping. (R) 15 mild general mobilization exercises, 10 repetitions each, program started with six 30-minute sessions (twice a week) in water. Next three weeks, same principles in gymnasium. If pain occurred: stop.
Outcomes	Overall improvement at 52 weeks (I) 76% (R) 70% "very satisfactory" or "satisfactory, little discomfort". Not significantly different. Medians: pre-treatment post-treatment, six, 12, 26, 52 weeks: On low-back pain scale 0 to 30, (I) 5.5, 2.0, 1.8, 5.2, 3.7; (R) 7.1,3.4, 2.4,.5.5,6.5 no significant differences; on leg pain scale (0 to 30), (I) 4.5, 2.2, 3.0, 3.0, 0.8, (R) 4.8, 3.2, 3.0, 5.0, 2.2; no significant differences; on disability scale (0 to 30) (I) 10.8, 4.5, 4.4, 4.0, 4.2, (R) 11.5, 6.1, 4.3, 6.5, 6.0, statistically significant at 26 weeks. Physical impairment scale (0 to 40), pre-treatment, post-treatment and six weeks (I) 16.2, 11.8, 12.5, (R) 16.8, 11.8, 12.3, no significant different. All scales are sub-scales of Low-Back Pain Rating Scale (high scores denote poor outcome) Days of work in (I) significant less on 26 and 52 weeks. Number of patients not returned to work (I) 14.3% (R) 30%: statistically significant
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Yes	Randomized by drawing of lots
Allocation concealment?	Yes	A - Adequate
Blinding?	No	
Blinding?	No	
Blinding?	No	
Incomplete outcome data addressed?	No	
Incomplete outcome data addressed?	Unclear	Unclear from text
Similarity of baseline characteristics?	Yes	
Co-interventions avoided or similar?	Unclear	Unclear from text
Compliance acceptable?	Yes	
Timing outcome assessments similar?	Yes	

Manniche 1993b

Methods	Randomized by drawing envelopes
Participants	62 patients (30 men, 32 women) with chronic low-back pain occurring 14 to 60 months after first time discectomy for lumbar disc protrusion and patients self reported global assessment of operation outcome was “good”, “fair” or “unchanged” . Interventions start 14 to 60 months post surgery
Interventions	(I) (N = 31) Intensive dynamic exercise with hyperextension, start session with hot pack (optional) (20 minutes), followed by 1) trunk lifting, 2) leg lifting,: one and two with greatest possible extension, 3) abdominal exercise. All in series of 10; one minute rest in between), 4) pull to neck (50 times). two sessions a week (one session: 60-90 minutes), total of 24 sessions in three months. (R) (N = 31) exactly same procedure, but in one and two movement range back and hip only from 90 degrees flexion to 0 degrees. No hyperextension.
Outcomes	Overall improvement post treatment, three months and one year (at one year (I) 38%, (R) 61% scored “very satisfactory” or “satisfactory, little discomfort”) not statistically significant.Improvement functional status (low-back pain rating scale 0 - 130) post-treatment, three, 12 months. (Median 10th -90th percentile): (I) 10 (0 - 31), 8 (-15 - 28), 3 (-11 - 23), (R) 7 (-13 - 22), 1 (-14 - 9), 0 (-26 - 9). Statistically significant at three months only. Post-treatment both groups significantly improve
Notes	

Risk of bias

Item	Authors’ judgement	Description
Adequate sequence generation?	Yes	Randomized by drawing envelopes
Allocation concealment?	Yes	A - Adequate
Blinding?	No	
Blinding?	No	
Blinding?	No	
Incomplete outcome data addressed?	No	
Incomplete outcome data addressed?	Yes	
Similarity of baseline characteristics?	Yes	
Co-interventions avoided or similar?	Yes	
Compliance acceptable?	Yes	
Timing outcome assessments similar?	Yes	

Ostelo 2003

Methods	Randomized by a-priori prepared, opaque and sealed envelopes.
Participants	105 patients still suffering complaints six weeks post surgery.
Interventions	(I: N = 52.) Behavioral graded activity (operant therapy) using graded activity and positive reinforcement , time-contingency management . Based on baseline measurements an individually graded exercise training program established, using quota setting. in total 18 sessions (30 minutes a session) over a three months period. (R: N = 53) Physiotherapiy program: ADL instructions, exercise trunk muscles (increase strength and stability). mobilization exercises. Number of sessions (of 30 minutes each) at the discretion of therapists (max 18 sessions)
Outcomes	Global Perceived Effect: I: 48% recovered versus R: 67% (three short-term) and 75% (I) versus 73% on the one year follow-up. Functional status (24 item RDQ): I: mean improvement (5.2 SD: 5.9) versus (5.6 SD: 5.3) for R on the short term, long-term: I: (7.0 SD: 5.5) versus R: (7.0 SD: 5.3) Pain back (VAS): mean improvement : I: (9.3 SD: 27.8) vs R: (16.0 SD: 25.3) short-term; one year follow-up: I: (17.6 SD: 32.5) vs R: (22.4 SD: 33.0) Cost-effectiveness analysis: the total direct costs in behavioral graded activity are 639 EURO [95% CI: 91; 1368] higher than physiotherapy.
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Yes	Randomized by a-priori prepared, opaque and sealed envelopes.
Allocation concealment?	Yes	A - Adequate
Blinding?	No	
Blinding?	No	
Blinding?	No	
Incomplete outcome data addressed?	No	
Incomplete outcome data addressed?	Yes	
Similarity of baseline characteristics?	Yes	
Co-interventions avoided or similar?	No	
Compliance acceptable?	Yes	
Timing outcome assessments similar?	Yes	

Scrimshaw 2001

Methods	Randomisation by random numbers table, unclear concealment
Participants	81 patients undergoing spinal surgery randomised, 59 of whom underwent laminectomy or discectomy. Others were operated for fusion
Interventions	(I) (N = 32) standard postoperative care (isometric and dynamic exercises, progress as tolerated) AND active and passive exercises for neural mobilization (six days in hospital, encouraged to continue for at least six weeks) (R) standard postoperative care ONLY (isometric and dynamic exercises, progress as tolerated)
Outcomes	Overall improvement at 12 months (I) 67.7% vs (R) 68.9%; Pain (VAS) six weeks score (I) 26.6 (SD:29.3) vs (R) 33.4 (SD:30.6); at 12 mos (I) 33.4 (SD:34.2) vs (R) 25.7 (SD:29.18); functional status (QBPQ) at six weeks (I) 34.9 (SD:22.9) vs (R) 30.4 (SD:22.8), at 12 months (I) 29.9 (SD:24.1) vs (R) 27.2 (24.8)
Notes	Unpublised data used for analyses so that only the 59 patients who underwent laminectomy or discectomy were included.

Risk of bias

Item	**Authors' judgement**	**Description**
Adequate sequence generation?	Yes	Randomisation by random numbers table
Allocation concealment?	Unclear	B - Unclear
Blinding?	No	
Blinding?	No	
Blinding?	No	
Incomplete outcome data addressed?	Yes	
Incomplete outcome data addressed?	Yes	
Similarity of baseline characteristics?	Yes	
Co-interventions avoided or similar?	Yes	
Compliance acceptable?	No	
Timing outcome assessments similar?	Yes	

Timm 1994

Methods	Randomly assigned
Participants	250 employers (68 females) in manufacturing segment of automobile industry, aged 34 to 51, with chronic low-back pain for at least six months following a single-level lumbar laminectomy (L5 segment) performed at least one year before start experiment

Interventions	(I1) (N = 50) Physical agents: three sessions/week for eight weeks (24 sessions) hot packs (20 minutes), ultrasound (paravertebral musculature 1.5W/cm^2, six minutes), TENS in non-clinical setting (100-msec pulse, 100 pulses/sec, "to tolerance")(I2) (N = 50) joint manipulation: large-amplitude low velocity manual therapy procedures (Maitland grades III or IV) combined with oscillations or sustained stretches. (I3) low-tech exercise: McKenzie under supervision (plus spinal stabilization). (I4) (N = 50) high-tech exercise: cardiovascular. (bicycle), isotonic trunk muscle training (DAPRE), isokinetic exercises flexion/extension left/right rotation (Cybex TEF & TORSO) (R) (N = 50) no treatment.
Outcomes	Functional status (Oswestry) Mean (SD) pretest (I1) (I2) (I3) (I4) (R): 37 (2.6), 36 (4.1), 35 (4.0), 33 (4.7) 37 (1.8) posttest 37 (1.7), 32 (5.1), 14 (4.9), 15 (3.6) 37 (2.4). (I3) and (I4) significantly better (I1), (I2) (R). No significant differences between (I3) and (I4). ROM Flexion (modified-modified Schober in cm) Mean (SD) pretest (I1) (I2) (I3) (I4) (R): 6.4 (1.5), 6.3 (1.4), 6.3 (1.4), 6.3 (1.4) 6.3 (1.5) posttest: 6.3 (1.5), 6.5 (2.2), 8.8 (2.4), 9.1 (2.6), 6.2 (1.5). (I3) and (I4) significantly better (I1), (I2) (R). No significant differences between (I3) and (I4). Lifting force output (in N) Mean (SD) pretest (I1) (I2) (I3) (I4) (R): 374 (107), 387 (80), 352 (98), 356 (111), 360 (102) posttest: 378 (98), 382 (87), 627 (117), 705 (108), 363 (94). (I3) and (I4) significantly better (I1), (I2) (R). No significant differences between (I3) and (I4). Weeks to re-entry into treatment (I1) (I2) (I3) (I4) (R); Mean (SD): 2.0 (0.5), 5.7 (1.3), 91.4 (60.1), 52.8 (3.6), 1.6 (0.2). (I3) significantly better than others. (I3) significantly more cost-effective than other
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Unclear	Randomly assigned
Allocation concealment?	Unclear	B - Unclear
Blinding?	No	
Blinding?	No	
Blinding?	No	
Incomplete outcome data addressed?	Unclear	Unclear from text
Incomplete outcome data addressed?	Unclear	Unclear from text
Similarity of baseline characteristics?	Yes	
Co-interventions avoided or similar?	No	
Compliance acceptable?	Yes	
Timing outcome assessments similar?	Yes	

Yilmaz 2003

Methods	Randomization or concealment not described

Yilmaz 2003

(*Continued*)

Participants	42 patients (22 male, 20 female), age (range: 22-60) included one month after first time
Interventions	(I1, N = 14) dynamic lumbar stabilization exercise for eight weeks under supervision; (I2, N = 14) Flexion - extension program (Williams-McKenzie) home program for eight weeks; (C) no treatment.
Outcomes	Pain (VAS scores at post treatment) (I1) 1.14 (0.86) vs (I2) 2.93 (2.02) vs (C) 4.29 (1.90). Functional status (Scores on Modified Oswestry at post treatment) (I1) 8.5 (4.8) vs (I2) 12.93 (4.23) vs (C) 17.71 (6.23)
Notes	

Risk of bias

Item	**Authors' judgement**	**Description**
Adequate sequence generation?	Unclear	Not described in text
Allocation concealment?	Unclear	B - Unclear
Blinding?	No	
Blinding?	No	
Blinding?	No	
Incomplete outcome data addressed?	Unclear	Unclear from text
Incomplete outcome data addressed?	Unclear	Unclear from text
Similarity of baseline characteristics?	Yes	
Co-interventions avoided or similar?	Unclear	Unclear from text
Compliance acceptable?	Unclear	Unclear from text
Timing outcome assessments similar?	Yes	

Yilmaz 2003 (1)

Methods	
Participants	
Interventions	
Outcomes	
Notes	

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Brennan 1994	not randomised
Burke 1994	not randomised
Kitteringham 1996	not randomised
Lavyne 1992	no active rehabilitation but epidural corticosteroids
Le Roux 1999	no active rehabilitation but Ketorolac during wound closure
Rotthaupt 1997	no adequate randomisation (date of birth)
Woischnek 2000	descriptive pilot study

Characteristics of ongoing studies *[ordered by study ID]*

Selkowitz 2006

Trial name or title	The immediate and long-term effects of exercise and patient education on physical, functional, and quality-of-life outcome measures after single-level lumbar microdiscectomy: a randomised controlled trial protocol.
Methods	
Participants	Patients after single level lumbar microdiscectomy
Interventions	Excercis versus patient education
Outcomes	Oswestry Disability Questionnaire, Roland-Morris Disability Questionnaire, SF-36 quality of life assessment, Subjective Quality of Life Scale, 50-foot Walk, Repeated Sit-to-Stand, and a modified Sorensen test.
Starting date	
Contact information	Selkowitz, Department of Physical Therapy Education, Western University of Health Sciences, 309 E. Second St., Pomona, CA 91766, USA
Notes	

DATA AND ANALYSES

Comparison 1. Treatments that start four to six weeks post-surgery. Exercise versus no treatment

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Pain on VAS (post-treatment)	5	122	Mean Difference (IV, Random, 95% CI)	-11.13 [-18.44, -3.82]
2 Functional status on Modified Oswestry (post-treatment)	4	102	Mean Difference (IV, Random, 95% CI)	-6.50 [-9.26, -3.74]

Comparison 2. Treatments that start four to six weeks post-surgery. High-intensity exercise versus low-intensity exercise programs

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Pain (short-term)	2	103	Mean Difference (IV, Random, 95% CI)	-10.67 [-17.04, -4.30]
2 Function (short-term)	2	103	Std. Mean Difference (IV, Random, 95% CI)	-0.77 [-1.17, -0.36]

Comparison 3. Treatments that start four to six weeks post-surgery. Supervised programs versus home exercises

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Functional status (short-term)	3	95	Std. Mean Difference (IV, Random, 95% CI)	-1.17 [-2.63, 0.28]
2 Pain (short-term)	3	95	Std. Mean Difference (IV, Random, 95% CI)	-1.12 [-2.77, 0.53]

Analysis 1.1. Comparison 1 Treatments that start four to six weeks post-surgery. Exercise versus no treatment, Outcome 1 Pain on VAS (post-treatment).

Review: Rehabilitation after lumbar disc surgery

Comparison: 1 Treatments that start four to six weeks post-surgery. Exercise versus no treatment

Outcome: 1 Pain on VAS (post-treatment)

Study or subgroup	Treatment N	Mean(SD)	No treatment N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Dolan 2000	9	18 (7)	11	30 (8)		23.7 %	-12.00 [-18.58, -5.42]
Filiz 2005	20	4.5 (1.59)	10	13.25 (7.34)		26.2 %	-8.75 [-13.35, -4.15]
Filiz 2005 (1)	20	12 (3.67)	10	13.25 (7.34)		26.0 %	-1.25 [-6.08, 3.58]
Yilmaz 2003	14	11.4 (8.6)	7	42.9 (19)		13.3 %	-31.50 [-46.28, -16.72]
Yilmaz 2003 (1)	14	29.3 (20.2)	7	42.9 (19)		10.8 %	-13.60 [-31.21, 4.01]
Total (95% CI)	**77**		**45**			**100.0 %**	**-11.13 [-18.44, -3.82]**

Heterogeneity: $Tau^2 = 47.49$; $Chi^2 = 19.10$, df = 4 (P = 0.00075); $I^2 = 79\%$

Test for overall effect: Z = 2.98 (P = 0.0028)

Analysis 1.2. Comparison 1 Treatments that start four to six weeks post-surgery. Exercise versus no treatment, Outcome 2 Functional status on Modified Oswestry (post-treatment).

Review: Rehabilitation after lumbar disc surgery

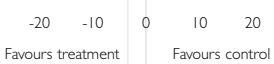
Comparison: 1 Treatments that start four to six weeks post-surgery. Exercise versus no treatment

Outcome: 2 Functional status on Modified Oswestry (post-treatment)

Study or subgroup	Treatment N	Mean(SD)	No treatment N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Filiz 2005	20	7.05 (4.87)	10	15.1 (8.55)		23.4 %	-8.05 [-13.76, -2.34]
Filiz 2005 (1)	20	11.65 (7.21)	10	15.1 (8.55)		20.0 %	-3.45 [-9.62, 2.72]
Yilmaz 2003	14	8.5 (4.83)	7	17.71 (6.23)		27.5 %	-9.21 [-14.47, -3.95]
Yilmaz 2003 (1)	14	12.93 (4.23)	7	17.71 (6.23)		29.1 %	-4.78 [-9.90, 0.34]
Total (95% CI)	**68**		**34**			**100.0 %**	**-6.50 [-9.26, -3.74]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 2.67$, df = 3 (P = 0.44); $I^2 = 0.0\%$

Test for overall effect: Z = 4.61 (P < 0.00001)



Analysis 2.1. Comparison 2 Treatments that start four to six weeks post-surgery. High-intensity exercise versus low-intensity exercise programs, Outcome 1 Pain (short-term).

Review: Rehabilitation after lumbar disc surgery

Comparison: 2 Treatments that start four to six weeks post-surgery. High-intensity exercise versus low-intensity exercise programs

Outcome: 1 Pain (short-term)

Study or subgroup	High intensity N	Mean(SD)	Low intensity N	Mean(SD)	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Danielsen 2000	39	23 (4.6)	24	37 (5.6)		48.8 %	-14.00 [-16.67, -11.33]
Filiz 2005	20	4.5 (1.59)	20	12 (3.67)		51.2 %	-7.50 [-9.25, -5.75]
Total (95% CI)	**59**		**44**			**100.0 %**	**-10.67 [-17.04, -4.30]**

Heterogeneity: Tau² = 19.80; Chi² = 15.95, df = 1 (P = 0.00007); I² =94%

Test for overall effect: Z = 3.28 (P = 0.0010)

Analysis 2.2. Comparison 2 Treatments that start four to six weeks post-surgery. High-intensity exercise versus low-intensity exercise programs, Outcome 2 Function (short-term).

Review: Rehabilitation after lumbar disc surgery

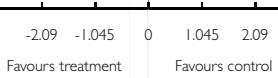
Comparison: 2 Treatments that start four to six weeks post-surgery. High-intensity exercise versus low-intensity exercise programs

Outcome: 2 Function (short-term)

Study or subgroup	High intensity N	Mean(SD)	Low intensity N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
Danielsen 2000	39	5.1 (1.25)	24	6.1 (1.25)		59.7 %	-0.79 [-1.32, -0.26]
Filiz 2005	20	7.05 (4.87)	20	11.65 (7.21)		40.3 %	-0.73 [-1.38, -0.09]
Total (95% CI)	**59**		**44**			**100.0 %**	**-0.77 [-1.17, -0.36]**

Heterogeneity: Tau² = 0.0; Chi² = 0.02, df = 1 (P = 0.89); I² =0.0%

Test for overall effect: Z = 3.69 (P = 0.00023)



Analysis 3.1. Comparison 3 Treatments that start four to six weeks post-surgery. Supervised programs versus home exercises, Outcome 1 Functional status (short-term).

Review: Rehabilitation after lumbar disc surgery

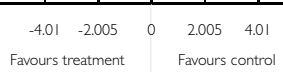
Comparison: 3 Treatments that start four to six weeks post-surgery. Supervised programs versus home exercises

Outcome: 1 Functional status (short-term)

Study or subgroup	Supervised N	Mean(SD)	Home N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
Filiz 2005	20	4.5 (1.59)	20	12 (3.67)		32.9 %	-2.60 [-3.46, -1.74]
Johannsen 1994	11	0 (0.87)	16	0 (0.87)		33.7 %	0.0 [-0.77, 0.77]
Yilmaz 2003	14	8.5 (4.83)	14	12.93 (4.23)		33.5 %	-0.95 [-1.74, -0.16]
Total (95% CI)	**45**		**50**			**100.0 %**	**-1.17 [-2.63, 0.28]**

Heterogeneity: $Tau^2 = 1.49$; $Chi^2 = 19.63$, df = 2 (P = 0.00005); $I^2 = 90\%$

Test for overall effect: Z = 1.58 (P = 0.11)



Analysis 3.2. Comparison 3 Treatments that start four to six weeks post-surgery. Supervised programs versus home exercises, Outcome 2 Pain (short-term).

Review: Rehabilitation after lumbar disc surgery

Comparison: 3 Treatments that start four to six weeks post-surgery. Supervised programs versus home exercises

Outcome: 2 Pain (short-term)

Study or subgroup	Supervised N	Mean(SD)	Home N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
Filiz 2005	20	4.5 (1.59)	20	12 (3.67)		33.0 %	-2.60 [-3.46, -1.74]
Johannsen 1994	11	2.8 (1.3)	16	2.4 (1.08)		33.6 %	0.33 [-0.44, 1.10]
Yilmaz 2003	14	11.4 (8.6)	14	29.3 (20.2)		33.4 %	-1.12 [-1.92, -0.31]
Total (95% CI)	**45**		**50**			**100.0 %**	**-1.12 [-2.77, 0.53]**

Heterogeneity: $Tau^2 = 1.95$; $Chi^2 = 24.65$, df = 2 (P<0.00001); $I^2 = 92\%$

Test for overall effect: Z = 1.33 (P = 0.18)

APPENDICES

Appendix 1. MEDLINE search strategy

1. exp "Clinical Trial [Publication Type]"/
2. randomized.ab,ti.
3. placebo.ab,ti.
4. dt.fs.
5. randomly.ab,ti.
6. trial.ab,ti.
7. groups.ab,ti.
8. or/1-7
9. Animals/
10. Humans/
11. 9 not (9 and 10)
12. 8 not 11
13. dorsalgia.ti,ab.
14. exp Back Pain/
15. backache.ti,ab.
16. (lumbar adj pain).ti,ab.
17. coccyx.ti,ab.
18. coccydynia.ti,ab.
19. sciatica.ti,ab.
20. sciatica/
21. spondylosis.ti,ab.
22. lumbago.ti,ab.
23. or/13-22
24. exp Spine/
25. discitis.ti,ab.
26. exp Spinal Diseases/
27. (disc adj degeneration).ti,ab.
28. (disc adj prolapse).ti,ab.
29. (disc adj herniation).ti,ab.
30. spinal fusion.sh.
31. spinal neoplasms.sh.
32. (facet adj joints).ti,ab.
33. intervertebral disk.sh.
34. postlaminectomy.ti,ab.
35. arachnoiditis.ti,ab.
36. (failed adj back).ti,ab.
37. or/24-36
38. Oswestry.tw.
39. Roland-Morris.tw.
40. or/38-39
41. 23 or 37 or 40
42. exp Physical Therapy Modalities/
43. physiotherapy.mp.
44. exp Rehabilitation/
45. rehabilitation.mp.
46. exp Exercise/
47. exp Exercise Movement Techniques/
48. exercise.mp.
49. or/42-48

50. 12 and 41 and 49

Appendix 2. EMBASE search strategy

1. Clinical article/
2. clinical study/
3. Clinical trial/
4. controlled study/
5. randomized controlled trial/
6. major clinical study/
7. double blind procedure/
8. multicenter study/
9. single blind procedure/
10. phase 3 clinical trial/
11. phase 4 clinical trial/
12. crossover procedure/
13. placebo/
14. or/1-13
15. allocat$.mp.
16. assign$.mp.
17. blind$.mp.
18. (clinica$ adj25 (study or trial)).mp.
19. compar$.mp.
20. control$.mp.
21. cross?over.mp.
22. factorial$.mp.
23. follow?up.mp.
24. placebo$.mp.
25. prospectiv$.mp.
26. random$.mp.
27. ((singl$ or doubl$ or trebl$ or tripl$) adj25 (blind$ or mask$)).mp.
28. trial.mp.
29. (versus or vs).mp.
30. or/15-29
31. 14 or 30
32. human/
33. nonhuman/
34. animal/
35. animal experiment/
36. 33 or 34 or 35
37. 32 not 36
38. 31 not 36
39. 31 and 37
40. 38 not 39
41. dorsalgia.mp.
42. exp back pain/
43. backache.mp.
44. (lumbar adj pain).mp.
45. coccyx.mp.
46. coccydynia.mp.
47. sciatica.mp.
48. sciatica/
49. spondylosis.mp.

50. lumbago.mp.
51. or/41-50
52. exp spine/
53. discitis.mp.
54. exp spinal diseases/
55. (disc adj degeneration).mp.
56. (disc adj prolapse).mp.
57. (disc adj herniation).mp.
58. spinal fusion.mp.
59. spinal neoplasms.mp.
60. (facet adj joints).mp.
61. intervertebral disk.mp.
62. postlaminectomy.mp.
63. arachnoiditis.mp.
64. (failed adj back).mp.
65. or/52-64
66. Oswestry.mp.
67. roland-morris.mp.
68. 66 or 67
69. 51 or 65 or 68
70. exp PHYSIOTHERAPY/
71. exp REHABILITATION/
72. exp EXERCISE/
73. physical therapy.mp.
74. exercise.mp.
75. rehabilitation.mp.
76. physiotherapy.mp.
77. or/70-76
78. 40 and 69 and 77

Appendix 3. CINAHL search strategy

1. Randomized Controlled Trials.mp.
2. clinical trial.pt.
3. exp Clinical Trials/
4. (clin$ adj25 trial$).tw.
5. ((singl$ or doubl$ or trebl$ or tripl$) adj25 (blind$ or mask$)).tw.
6. exp PLACEBOS/
7. placebo$.tw.
8. random$.tw.
9. exp Study Design/
10. (latin adj square).tw.
11. exp Comparative Studies/
12. exp Evaluation Research/
13. Follow-Up Studies.mp.
14. exp Prospective Studies/
15. (control$ or prospectiv$ or volunteer$).tw.
16. Animals/
17. or/1-15
18. 17 not 16
19. dorsalgia.mp.
20. exp Back Pain/
21. backache.mp.

22. (lumbar adj pain).mp. [mp=title, subject heading word, abstract, instrumentation]
23. exp COCCYX/
24. exp SCIATICA/
25. coccyx.mp.
26. sciatica.mp.
27. exp Low Back Pain/
28. coccydynia.mp.
29. sciatica.mp. or exp SCIATICA/
30. exp Lumbar Vertebrae/ or exp Spondylolisthesis/ or exp Spondylolysis/
31. lumbago.mp.
32. or/19-31
33. exp SPINE/
34. exp Intervertebral Disk/
35. exp Spinal Diseases/
36. (disc adj degeneration).mp. [mp=title, subject heading word, abstract, instrumentation]
37. (disc adj prolapse).mp. [mp=title, subject heading word, abstract, instrumentation]
38. (disc adj herniation).mp. [mp=title, subject heading word, abstract, instrumentation]
39. exp Spinal Fusion/
40. (facet adj joint$).mp. [mp=title, subject heading word, abstract, instrumentation]
41. exp Laminectomy/
42. exp KYPHOSIS/
43. (failed adj back).mp. [mp=title, subject heading word, abstract, instrumentation]
44. or/33-43
45. oswestry.mp.
46. roland-morris.mp.
47. or/45-46
48. 32 or 44 or 47
49. exp Physical Therapy/
50. physiotherapy.mp.
51. exp REHABILITATION/
52. rehabilitation.mp.
53. exp EXERCISE/
54. exercise.mp.
55. or/49-54
56. 18 and 48 and 55

Appendix 4. PsycINFO search strategy

(KW=(Randomized controlled trial?) or KW=(clinical trial?) or KW=(clin* within 25 trial*) or kw=(sing* within 25 blind*) or kw=(sing* within 25 mask*) or kw=(doubl* within 25 blind*) or kw=(doubl* within 25 mask*) or kw=(trebl* within 25 blind) or kw=(trebl* within 25 mask*) or kw=(tripl* within 25 blind*) or kw=(tripl* within 25 mask*) or KW=(placebo*) or KW=(random*) or DE=(Research Design) or KW=(Latin square) or KW=(comparative stud*) or KW=(evaluation stud*) or kw=(follow up stud*) or DE=(Prospective studies) or KW= (control*) or KW=(prospective*) or KW=(volunteer*)) and (DE=(back) or DE = (back pain) or DE=(neck)) and (KW=(physiotherapy) or DE=(rehabilitation) or DE=(exercise) or DE=(physical therapy) or KW=(lumbar diskectomy)or KW=(post operative) or KW=(discectomy) or KW=(back surgery) or KW=(lumbar surgery)or KW=(lumbar disk herniation))

FEEDBACK

Comments on version of review published in The Cochrane Library 2002, issue 2

Summary

January 2005

Feedback 1: The results are described almost entirely in terms of whether or not they were statistically significant, and very few numbers are presented. It would be much more informative to state how big the differences between the groups were (a relative risk or mean difference, or other measure of the size of the difference), with a confidence interval to indicate the uncertainty around the estimate. The statistical significance of a result is of little importance, and alone is very uninformative.
Feedback 2: Thanks for this - I just wanted to correct a possible misunderstanding. I wasn't criticising the lack meta-analysis and overall effect estimate - this is a very reasonable position when the trials are heterogeneous. My criticism was about description of the results of the included trials as "statistically significant" or not, which does not give much idea of the size of the differences that they found. It would be much better to quote risk ratios or differences and confidence intervals.

Reply

Response 1: It is always more informative if one can calculate an overall effect size ... provided there are sufficient data and it makes clinical sense to do so. However, you have identified the challenges facing authors who try to synthesize the data in this field. The authors only found 13 studies that met the inclusion criteria, and felt that for the studies that did include sufficient data, there was too much heterogeneity in the duration and intensity of the interventions and the timing of outcome measures to pool the data.
You also comment on the lack of clinical relevance. Our guidelines have now changed, and ask authors to include this parameter in their reviews. Since this review is due for updating, I would anticipate the author including this in the updated review.
I will pass on your comments to the authors, so that they can take consider them as they complete the update.
Response 2: thanks for clarifying. And the editorial board does agree with you! As I'm sure you are aware, authors often describe their results as 'statistically' significant because they are, but for a variety of reasons their results really mean little or nothing from a clinical perspective. The rheumatology field is ahead of the back pain field in definitions, calculations and reporting of minimum clinically important differences. At our last international forum on back pain research (Edmonton, Canada, October 2004) there was a lot of discussion on this, but no consensus yet. There has been some consensus on patient-centred outcomes of import, but again, the older trials don't necessarily follow this. The other really unfortunate thing is that much of the literature just doesn't give any stats at all! The newer trials are better, but its still an uphill battle, despite the widespread acceptance of the CONSORT and TREND statements.

Contributors

Dr Simon Gates, Trials Researcher/Statistician
Victoria Pennick, Back Group Coordinator

WHAT'S NEW

Last assessed as up-to-date: 14 November 2007

Date	Event	Description
23 June 2008	Amended	Converted to new review format.
19 March 2008	New citation required and conclusions have changed	In contrast to the original review, we only included RCTs in this update. In total, five new RCTs were

(*Continued*)

Date	Event	Description
		included, yielding a total of 14 included RCTs. Therefore, it was now possible to pool the data in three comparisons. In addition, in this update we used the GRADE approach, as recommended by the Editorial Board of the Cochrane Back Review Group (CBRG), while in the original review the 'levels of evidence' approach was used. The following 'new' results were found, none of which are supported by high quality evidence 1) Adding neural mobilization to an exercise program is not effective on pain and functional disability in the short-term and the long-term. 2) Exercise programs that start four to six weeks post-surgery lead to a faster decrease in pain and functional disability as compared to no treatment 3) A behavioural graded activity program is not more effective than a standard physiotherapy program 4) Supervised training does not seem to be more effective than home-based training in the short-term.
19 May 2007	New search has been performed	The literature search was updated to May 19, 2007.

HISTORY

Protocol first published: Issue 2, 2001

Review first published: Issue 2, 2002

Date	Event	Description
1 June 2007	New search has been performed	the literature search was updated to June 1st, 2007

CONTRIBUTIONS OF AUTHORS

Pairs of review authors (Henrica de Vet & Maurits van Tulder and for the update Raymond Ostelo & Leonardo Costa) identified and selected all studies. Also in pairs, Leonardo Costa, Christopher Maher, Maurits van Tulder and Raymond Ostelo assessed the methodological quality of studies and performed the data extraction. Raymond Ostelo, Henrica de Vet and Maurits van Tulder conducted the data analyses. All review authors were involved in writing the review protocol and the final draft of the review.

DECLARATIONS OF INTEREST

Raymond Ostelo, first author of this review, is also the first author of one of the included studies.

As this is a potential conflict of interest, he was not involved in the methodological quality assessment, data extraction or any other decision regarding this trial.

INDEX TERMS

Medical Subject Headings (MeSH)

*Exercise Therapy; Intervertebral Disk [*surgery]; *Lumbar Vertebrae; Postoperative Period; Recovery of Function

MeSH check words

Humans