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# The effect of early rehabilitation after lumbar spine surgery: a systematic review and meta-analysis

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## Abstract

**Background** Evidence-based data are required to provide insightful information on the timing of rehabilitation after lumbar spine surgery (LSS).

**Objectives** The aim of this study is to systematically review the outcomes of early rehabilitation interventions and conduct its meta-analysis in patients after LSS.

**Patients and methods** A total of 1183 articles were retrieved through PubMed ($n=793$), Web of Science ($n=721$), Scopus ($n=335$), and ScienceDirect ($n=83$) databases. Fourteen studies were included in the systematic review. The quality analysis and risk of bias assessment of the trials included in the systematic review were performed using the Physiotherapy Evidence Database (PEDro) scoring and classification system. Narrative synthesis and standardized mean difference based pooling results were given for the systematic review and meta-analysis, respectively.

**Results** The additional benefit of early rehabilitation on physical function was moderately effective (ES: −0.62, 95% CI −1.00; −0.25) at the 1-month follow-up. In terms of pain, early rehabilitation provided additional improvement at 1 month (ES: 0.34, 95% CI −0.03; 0.71), 3 months (ES: −0.14, 95% CI −0.37; 0.10), 6 months (ES: 0.35, 95% CI 0.04; 0.65) and 1 year (ES: 0.21, 95% CI −0.09; 0.52) follow-up at a low level of evidence.

**Conclusions** This systematic review demonstrated that early rehabilitation mainly improved disability in the early period (1-month follow-up). Regarding pain, short-term (1 month) and mid-term (6 months) follow-ups showed the most significant additional benefit. The positive effects of starting rehabilitation early after surgery on pain may have positively affected disability, specifically in the early period (1 month).

**Keywords** Accelerated, Decompression, Fast-track, Enhanced, Exercise

## Background

The diagnosis of degenerative lumbar spinal stenosis and back pain has increased over time due to longer life expectancies, the desire for a higher quality of life, awareness of the condition, and the availability of cutting-edge imaging tools. Patients with severe lower back pain who do not respond to nonsurgical treatments for 3–6 months frequently have lumbar spine surgery (LSS) [1]. LSS is widespread in the older population and is becoming more common as the average lifespan rises [2]. Lumbar spinal fusion has emerged as the most widely utilized surgical procedure, with a rate of 13.8% for degenerative disk disease due to its superiority in terms of effectiveness [3, 4].

The typical success rate for lumbar spine procedures regarding capacity to work, neurological symptoms, and leg/back diskomfort is between 45 and 72% and reported

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satisfactory clinical outcomes to range from 16 to 95% [5, 6]. Questionnaires on patients' expectations after LSS demonstrated that pain reduction and better mobility are the most expected results [7]. Numerous studies have demonstrated the efficacy of rehabilitation as the primary treatment for low back pain. However, research has demonstrated that rehabilitation after LSS is preferable to only rehabilitation including non-operative treatment but remains unclear, whereas a recent systematic review concluded that surgery might be more efficacious than unstructured care but may not be more efficacious than structured cognitive-behavioral therapy [8].

A recent meta-analysis demonstrated that standard treatment after lumbar fusion surgery does not significantly reduce disability and pain at 6 months compared to rehabilitation that combines an exercise program with cognitive behavioral therapy. Additionally, multimodal rehabilitation, which incorporates exercise therapy and cognitive behavioral training, is more effective than exercise therapy alone at reducing disability and pain-related fear [9, 10]. The most common specialized exercises are the Williams and McKenzie exercise regimens, floor exercises with the exercise ball or band, co-contraction for the transversus abdominus/multifidus muscles, and lumbopelvic stabilization. These exercise routines have been found to be both short- and long-term beneficial concerning low back issues such as persistent pain, lumbar spinal stenosis, and lumbar disk degeneration [11, 12]. According to a recent systematic review and meta-analysis, rehabilitation that includes cognitive therapy or counseling while the patient participates in an activity program has better results than exercise-only rehabilitation for lumbar fusion surgery [13].

The timing of the rehabilitation therapy is a crucial consideration. A study showed that ambulation within 8 h after elective cervical and LSS improved outcomes such as less complication rate, shorter hospital stays, lower 90-day readmission, and lower urinary retention rate compared to the patients who ambulated between 8 and 24 h [14]. Systematic reviews have demonstrated the significance of the timing of rehabilitation following procedures other than LSS. For instance, early rehabilitation following spinal cord injury was related to better functional outcomes and shorter hospital stays, according to a recent review [15]. Additionally, Greenwood et al.'s comprehensive review and meta-analysis showed that rehabilitation reduces short- and long-term impairment and fear avoidance behavior after lumbar fusion surgery. However, the effect of early rehabilitation after LSS has not been thoroughly evaluated [16].

More evidence-based data for better patient outcomes in rehabilitation practice would emerge from a systematic review and meta-analysis that provides insightful information on the timing of rehabilitation after lumbar spine surgery (LSS). To date, no systematic review has focused on the effectiveness of early rehabilitation after LSS. Additionally, a more thorough evaluation is required to highlight existing exercise alternatives and rehabilitation strategies that do not involve exercises that can be performed throughout the postoperative period of lumbar surgeries.

## Aim of the work

The aim of this study is to systematically review the outcomes of early rehabilitation interventions and conduct its meta-analysis in patients after LSS.

## Patients and methods

### Search strategy

"Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA)" and "Cochrane Handbook for Systematic Reviews of Interventions" guidelines were considered for the methodological design of the review [17, 18]. Between November 2022 and January 2023, the literature search was performed through PubMed, Web of Science, Scopus and ScienceDirect databases with the specific keywords presented in "Appendix". The "Medical Subject Headings (MeSH)" database was used to identify keywords. The terms "Lumbar surgery", "Early rehabilitation", "Enhanced rehabilitation", "Accelerated rehabilitation", and "Fast-track rehabilitation" were combined with Boolean operators to focus on studies concentrating on early rehabilitation after LSS. The search was performed independently by two separate researchers of the study.

#### Eligibility criteria

Before the screening procedures, the study's investigators determined the inclusion and exclusion criteria to ensure that the studies included in the systematic review had a more homogeneous sample and methodology. Inclusion criteria for the review were: (1) studies focusing on the effectiveness of early rehabilitation after LSS, (2) studies with a randomized controlled design. Exclusion criteria for the review: (1) studies focusing on the efficacy of rehabilitation before LSS, (2) studies with other non-randomized controlled research designs and designs, (3) articles published in a language other than English, (4) duplicate publications, (5) publications for which the full text was not available, (6) studies focusing on the efficacy of medical interventions other than rehabilitation after surgery.

#### Study selection and data extraction

The datasets containing the independent searches of two researchers were imported into Rayyan (QCRI, Qatar) software. Rayyan is a practical and automated article management tool for systematic reviews. Owing to this software, duplicate records can be detected automatically [19]. On the other hand, it is possible to manually mark the inclusion of trials in the review with "yes", "no", and "maybe" commands on the title/summary.

The two investigators who performed the screening evaluated the trials' eligibility by considering the study's inclusion/exclusion criteria through the Rayyan software. When two investigators disagreed on trial selection, a consensus was reached by considering the opinion of an experienced investigator who is an expert in the field of neurosurgical rehabilitation and knowledgeable about the systematic review methodology. The CONSORT flowchart of the systematic review is presented in Fig. 1. "Author, purpose, gender, sample, sample size, intervention, assessment and outcomes sections of the included studies were recorded (Table 1).

### Quality and risk of bias assessment

The quality analysis and risk of bias assessment of the trials included in the systematic review were performed using the Physiotherapy Evidence Database (PEDro) scoring and classification system. The primary purpose of selecting the PEDro tool was to include specific items to

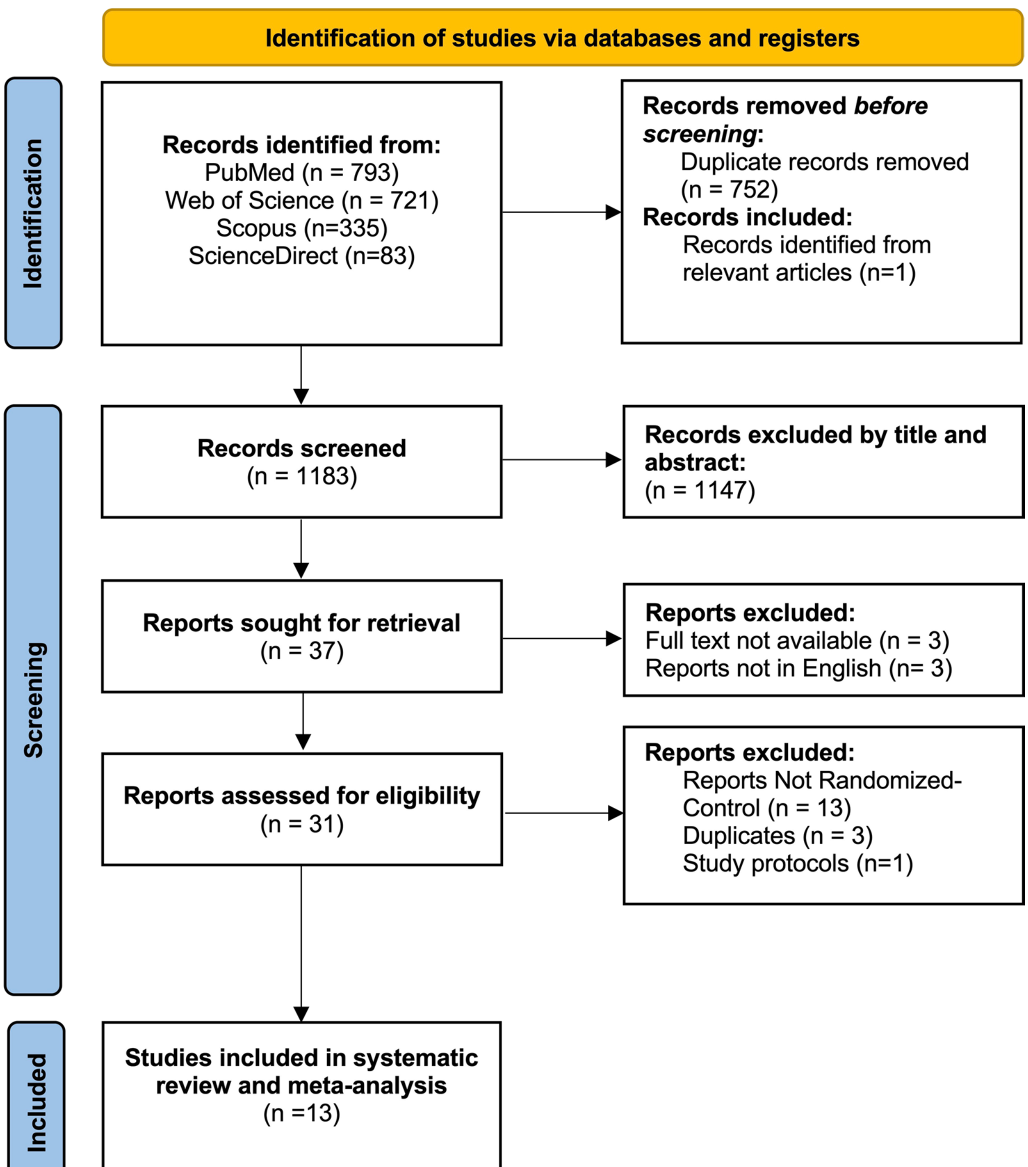


**Fig. 1** PRISMA flow diagram of the study

**Table 1** Characteristics of the included studies

| Author | Objective | Gender (%) | Sample (n) | Interventions | Outcomes | Results |
|---|---|---|---|---|---|---|
| Abbott et al. [7] | The purpose of this study was to compare the efficacy of psychomotor therapy focusing on cognition, behavior, and motor relearning to that of exercise therapy during the first 3 months after lumbar fusion | 35% F (SG) 31% F (CG) | Lumbar Fusion Surgery ($n = 110$) | *Psychomotor group:*<br>A 90-min outpatient physical therapy session was also added to the home training program 3, 6, and 9 weeks after the surgery up to 12 weeks post-operatively<br>*Control group:*<br>Patients were given a one-time, 20-min home training program that included dynamic exercises before being diskharged from the hospital to be continued up to 12 weeks post-operatively | ODI<br>VAS<br>EQ-5D<br>BBQ<br>SF-36<br>SES<br>TSK<br>CSQ-CAT<br>CSQ-COP<br>CSQ-ADP<br>Questionnaire (on Work Status, Sickness Leave, External Health Care Use, Analgesic Use, Treatment Satisfaction, Training Frequency and Reoperation Rates) | Psychomotor therapy showed better results on pain coping, functional disability, self-efficacy, outcome expectancy, fear of movement, and reinjury at 3,6, and 12 months ($p < 0.001$)<br>The results were nonsignificant at 2 to 3 years follow-up ($p > 0.001$)<br>Psychomotor therapy group's employment rates were higher, and sickness leave duration of longer than 6 months were significantly less ($p < 0.05$) |
| Choi et al. [12] | The purpose of this study is to assess the impact of a postoperative early isolated lumbar extension muscle-strengthening program on pain, disability, return to work, and back muscular strength after lumbar disk surgery | 43% F (SG)<br>55% F (CG) | Lumbar Microdiskectomy or Percutaneous Endoscopic diskectomy ($n = 75$) | *Early rehabilitation group:*<br>Post-operative protocol was common during the first 6 weeks. Patients started lumbar extension exercise regimen for 12 weeks using MedX 6 weeks after surgery<br>*Control Group:*<br>Advice was given to patients on how to keep a good posture and steer clear of physically demanding tasks.Handouts for simple spinal conditioning exercises to practice at home to be applied after the 2nd week were distributed | ODI<br>VAS<br>Lumbar Extensor Power<br>Cross-sectional area of Multifidus and Longissimus Muscles (mm2)<br>Questionnaire on Percentage of Return to work (%) | The study group yielded better results on lumbar extensor power, the cross-sectional area of multifidus and longissimus muscle, pain, and the number of returns to work at 4 months ($p < 0.05$)<br>There was no significant difference between groups in terms of disability ($p > 0.05$) |

**Table 1** (continued)

| Author | Objective | Gender (%) | Sample (n) | Interventions | Outcomes | Results |
|---|---|---|---|---|---|---|
| Danielsen et al. [20] | The aim of this study is to evaluate the effect of an early exercise compared with a standard care program | 38.5% F (SG)<br>29.2% F (CG) | Arctomy & Microsurgical Lumbar disk Herniation ($n=63$) | *Training group:*<br>The training group adhered to the control group's routine for the first 3 weeks. 4 weeks after the surgery, the intervention began. For 8 weeks, the training group participated in a rehabilitation program three times each week. Each exercise had a different number of repetitions, ranging from 2×15 at the start to 3×30 at the end of the training period. Each training session lasted 40 min<br>*Control group*:<br>After relaxing and recuperating their backs for 2 months following the surgery, the control group engaged in a gentle program of 2 to 3 back exercises at home | VAS<br>Roland's Disability Questionnaire<br>Wonca's Functional Status Measures | Significant difference was found in favor of the training group regarding pain, disability and functionality at 6 months ($p<0.05$), turning nonsignificant after 1 year ($p>0.05$)<br>Control groups were more likely to report an improvement in their own health at both 6 and 12 months ($p<0.05$) |
| Donceel et al. [21] | This study aims to demonstrate how early rehabilitation is primarily concerned with the impact of early mobilization on return to work | N/A | Lumbar disk Herniation Surgery ($n=710$) | *Early rehabilitation group:*<br>Medical advisers examined the patients monthly, starting at 6 weeks post operatively. They used a newly made protocol to motivate the patients and treating physicians toward social and professional reintegration<br>*Control Group:*<br>Patients haven't received rehabilitation during the post-operative period | Standardized Questionnaire (on Demographic Data, Employment Status, Heaviness of Work, Work Satisfaction, Smoking Behavior, Education, Reported Symptoms Lasting more than 1 year before operation, Back operations in the past, Onset of Back Problems, Location of Pain, Signs of Paresis before intervention, Pending litigation, Period of Work Capacity before surgical intervention) | Rehabilitation-focused group returned to work at a higher rate at 1 year follow-up ($p<0.001$) |

**Table 1** (continued)

| Author | Objective | Gender (%) | Sample (n) | Interventions | Outcomes | Results |
|---|---|---|---|---|---|---|
| He et al. [22] | The purpose of this study is to demonstrate the impact of a nurse-led early rehabilitation program on the postoperative recovery of patients having orthopedic robot-assisted minimally invasive lumbar internal fixation for lumbar degenerative lesions | 55% F (SG) 52% F (CG) | Robot-assisted Minimally Invasive Internal Lumbar Spine Fixation<br>($n = 78$) | *Nurse-led Early rehabilitation group:*<br>The nurse-led early rehabilitation program including counseling on mental health issues, breathing exercises, abdominal massages, wearing lumbar supports, double bedside help, and tailored diskharge rehabilitation guidance starting on the first day until diskharge was performed<br>*Control group:*<br>After lumbar spine surgery, the standard care paradigm was put into place | ODI<br>VAS<br>BI<br>Patients' Compliance with the Exercise Program on Days 1 and 4 (Full/Part/Non-Compliance)<br>Postoperative Conditions (Drainage Time, Time from Placement of Surgical Plasma Drainage Tube to Its Removal; Postoperative First Time on The Floor After Surgery, Time from the Completion of Surgery to Return to the Ward o the Time Oof Getting Out of Bed and Standing in Lumbar Support; Postoperative Hospitalization Time, Time from the Completion of Surgery to diskharge.)<br>Complication Rates | Nurse-led early rehabilitation group significantly had better first time on the floor and shorter hospital stay ($p < 0.05$)<br>The probability of constipation and abdominal distension was significantly lower in the observation group ($p < 0.05$)<br>At 3 days, pain, functional recovery and daily living ability was better in the study group ($p > 0.05$)<br>Control group had better compliance at day 1 and 4 ($p < 0.001$)<br>There was no difference between the two groups at 1 month. ($p > 0.05$) |
| Kernc et al. [23] | The aim of this study is to evaluate the security and effects of early rehabilitation beginning, including objective measurement outcomes following lumbar spine fusion based on strength training concepts | 31% F (SG)<br>64% F (CG) | Lumbar Spine Fusion<br>($n = 27$) | *Strength training group:*<br>3 weeks following surgery, the strength training group began their rehabilitation. Throughout a period of 9 weeks, patients engaged in twice-weekly exercise with an emphasis on lumbopelvic stability muscle activation. From week one through week five, isometric exercises with a 45-s break in between were used. Exercise lasts for 20, 25, and 30 s if the perceived effort is below 8 on the Borg scale<br>*Control group:*<br>Patients adhered to the typical postoperative regimen, which restricted exercises at that point in the healing process | 6MWT<br>CST<br>SRH<br>ODI<br>VAS<br>Isometric Trunk Muscle Strength (nanometer)<br>Intraabdominal Pre-Activation Pattern (seconds) | The early rehabilitation group improved significantly more than the control group at 3 months. ($p < 0.05$)<br>No training effects were seen at 18 months ($p > 0.05$) |

**Table 1** (continued)

| Author | Objective | Gender (%) | Sample (n) | Interventions | Outcomes | Results |
|---|---|---|---|---|---|---|
| Kjellby-Wendt et al. [24] | The purpose of this study was to compare the outcomes of two treatment regimens administered 5–7 years after surgical correction of lumbar disk herniation: one early active training (EAT group) and one less aggressive regimen (control group) | 30% F (SG) 23% F (CG) | Lumbar Microdiskectomy ($n = 52$) | *Early active training group:*<br>Patients received exercises to increase range of motion of the leg. Starting from the 1st day, throughout the course of a 12-week period, the physiotherapist gave instructions to patients 4 times. Patients instructed to increase their physical activity, and detailed instructions on how to manage pain were also given<br>*Control group:*<br>Patients did not do exercises to increase range of motion of the leg, but they did abdominal exercises and exercises to increase flexion and lateral flexion of the trunk were also added 6 weeks after surgery Starting from the 1st day, throughout the course of a 12-week period, the physiotherapist gave instructions to patients 3 times. They were not instructed to increase their physical activity, and instructions on how to manage pain were also less detailed | The Straight Leg Raising Test (and its Difficulty and Location)<br>BDI<br>VAS<br>Questionnaire (on Remaining Sciatica, Days of Sick Leave<br>Rate of Return to Work<br>Early Retirement<br>Satisfaction with the Procedure) | There was no apparent difference between the groups at 5–7 years follow-up ($p > 00.5$) |

**Table 1** (continued)

| Author | Objective | Gender (%) | Sample (n) | Interventions | Outcomes | Results |
|---|---|---|---|---|---|---|
| LeBlanc et al. [25] | This study compared the effects of early versus later exercise intervention following a unilateral lumbar microdiskectomy on low back pain intensity, fear avoidance, neurodynamic mobility, and function | 58.% F (SG) 53% F (CG) | Lumbar Microdiskectomy ($n = 40$) | *Early rehabilitation group:*<br>Patients received low back care education during visits 1–2, 4–6, and 8–10 weeks. Group 1 received the initial level of the exercise protocol at 1–2 weeks, and the progressive level at 4–6 weeks<br>*Control group:*<br>Patients received low back care education 3 times at 1–2, 4–6, and 8–10 weeks after surgery. Patients got all exercises (beginning and advanced levels) at 4–6 weeks, along with instructions on how to move from the beginning to the advanced levels | ODI<br>NPRS<br>FABQ<br>PSFS<br>50-Foot Walk Test | There was no significant difference among groups within each group at 1–2, 4–6, 8–10 weeks after surgery ($p > 0.001$) |
| Newsome et al. [19] | The purpose of this study is to find out if starting activities right away after a lumbar microdiskectomy helped patients recover their independence more quickly while posing the same level of risk for consequences | 54% F (SG) 27% F (CG) | Lumbar Microdiskectomy ($n = 30$) | *Early rehabilitation group:*<br>On the first postoperative day, participants received an instruction sheet, exercises, and help getting out of bed, which usually occurred 4 to 5 h following surgery. Beginning 2 h after surgery and continuing ten times on each leg every 30 min, a physical therapist on the spinal ward passively flexed one patient's hip and knee toward the chest within their range of motion and tolerance<br>*Control group:*<br>Participants received the same instruction sheet and exercises on the first postoperative day, as well as assistance to get out of bed on average 4 to 5 h after surgery. Patients in the control group did not perform the passively aided or actively assisted hip/knee flexion exercises | ODI<br>VAS<br>Return to Work (weeks)<br>Short Form McGill Pain Questionnaire<br>Time from the End of the Operation to the Patient to Becoming Independently Mobile (hours) | The early rehabilitation group showed reduced time to independent mobility and return to work ($p < 0.001$)<br>There were no significant differences in disability and pain scores at 4 weeks and 3 months ($p > 0.001$) |

**Table 1** (continued)

| Author | Objective | Gender (%) | Sample (n) | Interventions | Outcomes | Results |
|---|---|---|---|---|---|---|
| Oestergaard et al. [26] | The aim of this study is to assess if starting rehabilitation 6 weeks following surgery instead of 12 weeks is more cost-effective | 47% F (SG)<br>58% F (CG) | Lumbar Spinal Fusion ($n = 82$) | *Early rehabilitation (6-week) group:*<br>6 weeks after surgery, the patient started receiving early rehabilitation, which consisted of 4 group sessions and instructions for at-home exercises<br>*Control (12-week) group:*<br>The identical rehabilitation plan, which included four group sessions and instructions for at-home exercises, began for the patients 12 weeks after surgery | ODI<br>EQ-5D<br>QALY<br>Health Care and Productivity Costs (euros) | The improvement regarding functional disability in the 12-week group were significantly better than that in the 6 weeks group at 6 months and 1 year ($p < 0.05$)<br>The number of extra hospital admissions and outpatient visits in the 6w-group compared to the 12w-group were considerably higher ($p < 0.05$)<br>There was no significant difference between groups regarding cost effectiveness ($p > 0.05$) |
| Ozkara et al. [13] | The purpose of this study is to assess the effects of exercise programs on patients who had undergone lumbar microdiskectomy surgery in terms of pain, back impairment, behavioral outcomes, overall health parameters and back mobility | 63% F (SG)<br>53.3%(CG) | Lumbar Microdiskectomy ($n = 43$) | *Exercise group:*<br>Home based exercises started from the postoperative 1st day, 2 sets of each exercise daily, 3 days a week<br>*Control group:*<br>Control group hasn't received exercise therapy during the post-operative period | ODI<br>VAS<br>BDI<br>SF-36 | At 12 weeks, exercise group significantly improved disability, lower back pain ($p < 0.05$), but the return to life and patient satisfaction was not significant among groups ($p > 0.05$) |
| Oosterhuis et al. [18] | The purpose of this study is to determine whether early rehabilitation after lumbar disk surgery is effective and cost-effective when compared to no referral | 57% F (SG)<br>59% F (CG) | Lumbar disk Surgery ($n = 169$) | *Early rehabilitation group:*<br>Starting the 1st day, patients were given 30-min exercise according to the national guidelines, up to 6–8 weeks<br>*Control group:*<br>Conventional physiotherapy program without rehabilitation was ordered | ODI<br>FABQ<br>Global Perceived Effect Scale<br>Short From 12<br>EQ-5D-3L<br>Credibility/Expectancy Questionnaire<br>Örebro Musculoskeletal Pain Screening Questionnaire<br>Pain Coping Inventory | There was no significant difference between groups in 26 weeks ($p < 0.05$) |

**Table 1** (continued)

| Author | Objective | Gender (%) | Sample (n) | Interventions | Outcomes | Results |
|---|---|---|---|---|---|---|
| Zhang et al. [27] | The purpose of this study is to investigate the effects of postoperative functional exercise on patients who had lumbar disk herniation treated with percutaneous transforaminal endoscopic diskectomy | 48% F | Percutaneous Transforaminal Endoscopic diskectomy After Lumbar disk Herniation ($n = 92$) | *Early rehabilitation group:* Patients conducted early functional exercises of passive and autonomic activities after their operations including extension and flexion exercises of the lower limbs, toes and neck for 12 weeks. Patients have been called twice in the first 6 weeks to address questions or problems<br>*Control group:* Patients conducted routine functional exercises after their operations | SF-36<br>Lumbar Function Scale<br>Spine Stability (Lateral X-Ray)<br>Lumbar curvature (MRI)<br>Lordosis index (MRI)<br>Sacral Inclination Angle (MRI)<br>Short-term Curative Effects (Excellent/Good/Poor)<br>Long-term Curative Effects (Excellent/Good/Poor) | All parameters showed significant improvement in the control group ($p < 0.05$) |

SG, Study Group; CG, Control Group; F, Female; VAS, Visual Analog Scale; ODI, Oswestry Disability Index; SES, Self-Efficacy Scale; TSK, Tampa Scale for Kinesiophobia (TSK); BBQ, Back Beliefs Questionnaire; BI, Barthel index; CSQ-CAT, Catastrophizing Subscale of Coping Strategy Questionnaire; CSQ-COP, Coping Strategies to Control Pain; CSQ-ADP, Coping Strategies To Decrease Pain; CCF-S, Craniocervical Flexion Strength Test; CCF-E, Craniocervical Flexion Endurance Test; DPQ, Dallas Pain Questionnaire; MPI, Multidimensional Pain Inventory; EQ-5D, European Quality of Life Questionnaire; BDI, Beck Depression Index; FABQ, Fear-Avoidance Beliefs Questionnaire; NPRS, Numeric Pain Rating Scale; PSFS, Patient-Specific Functional Scale N/A, Not Available; SF-36, Short Form Health Survey; CST, Chair Stand Test; SRH, Standing Reach Height Test; 6MWT, 6-Minute Walking Test

QALY, Quality-adjusted Life Year

audit the design of trials, including rehabilitation interventions. PEDro scoring was performed independently by the two investigators of the study. In case of disagreement, a consensus was achieved by obtaining the opinion of a third expert academic. PEDro addresses the level of evidence of the trials with 11 items, including eligibility criteria, random allocation, concealed allocation, baseline comparability, blind subjects, blind therapists, blind assessors, adequate follow-up, intention-to-treat analysis, between-group comparisons, point estimates and variability. Both items are scored with "Yes" (1-point) or "No" (0-point). The first question (eligibility criteria) is not included in the scoring. PEDro scores are classified as "excellent (9–10 points)", "good (6–8 points)", "moderate (4–5 points)", and "poor (0–3 points)". The validity and reliability of PEDro have been demonstrated [20].

### Evidence synthesis and meta-analysis

The review results were presented, considering the principles of narrative synthesis when pooling was not possible. The procedures of "developing a preliminary synthesis, exploring relationships within and between studies, and determining the synthesis's robustness" were regarded during the synthesis. Then, the results were shown, considering the qualitative and quantitative characteristics of the trials. In the meta-analysis section, numerical data on pooling were presented. Meta-Mar software (Philipps-Universität Marburg, Germany) calculated effect size and associated statistics [28]. The "Standardized Mean Difference (SMD)" was calculated regarding the "mean, standard, and sample size" of the relevant pooled parameter. Unknown standard deviation and confidence interval values were calculated according to the "Cochrane Handbook" guidelines [17]. "SMD, CI, weighted average effect size and p-value" values were given for each parameter pooled for meta-analysis. The heterogeneity of the measurements was analyzed with "I2, Tau2, and Chi2". Meta-analysis results were schematized with Forest plots.

## Results

A total of 1183 articles were retrieved through PubMed ($n=793$), Web of Science ($n=721$), Scopus ($n=335$), and ScienceDirect ($n=83$) databases. Fourteen studies were included in the systematic review. After excluding duplicate and irrelevant studies for systematic review, 37 articles were analyzed according to the eligibility criteria. We excluded 24 studies that did not meet the eligibility criteria. Finally, 13 studies were included in the systematic review (Fig. 1).

### Quality analysis and risk of bias results

The median score calculated for the PEDro total score of the 13 studies included in the systematic review was 5 (range = 3–8) [22–25, 29–37]. According to the PEDro classification, there were 5 "good" [24, 25, 29, 31, 34], 6 "moderate" [22, 23, 30, 33, 35, 37], and 2 "poor" [32, 36] evidence-level studies. All studies provided details on eligibility criteria and random allocation [22–25, 29–37]. Seven studies stated that allocations were concealed [23–25, 29, 31, 33, 34]. Most studies (nine) provided information on the homogeneity of the groups in terms of baseline comparability for assessment parameters [23–25, 29–31, 34–36]. None of the studies mentioned the identity of "therapists and subjects". Only three studies reported that the assessors were blind [24, 31, 35]. Nine studies reported appropriate monitoring procedures [22, 25, 29–32, 34, 36, 37]. Two studies calculated the intention-to-treat analysis [25, 29]. Only one study did not provide data on between-group comparison [36], point estimates and variability (e.g., intergroup comparison, SD, CI) [32]. Regarding items, the median value for total scores calculated from the scores of 14 studies was 9. Accordingly, items 3, 5, 6, 7, and 9 were below the median value (Table 2).

### Study characteristics

A total of 1658 patients were available in 13 studies included in the systematic review [22–25, 29–37]. Four studies included Lumbar Microdiskectomy [22, 24, 35, 36], 3 Lumbar Fusion Surgeries [23, 29, 34], 2 Lumbar disk Herniation Surgeries [25, 32], one Microsurgical Lumbar disk Herniation [31], one study included "Lumbar Microdiskectomy or Percutaneous Endoscopic diskectomy", one "Percutaneous Transforaminal Endoscopic diskectomy [30] and one Robot-Assisted Minimally Invasive" and "Minimally Invasive Internal Lumbar Spine Fixation" [33]. All the studies focused on the effectiveness of early rehabilitation. Ten ODI, 9 VAS, 3 SF-36, 2 BDI, EQ-5D, 2 FABQ, two muscle strength and one each 50 Foot Walking Test, 6MWT, BBQ, BI, Complication Rates, Reliability/Expectation Questionnaire, Multifidus and Longissimus Muscle Cross Sectional Area ($mm^2$), CSQ, CST, Early Retirement, EQ-5D-3L, Global Perceived Impact Scale, Health Care and Productivity Costs (euros), Intraabdominal Pre-Activation Pattern (seconds) Long Term Curative Effects (Excellent/Good/Bad), Lordosis index (MRI), Lumbar curvature (MRI), Lumbar Function Scale, Orebro Musculoskeletal Pain Screening Questionnaire, Pain Coping Inventory, Patients' 1st and 4th and 4. Days (Complete/Partial/Non-Compliant), Postoperative Conditions (Drainage Time,

Time from Placement to Removal of Surgical Plasma Drainage Tube, Time to Lying on the Floor for the First Time After Surgery, Time from Completion of Surgery to Return to the Ward, Time to Get Out of Bed and Standing on Lumbar Support; Time of Postoperative Hospitalization, Time from Completion of Surgery to diskharge.), PSFS, QALY, Questionnaire (Remaining Sciatica, Sick Leave Days, Questionnaire (Working Status, Sick Leave, External Healthcare Use, Analgesic Use, Treatment Satisfaction, Frequency of Education and Reoperation Rates), Percentage Return to Work Questionnaire (%), Return to Work Rate, Return to Work (weeks), Roland's Disability Questionnaire, Sacral Tilt Angle (MRI), Satisfaction with Procedure), SES, Short Form McGill Pain Questionnaire, Less than 12, Short-Term Curative Effects (Excellent/Good/Bad), Spinal Stability (Lateral X-Ray), SRH (Table 1) [22–25, 29–37].

#### Quantitative synthesis results

Regarding pain parameters evaluated by VAS, the advantage of early rehabilitation (min 3 months, max 1 year) was emphasized in 5 of 9 studies [24, 29–31, 34]. Four studies emphasized that early rehabilitation did not contribute more to pain (min 1 month, max 7 years) [22, 33, 35, 36]. Four of the nine studies that evaluated ODI-based physical function reported that early rehabilitation (min 3 months, maximum 1 year) provided significantly more improvement [23, 24, 29, 34]. Five studies reported no additional benefit from early initiation of rehabilitation (min 1 week, max 3 years) [22, 25, 30, 33, 36]. Most of the studies (four) reported that early rehabilitation had no additional positive effect on quality of life. Two studies showed that early rehabilitation did not positively affect depression and fear avoidance beliefs [29, 35, 36]. Detailed results of the studies are presented in Table 1.

#### Meta-analysis results

Of the seven homogeneous studies, five evaluated pain evaluated by VAS [25, 29, 31, 33, 36], six assessed function by ODI [23–25, 29, 33, 36], and 3 included quality of life measurement by EQ-5D and SF-36 [23, 24, 29]. The additional benefit of early rehabilitation on physical function was moderately effective (ES: −0.62, 95% CI −1.00; −0.25) at the 1-month follow-up. However, at 3 months (ES: 0.06, 95% CI −0.17; 0.29), 6 months (ES: 0.09, 95% CI −0.15; 0.33) and 1 year (ES: 0.08, 95% CI −0.21; 0.37) follow-up, the contribution of early rehabilitation to physical function was at a low level of evidence. In terms of pain, early rehabilitation provided additional improvement at 1 month (ES: 0.34, 95% CI −0.03; 0.71), 3 months (ES: −0.14, 95% CI −0.37; 0.10), 6 months (ES: 0.35, 95% CI 0.04; 0.65) and 1 year (ES: 0.21, 95% CI −0.09; 0.52) follow-up at a low level of evidence. Finally, early rehabilitation was found to have a small effect size at 3 months (mental component) (ES: 0.13, 95% CI −0.20; 0.47) and 1 year (general quality of life) (ES: −0.04, 95% CI −0.33; 0.25) follow-up (Figs. 2, 3, 4).

## Discussion

This systematic review demonstrated that early rehabilitation mainly improved disability in the early period (1-month follow-up). Regarding pain, short-term (1 month) and mid-term (6 months) follow-ups showed the most significant additional benefit. There is insufficient evidence for the effectiveness of early rehabilitation in terms of quality of life and psychosocial status. The positive effects of starting rehabilitation early after surgery on pain may have positively affected disability, specifically in the early period (1 month). Future trials should elaborate on which types of exercises may be more effective in early rehabilitation.

In the early period, muscle strength, activities of daily living training, core stabilization, balance and gait training can provide more gains in the physical functions of individuals after lumbar surgery [13, 26]. In addition, earlier progress in joint range of motion may lead to less disability. Rehabilitation practices aimed at reducing pain after lumbar spine surgery may contribute more to improving function [16]. However, excessive training on the range of motion in the early period may cause an increase in the pain level of individuals. On the other hand, it is also comprehended that individuals have few gains in disability levels due to avoidance of functionality, fear of movement, and increased fear-avoidance beliefs to avoid pain [38, 39]. In this respect, our meta-analysis is unique to emphasize the gains in pain and function more clearly. In particular, we interpreted that improvement in early disability may be due to improvement in early and mid-term pain because the effect size in individuals' mid- and long-term functional improvements was low. However, since psychological and social multidimensional parameters (kinesiophobia, fear-avoidance, compliance, satisfaction) may affect physical function, more comprehensive psychosocial evaluations should be evaluated in future trials.

#### Analyzing the quality and bias risk of the studies

The median quality score of the studies included in the systematic review was moderate. Failure to mention the allocation procedure in some of the studies may have increased the risk of bias. However, the lack of blinding primarily decreased the methodologic quality. The fact that therapists and patients were not blinded in any study may suggest intervention bias. The use of assessor blinding in only three studies may suggest a suspicion

**Table 2** PEDro scores of the trials

| Article | Q-1 | Q-2 | Q-3 | Q-4 | Q-5 | Q-6 | Q-7 | Q-8 | Q-9 | Q-10 | Q-11 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Abbott et al. [7] | Y | Y | Y | Y | N | N | N | Y | Y | Y | Y | 7 |
| Choi et al. [12] | Y | Y | N | Y | N | N | N | Y | N | Y | Y | 5 |
| Danielsen et al. [20] | Y | Y | Y | Y | N | N | Y | Y | N | Y | Y | 8 |
| Donceel et al. [21] | Y | Y | N | N | N | N | N | Y | N | Y | N | 3 |
| He et al. [22] | Y | Y | Y | N | N | N | N | Y | N | Y | Y | 5 |
| Kernc et al. [23] | Y | Y | Y | Y | N | N | N | Y | N | Y | Y | 6 |
| Kjellby-Wendt et al. [24] | Y | Y | N | Y | N | N | Y | N | N | Y | Y | 5 |
| LeBlanc et al. [25] | Y | Y | N | Y | N | N | N | N | N | N | Y | 3 |
| Newsome et al. [19] | Y | Y | N | N | N | N | N | Y | N | Y | Y | 4 |
| Oestergaard et al. [26] | Y | Y | Y | Y | N | N | N | N | N | Y | Y | 5 |
| Ozkara et al. [13] | Y | Y | Y | Y | N | N | Y | N | N | Y | Y | 6 |
| Oosterhuis et al. [18] | Y | Y | Y | Y | N | N | N | Y | Y | Y | Y | 7 |
| Zhang et al. [27] | Y | Y | N | N | N | N | N | Y | N | Y | Y | 4 |
| Zhang | 13 | 13 | 7 | 9 | 0 | 0 | 3 | 9 | 2 | 12 | 12 | |

Q-1, Eligibility criteria; Q-2, Random allocation; Q-3, Concealed allocation; Q-4, Baseline comparability; Q-5, Blind subjects; Q-6, Blind therapists; Q-7, Blind assessors; Q-8, Adequate follow-up; Q-9, Intention-to-treat analysis; Q-10, Between-group comparisons; Q-11, Point estimates and variability

*Dark colors indicates high evidence regarding PEDro classification, median values (item total score) and item score (yes/no)

of outcome bias. However, it should be emphasized that the effect of assessor bias is weakened when considering that most measurements were patient-reported outcome measures. Especially in studies with sensitive measurements such as muscle strength and physical performance tests, it should be emphasized that assessor blinding will reduce the risk of bias in order to ensure protocol integrity. Future studies should consider CONSORT or STROBE procedures regarding bias and randomization procedures [21, 40, 41].

### Analyzing study characteristics

The types of surgery in the enrolled studies varied. In this respect, it should be considered that the difference in surgical procedures may have partially influenced the results regarding the rehabilitation procedure. The most commonly used surgical technique appears to be lumbar microdiskectomy [22, 24, 35, 36]. This finding suggests that especially minimally invasive methods are in the majority, and this advantageous situation for rehabilitation may produce more efficient results in terms of early rehabilitation.

The most preferred assessments in the studies are function and pain with ODI and VAS, respectively. The ODI is the gold standard scale used for many years in evaluating the lumbar region. The validity and reliability of VAS in postoperative patient follow-up have been emphasized in detail [42, 43]. Another point to be mentioned about the characteristics of the studies is that evaluations with non-standardized questionnaires were performed in some studies. Since the validity and reliability of non-standardized instruments have not been established, the consistency and responsiveness of the results are questionable [27]. On the other hand, the absence of studies addressing quality of life, psychosocial status, objective clinical measurements, and heterogeneous methodologies is indicative.

## Effectiveness of the early exercise interventions

### *Pain*

In more than half of the studies that addressed pain with VAS, the additional contribution of early rehabilitation was emphasized at follow-up from 3 months to 1 year [24, 29–31, 34]. In the meta-analysis, the pain was effective at a low-moderate level of evidence at 1- and 6-months follow-up [25, 29, 31, 33, 36]. In one study, early rehabilitation did not provide more effective results than the control group at a 6-month follow-up regarding pain assessed with the Örebro Musculoskeletal Pain Screening Questionnaire [25]. Early gains in terms of pain may also positively affect the disability levels of individuals. In this respect, the additional improvement gained at the 1-month follow-up suggests the effect of early rehabilitation on individuals regaining their physical functions in the early period. Considering that individuals complain of more pain in the acute period after lumbar spine surgery, short-term pain gain makes early rehabilitation advantageous. On the other hand, the maintenance of similar improvements in pain in the 6 months confirms the advantage of early rehabilitation in terms of pain in the medium term.

### *Disability*

The most apparent gain in physical function was observed in the early period (1-month follow-up) with

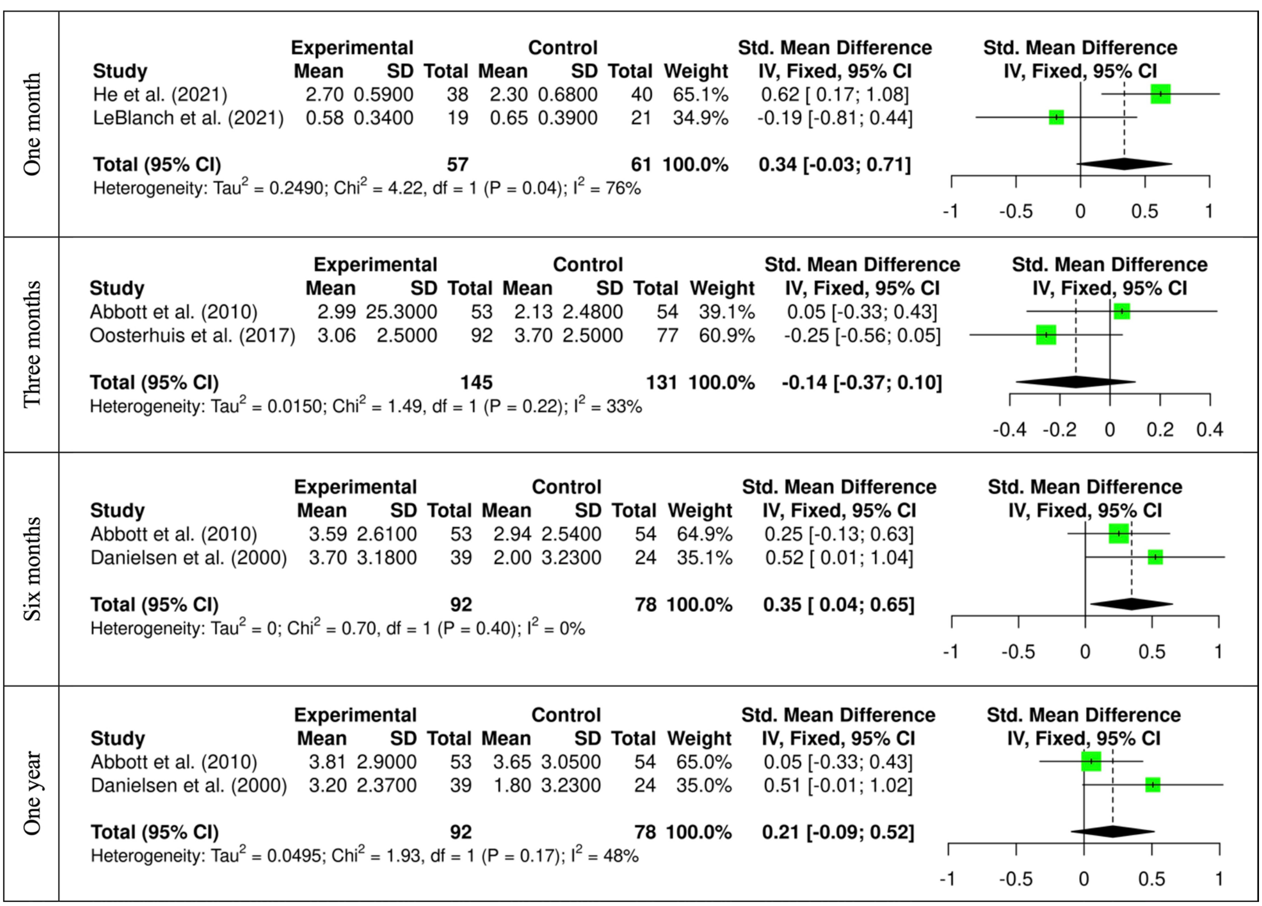


**Fig. 2** Forest-plot of the VAS score at 1 month, 6 months and 1 year

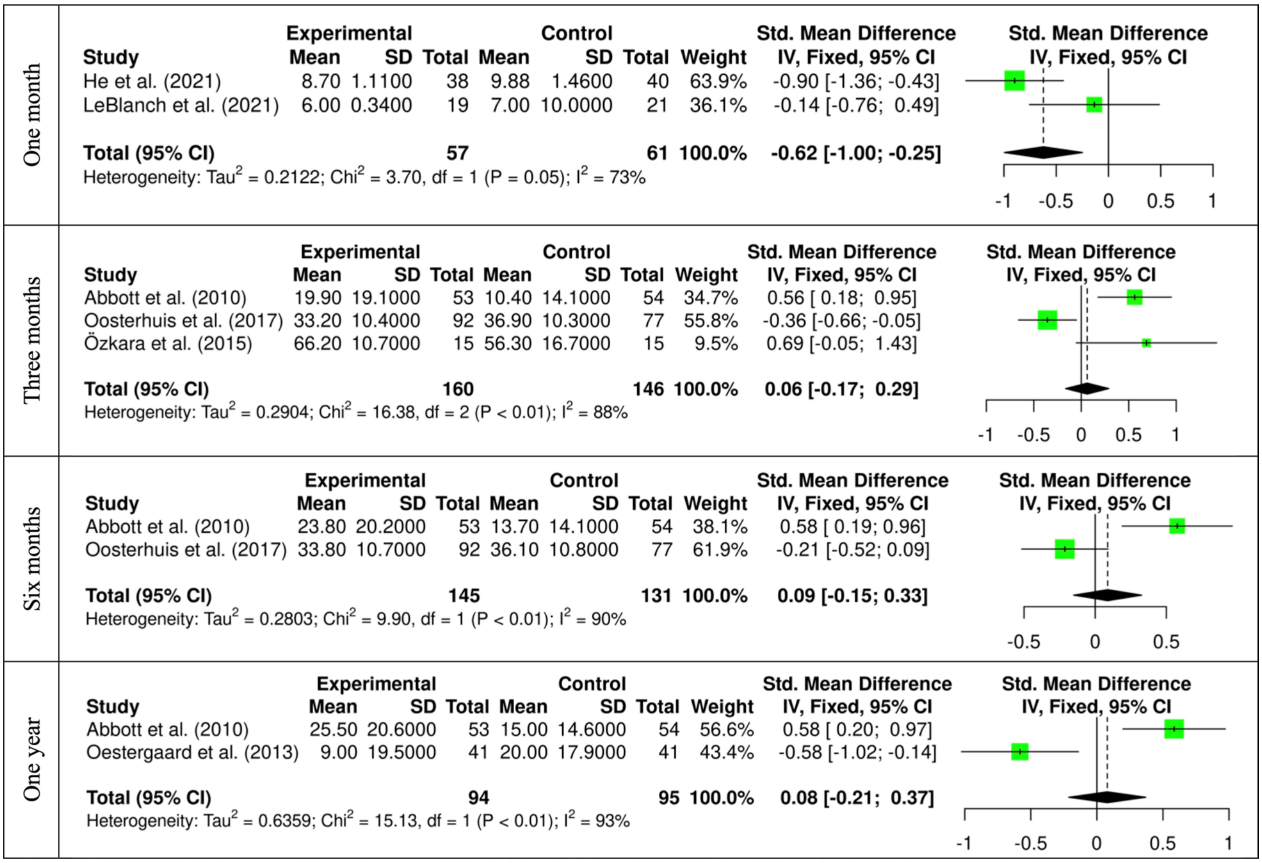


**Fig. 3** Forest-plot of the function (ODI) at 1, 3, 6 months and 1 year

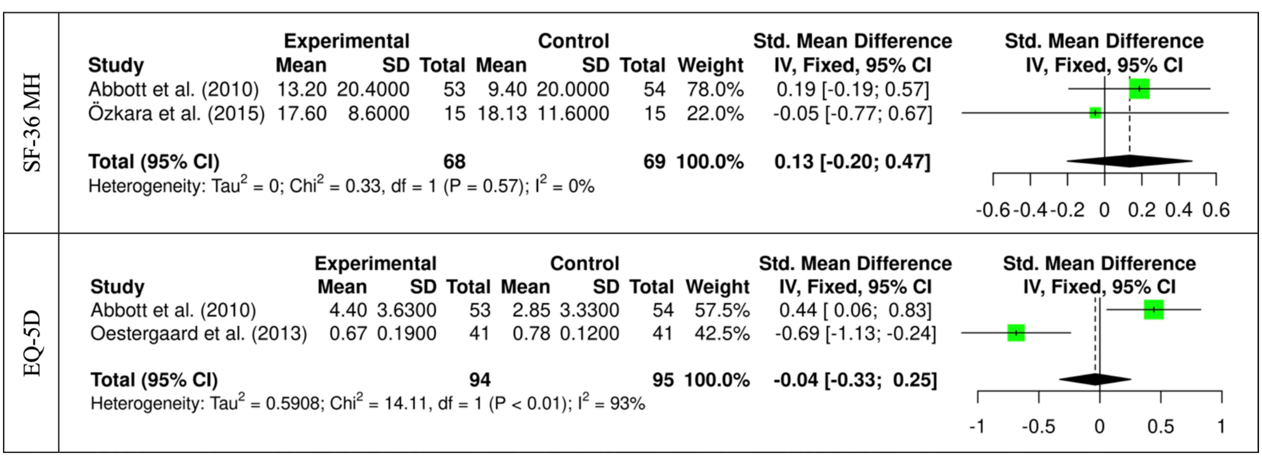


**Fig. 4** Forest-plot of the quality-of-life score at 3 months and 1 year

moderate evidence [33, 36]. Early rehabilitation efficacy was not noticed at an adequate level of evidence in later periods. Four of the studies evaluating physical function with ODI emphasized the superiority of early rehabilitation for a disability [23, 24, 29, 34], while the other five studies reported no additional contribution [22, 25, 30, 33, 36]. A study reporting the evaluation results with the Lumbar Function Scale reported the advantage of early rehabilitation [37]. The fact that improvements in physical function were reported only in the early period may be due to decreased pain in the early period. Although there is no additional advantage for individuals to start rehabilitation early in the middle and late periods, it may be valuable in clinical practice for secondary parameters such as independence in daily life and the shortening of hospitalization in the early period.

#### *Quality of life and psychosocial status*

According to the systematic review results, most studies noticed no additional contribution of rehabilitation to quality of life [29, 35, 36]. Meta-analysis results also supported these findings with a low effect size [23, 24, 29]. Since it is understood that gains in quality of life may occur in the long term, early rehabilitation was interpreted as usual when pain and disability outcomes were considered. It should be noted that long-term gains in disability and pain are similar in quality of life.

Psychological status is related to pain and the general condition of individuals. Studies showed that early rehabilitation did not positively affect depression and fear avoidance beliefs. Given the complex relationship of psychological state with other parameters such as pain, disability, satisfaction, complexity, kinesiophobia and heterogeneous study designs, it is difficult to make precise predictions. Future studies should focus more on secondary psychological parameters such as patient-oriented satisfaction and kinesiophobia [38, 39].

### Study limitations

Some databases (e.g., EMBASE) could not be searched because the authors did not have access. Non-standardized assessment tools in the studies may have provided some results of questionable validity and reliability. The effects of surgical techniques on the study could not be addressed. Since 14 studies were included, an exclusion criterion related to the surgical procedure would have reduced the number of studies included in the meta-analysis, reducing the efficiency of effect size analyzes. However, the possible effect of surgical procedures may be a limitation affecting the study results. Finally, different rehabilitation protocols applied within the scope of early rehabilitation may suggest heterogeneity in the studies considered in pooling analyzes.

## Conclusions

This systematic review demonstrated that early rehabilitation mainly improved disability in the early period (1-month follow-up). Regarding pain, short-term (1 month) and mid-term (6 months) follow-ups showed the most significant additional benefit. There is insufficient evidence for the effectiveness of early rehabilitation in terms of quality of life and psychosocial status. The positive effects of starting rehabilitation early after surgery on pain may have positively affected disability, specifically in the early period (1 month). Future trials should elaborate on which types of exercises may be more effective in early rehabilitation.

## Appendix: Keywords

**Search** strategy PubMed

| Search ID# | Search terms | Search options |
|---|---|---|
| S1 | Lumbar surgery AND Early rehabilitation | Boolean/Phrase |
| S2 | Lumbar surgery AND Enhanced rehabilitation | Boolean/Phrase |
| S3 | Lumbar surgery AND Accelerated rehabilitation | Boolean/Phrase |
| S4 | Lumbar surgery AND Fast-track rehabilitation | Boolean/Phrase |

793 references were included from PubMed

**Search** strategy web of science

| Search ID# | Search terms | Search options |
|---|---|---|
| S1 | Lumbar surgery AND Early rehabilitation | Boolean/Phrase |
| S2 | Lumbar surgery AND Enhanced rehabilitation | Boolean/Phrase |
| S3 | Lumbar surgery AND Accelerated rehabilitation | Boolean/Phrase |
| S4 | Lumbar surgery AND Fast-track rehabilitation | Boolean/Phrase |

721 references were included from Web of Science

**Search** strategy Scopus

| Search ID# | Search Terms | Search Options |
|---|---|---|
| S1 | Lumbar surgery AND Early rehabilitation | Boolean/Phrase |
| S2 | Lumbar surgery AND Enhanced rehabilitation | Boolean/Phrase |
| S3 | Lumbar surgery AND Accelerated rehabilitation | Boolean/Phrase |
| S4 | Lumbar surgery AND Fast-track rehabilitation | Boolean/Phrase |

335 references were included from Scopus

**Search** strategy ScienceDirect

| Search ID# | Search terms | Search options |
|---|---|---|
| S1 | Lumbar surgery AND Early rehabilitation | Boolean/Phrase |
| S2 | Lumbar surgery AND Enhanced rehabilitation | Boolean/Phrase |
| S3 | Lumbar surgery AND Accelerated rehabilitation | Boolean/Phrase |
| S4 | Lumbar surgery AND Fast-track rehabilitation | Boolean/Phrase |

83 references were included from ScienceDirect

Total result literature searches: 1183 references

**Abbreviations**

| | |
|---|---|
| SG | Study group |
| CG | Control group |
| F | Female |
| VAS | Visual Analog Scale |
| ODI | Oswestry Disability Index |
| SES | Self-Efficacy Scale |
| TSK | Tampa Scale for Kinesiophobia |
| BBQ | Back Beliefs Questionnaire |
| BI | Barthel Index |
| CSQ-CAT | Catastrophizing Subscale of Coping Strategy Questionnaire |
| CSQ-COP | Coping strategies to control pain |
| CSQ-ADP | Coping strategies to decrease pain |
| CCF-S | Craniocervical flexion strength test |
| CCF-E | Craniocervical flexion endurance test |
| DPQ | Dallas Pain Questionnaire |
| MPI | Multidimensional Pain Inventory |
| EQ-5D | European Quality of Life Questionnaire |
| BDI | Beck Depression Index |
| FABQ | Fear-Avoidance Beliefs Questionnaire |
| NPRS | Numeric Pain Rating Scale |
| PSFS | Patient-Specific Functional Scale |
| SF-36 | Short form health survey |
| CST | Chair stand test |
| SRH | Standing reach height test |
| 6MWT | 6-Minute walking test |

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**Consent for publication**
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**Competing interests**
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## Publisher's Note