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Rehabilitation after cervical and lumbar spine surgery

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- The total number of spine surgeries is increasing, with a variable percentage of patients remaining symptomatic and functionally impaired after surgery. Rehabilitation has been widely recommended, although its effects remain unclear due to lack of research on this matter. The aim of this comprehensive review is to resume the most recent evidence regarding postoperative rehabilitation after spine surgery and make recommendations.
- The effectiveness of cervical spine surgery on the outcomes is moderate to good, so most physiatrists and surgeons agree that patients benefit from a structured postoperative rehabilitation protocol and despite best timing to start rehabilitation is still unknown, most programs start 4–6 weeks after surgery.
- Lumbar disc surgery has shown success rates between 78% and 95% after 2 years of follow-up. Postoperative rehabilitation is widely recommended, although its absolute indication has not yet been proven. Patients should be educated to start their own postoperative rehabilitation immediately after surgery until they enroll on a rehabilitation program usually 4–6 weeks post-intervention.
- The rate of lumbar interbody fusion surgery is increasing, particularly in patients over 60 years, although studies report that 25–45% of patients remain symptomatic. Despite no standardized rehabilitation program has been defined, patients benefit from a cognitive-behavioral physical therapy starting immediately after surgery with psychological intervention, patient education and gradual mobilization. Formal spine rehabilitation should begin at 2–3 months postoperatively.
- Rehabilitation has benefits on the recovery of patients after spine surgery, but further investigation is needed to achieve a standardized rehabilitation approach.

Keywords

- postoperative rehabilitation
- physical therapy
- lumbar spine surgery
- cervical spine surgery
- post-surgery
- pain management
- physiotherapy

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Introduction

Overall, the indications for operating on spinal disorders are increasing as reflected by the total number of spine surgeries. Spine surgery usually involves decompression and/or fusion of one or more spine levels (1, 2, 3). However, regardless of the pathology and surgical technique used, there is a variable percentage of patients who remain symptomatic and with functional disability (2, 4, 5).

Following spine surgery, postoperative rehabilitation is considered important and is largely recommended by surgeons to help patients improve their functional status and achieve their recovery goals, aiming to extend activities of daily living, from personal care to housekeeping tasks in the short term as well as returning to work, sports and leisure activities in the long term (1, 3, 6, 7, 8).

Rehabilitation in the context of spine surgery may be proposed to improve physical and psychosocial functioning, prevent and treat complications, accelerate recovery, alleviate residual symptoms and treat accompanying diseases (3, 5, 7, 9, 10, 11). These programs can include physiotherapy (exercise therapy with stretching and strength training), cognitive-behavioral therapy and multidisciplinary protocols, which may include motor control modification and resumption of activities of daily living, work and physical activity and enhancement of pain-coping strategies. Rehabilitation programs may consist of supervised individual sessions, group training, home exercises, education or a combination of these (10, 11, 12).

The mechanisms explaining the positive effects of exercise therapy remain largely unclear, but local biomechanical changes and more central mechanisms, like distorted body schema or altered cortical representation of the back, as well as modification of motor control patterns, may play a role (4, 12, 13, 14, 15, 16). Furthermore, the therapist–patient relationship, changes in fear-avoidance

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beliefs, catastrophizing and self-efficacy regarding pain control should also be considered as resulting modifying factors (4, 5, 7, 12, 15).

The focus of the available research is mainly on technique validation and surgery results, while the postoperative management of this population has received relatively little attention (4, 6, 9, 15, 17, 18). Furthermore, there are no clear and standardized recommendations regarding postoperative rehabilitation treatment after spine surgery, for instance, if all patients have an indication for further postoperative rehabilitation treatment and whether its type and duration have an impact on the clinical and functional outcome after spine surgery (4, 7, 10, 19, 20).

The aim of this review is to resume the most recent evidence regarding postoperative treatment after cervical and lumbar spine surgery and make recommendations regarding postoperative mobilization and rehabilitation.

Methods

A comprehensive literature review was performed on the most recent evidence regarding rehabilitation modalities used after cervical and lumbar spine surgery. The search was performed on PubMed and EMBASE databases for articles published from October 2013 to December 2022. The search strategy was conducted using Boolean operators (AND, OR) to combine the following keywords: 'lumbar spine surgery, cervical spine surgery, postoperative rehabilitation, physical therapy, post-surgery, pain management, physiotherapy'. One author (T. B.) screened all the titles and abstracts of all database records and retrieved the full text of relevant studies for further analysis according to the inclusion and exclusion criteria. Any doubts were discussed with another author (A. R.). Both authors (T. B. and A. R.) screened the full text for inclusion in this systematic review. Only articles written in English were included. All articles including any type of postoperative intervention were included for review (bracing period, massage therapy, muscular exercises and cognitive and copying therapies). Small case series (<15) and case reports were excluded. The identification process of the articles collected is depicted in Fig. 1.

Cervical spine surgery

Indication for surgical treatment is increasing in patients with neck pain and radiculopathy not responding to conservative measures (7, 11, 21). Anterior cervical discectomy and fusion is currently the most common surgical procedure on the cervical spine, followed by cervical disc arthroplasty and posterior and anterior cervical foraminotomy (11, 16, 22). The effectiveness of cervical spine surgery on radicular pain is moderate to good, but the effects on neck function are less clear (4, 11). During the immediate postoperative period, there could be reduced neck motion (due to fusion), pain and postoperative immobilization, which can lead to decreased neck muscle function and, therefore, to the persistence of symptoms in many patients after surgery (7, 16, 22, 23). The atrophy and deconditioning of the neck muscle function may not spontaneously resolve and can persist over time (16, 23, 24).

Postoperative rehabilitation is largely recommended by the majority of surgeons although the scientific basis for this recommendation has not yet been well-established (7, 21), as there are few studies assessing the best practices of postoperative rehabilitation (7, 11, 21). The most recent studies are listed in Table 1.

The best timing to start postoperative rehabilitation is unknown; however, most protocols start at 4–6 weeks after surgery (4, 7, 22). In the meantime, the use of bracing can be advised depending on the surgical technique given that the use of a rigid cervical collar for 3 weeks can decrease pain and disability after non-plated discectomy and fusion (11, 25). Despite the most recent surgical techniques and instrumentation, the lack of decisive large case series on bracing leads most surgeons to still prescribe bracing after cervical spine surgery (26).

Despite the insufficient data, the most recent evidence argues that patients benefit from an active structured postoperative rehabilitation approach featuring

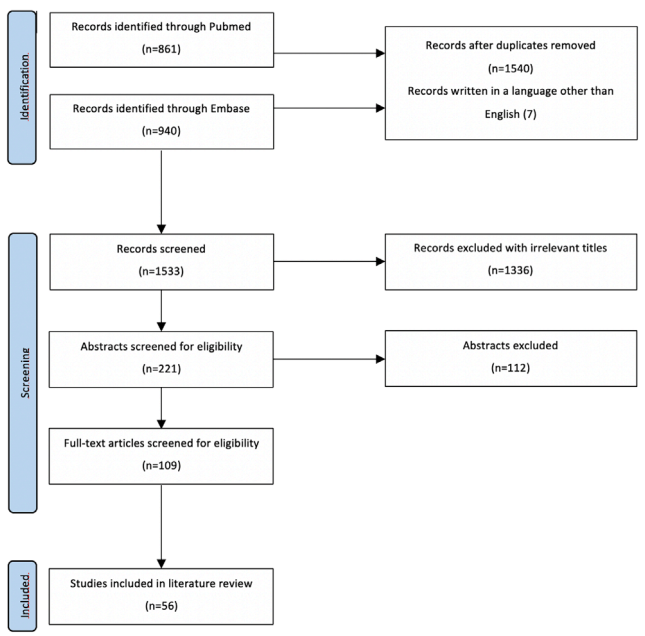


Figure 1
Flow chart of database searches and included studies.

Table 1 Summarized data from the included studies on postoperative treatment after cervical spine surgery.

Study	Study type	LOE*	Participants, *n*	Short-study description	FUT, months	Scales/ measures	Conclusions
Wibault *et al.* (4)	RCT†	II	201	Comparing the results of structured postoperative physiotherapy combining neck-specific exercises with a behavioral approach to a standard postoperative approach in patients who had undergone surgery for cervical disc disease with cervical radiculopathy at 6 months after surgery. During the first 6 weeks after the surgery, all patients were given the same orientations.	6	NDI; intensity and frequency of neck and arm pain; global outcome of treatment; expectation fulfillment	Structured postoperative physiotherapy showed only minor additional benefit compared with standard postoperative approach at 6 months. Patients who received structured postoperative physiotherapy reported higher expectation fulfillment
Coronado *et al.* (22)	Pilot RCT	III	30	Assessing the acceptability and preliminary safety and effects of an early home exercise program performed within the first 6 weeks after anterior cervical discectomy and fusion, comparatively to usual care.	12	Safety (adverse events, radiographic fusion, revision surgery); NDI; Numeric Rating Scale for neck and arm pain; General Health Survey (SF-12); Opioid utilization.	An early home exercise program was acceptable to patients and had the potential to be safely administered to individuals immediately after surgery. Benefits were noted for short-term neck pain and long-term opioid utilization. Larger trials are needed to confirm safety with standardized and long-term radiological assessment and treatment efficacy.
Caplan *et al.* (26)	RCA	III	577 (braced: 509; unbraced: 68)	Studies the impact of bracing on short-term outcomes related to safety, quality of care and direct costs in single-level anterior cervical discectomy and fusion (with plating).		QALY; SSI; Direct cost	The use of cervical bracing following single-level anterior cervical discectomy and fusion remains a widespread practice; Patients achieve similar outcomes with no difference in direct hospital costs and a reduction in costs to the patient by removing the cervical brace from their postoperative care. Cost analyses show no difference in direct costs between the two treatment approaches. Further evaluation of long-term outcomes and fusion rates will be necessary before definitive recommendations.

*Classification based on LOE assessment tool from Oxford Centre for Evidence-Based Medicine; †multicenter parallel group.
FUT, follow-up time; LOE, level of evidence; NDI, neck disability index; QALY, quality-adjusted life year; RCA, retrospective cohort analysis; RCT, randomized clinical trial; SSI, surgical site infection.

endurance exercises, isometric strengthening, stretching and neck and shoulder-specific functioning and aerobic activity, in line with patient tolerance, while placing a lower emphasis on passive modalities. These active treatment interventions are targeted at restoring function, and neck-specific exercises are usually well-tolerated (4, 7, 11, 27, 28). However, the implementation of a structured program of therapeutic exercises combined with a cognitive-behavioral protocol has shown slightly better results in neck disability, pain intensity, catastrophizing or satisfaction, as compared with a standard treatment after surgery (4, 11, 28). More investigation is needed with a focus on improving patient education approaches based on patient fears and expectations, starting immediately after surgery, in order to improve patient anxiety management, patient empowerment, gratitude and satisfaction (4, 11, 22, 28).

A recent pilot study shows that early home exercises may be safe and can improve short-term outcomes, although long-term outcomes have not changed between groups (22). Further investigation is needed to confirm the effects and safety of the intervention (11, 22).

Some patients can experience dysphagia after cervical spine surgery, mainly with anterior cervical approaches and, even though the majority will experience improvement of symptoms over 2 months, in some patients, significant pharyngeal impairments persist, and for these, specific rehabilitation is needed (29, 30, 31, 32). Considering the high degree of limitation and deterioration in quality of life that dysphagia can cause, studies are needed to explore the best measures and the most effective rehabilitation approach to managing dysphagia.

Hermansen *et al.* advocate that initial high intensity neck-related pain, nonsmoking status at the time of surgery and male sex are preoperative predictive factors of good surgical outcomes after anterior cervical discectomy and fusion (33). Therefore, these factors should be considered when choosing the best rehabilitation program, as they can be related to greater improvement in pain, disability and psychological impairment. Additional investigation is needed to set predictive outcomes criteria to select those that may benefit the most from rehabilitation after cervical spine surgery.

Rehabilitation management after cervical spine surgery still has a lack of powered randomized controlled trials addressing the effects of rehabilitation on muscular strength, neck-specific functioning, pain, physical activity, psychological impairment, dysphagia and quality of life (4, 11, 21).

Due to the lack of studies with significant results, more studies are also needed to assess whether different pathologies and surgical techniques also require distinct rehabilitation approaches as in the case of lumbar spine surgery. This may explain the absence of statistically significant results in the existing studies.

Lumbar spine

Lumbar disc surgery (discectomy/microdiscectomy)

Lumbar disc surgery has shown success rates between 78% and 95% after the first and second postoperative years (6, 12, 20, 34, 35). Therefore, there is still a percentage of patients who do not have the desired outcome, maintaining symptoms such as pain or inability to return to work and perform tasks (6, 8, 18, 34, 36, 37). Patients with lumbar disc herniation are usually between 30 and 50 years old and are productive members of society making surgery results particularly important in order to allow patients to return to their previous activity (19, 20, 34, 38).

Discectomy is the most common surgical spine procedure performed in Europe for patients with lumbar disc herniation who experience low back pain, most often accompanied by leg pain (8, 12, 18).

Although its absolute indication has not been proven, exercise or physical therapy protocols are widely recommended in the postoperative period of lumbar disc surgery, aiming to accelerate recovery and improve long-term performance as well as general health benefits (8, 18, 38, 39). So far, it has not been possible to establish guidelines for rehabilitation treatment in the postoperative period of lumbar disc surgery due to the great variability of results among the various studies performed (Table 2) and also because they have been classified with a low degree of evidence by the most recent systematic reviews (12, 20, 36).

It is considered that trunk muscle atrophy, muscle weakness, impaired neuromuscular activation and coordination due to disc disease and surgery may all contribute to pain recurrence and impaired physical function after lumbar disc surgery (8, 12, 18).

The majority of studies advocate that starting a rehabilitation program 4–6 weeks after surgery contributes to an improvement in disability, pain and physical function when compared to no treatment, and that high-intensity exercise protocols lead to faster improvement of these factors when compared with low-intensity exercise programs (6, 12, 18, 40) related to improvement of the function of pelvic, hip and trunk muscles (18, 40).

Comprehensive physiotherapy interventions are effective in improving muscle function, pain and disability after lumbar disc surgery. These multimodal interventions consist of a wide variety of active rehabilitation techniques, including a combination of education on the performance of daily functional tasks, functional weight-bearing, cardiovascular endurance exercises, lower limb strengthening and lumbar stabilization exercises, including stretching and strengthening (8, 18, 20, 36, 41). Also, when comparing supervised exercise programs with home exercises, none was superior to the other, and both proved to be effective in reducing pain and improving functional capacity when compared to no treatment (12, 34, 38).

So far, rehabilitation programs based on a biopsychosocial intervention model have shown no difference compared to standard rehabilitation programs (12). Still, the choice of a rehabilitation protocol considering the preferences and expectations of the patient can have a synergistic effect on recovery, mainly concerning compliance enhancement (3, 20, 34, 39).

There is great variability related to the time when a rehabilitation program should start, and there is no consensus on the duration or even the need to restrict activity after surgery (12, 18, 19, 34, 36, 40). Studies have shown that exercise programs starting immediately after surgery are not accompanied by higher rates of recurrence and are well tolerated, but they are neither significantly

Table 2 Summarized data from the included studies on postoperative treatment after lumbar disc surgery.

Study	Study type	LOE	Participants, *n*	Short-study description	FUT	Scales/measures	Conclusions
Ebenbichler *et al.* (8)	PRCT	II	111 (29: PT; 22: ST; 23: NT)	Long-term follow-up examination of patients who have taken part in a prior original randomized and controlled trial, for 3 months, after uncomplicated disc surgery to lumbar vertebral disc herniation, comparing: postoperative comprehensive PT and home exercise program; ST; and NT.	12 years post-operation	LBP-RS; Participant overall satisfaction (Likert scale); BDIS	Patients receiving comprehensive PT or ST (neck massage), in the immediate postoperative course reached a better functional health state than patients having no input, the difference being preserved for more than a decade. Comprehensive PT intervention may not be superior to the ST group, that could mean that comprehensive PT act both psychologically and physiologically.
Hebert *et al.* (18)	Parallel group PRCT	II	61	Gauging if a group that received a specific trunk muscles exercise program would experience greater improvements in clinical and muscle function outcomes than participants in a general trunk exercise program, following single-level lumbar discectomy. After 2 postoperative weeks, all participants initiated the respective exercise program for 8 weeks.	10-week postoperative assessment 6 months after surgery assessment performed by email or telephone	Low back pain disability assessed with the modified ODI; pain intensity: low back and lower extremity pain scores; global rating of change; sciatica frequency and sciatica bothersomeness indices; muscle function (brightness-mode, real-time ultrasound images).	Programs comprising specific or general trunk exercises have similar effects on disability, pain, global change, sciatica frequency and bothersomeness and LM muscle function at 10 weeks and 6 months after surgery.
Oosterhuis *et al.* (6)	Multicenter, RCT, economic evaluation	II	173	After discectomy, participants in the experimental group initiated a postoperative exercise therapy in primary care starting the first week after discharge, over 6–8 weeks. Participants assigned to the control group were not referred for rehabilitation after discharge from the hospital and they were requested to avoid referral for any rehabilitation therapy in the 6- to 8-week period.	26 weeks	Functional status (ODI); leg and back pain (numerical rating scale 0 to 10); global perceived recovery (7-point Likert scale); general physical and mental health; the outcomes to economic evaluation were quality of life and costs.	Rehabilitation after lumbar disc surgery starting immediately after lumbar disc surgery was neither effective nor cost-effective, compared to no referral for early rehabilitation. Both groups had similar results after surgery and early rehabilitation had no additional effect on pain, functional status, global perceived effect scale, general physical or mental health, or costs.
Rushton *et al.* (34)	Experimental parallel 1:1 PRCT	II	59 (29: at PL and 1:1 PT; 30: at PL)	Patients, post primary, single level, lumbar discectomy were randomized to either individualized 1:1 PT outpatient management including patient leaflet (PT/leaflet), or patient leaflet alone.	26 weeks	Low back pain assessed with Roland Morris Disability Questionnaire; Global Perceived Effect; VAS for leg and back pain; EuroQol-5D 5L (health-related quality of life); Tampa Scale for Kinesiophobia; Fear Avoidance and Beliefs Questionnaire; Straight Leg Raise; Schober- modified method for Range of lumbar movement.	Both interventions demonstrated a reduction on disability after lumbar disc surgery.

(Continued)

Table 2 Continued.

Study	Study type	LOE	Participants, *n*	Short-study description	FUT	Scales/measures	Conclusions
Paulsen *et al.* (39)	RCT	II	146	Comparison of the results on PRO of patients referred for standard physical rehabilitation with patients without reference (experimental group), after lumbar disc surgery. All participants were advised to begin normal daily activities and return to work as soon as possible.	2 years	Oswestry Disability Index after 6months; EuroQoL-5D; VAS for leg and back pain; and PRO were obtained prior to surgery and at 1, 3–6, 12 and 24 months postoperative.	Both groups showed statistically significant improvements on all measures after surgery. Referral to postoperative rehabilitation provided no additional effect on PROs compared to no referral. Future studies should seek to identify subgroups of patients who may benefit from a rehabilitation program, because patients that already have no pain and disability may not need further rehabilitation.
Paulsen *et al.* (19)	RCT	II	146	Investigating whether postoperative rehabilitation affects return to work, duration of postoperative sick leave, and working ability in patients after lumbar disc surgery. REHAB group: standard physical rehabilitation. HOME group: no intervention.	2 years	Self-reported measures: working ability, work status, and job type defined by the International Standard Classification of Occupations; duration of sick leave was obtained from follow-up questionnaires at 1 and 2 years after surgery.	Referral to postoperative rehabilitation does not affect duration of sick leave or working ability after lumbar disc surgery; Duration of preoperative leg pain and preoperative working ability had a significant association with duration of postoperative sick leave. These results may help identify patients that may benefit from rehabilitation.
Bono *et al.* (40)	PRCT	II	108 (55: 6-week restriction; 53: 2-week restriction)	Evaluating how short (2 week) vs long (6 week) postoperative restrictions following lumbar discectomy affect outcomes and reherniation rates.	1 year	Back and leg VAS; ODI; reherniation rates at 2 weeks, 6 weeks, 3 months and 1 year following the surgery.	Both groups obtained equivalent clinical outcomes regardless of the length of postoperative restriction. If patients had a low risk for a reherniation event, they may be confident that early return to activity at 2 weeks will not compromise outcomes neither increase the risk of reherniation.
Zoia *et al.* (35)	Monocentric, RCT	II	54 (29: group A; 25: group B)	Investigating if the use of a lumbar corset in patients who underwent surgery for lumbar disc herniation could affect the postoperative outcomes.	6 months	VAS; ODI; Roland Morris Disability Questionnaire.	Corset adoption does not improve the short-term and mid-term outcomes of patients after single-level lumbar discectomy. Its adoption should not be advised given the economic and potential muscular burden.
Ozkara *et al.* (44)	PRCT single-blind	II	30	Evaluate if an early home-based exercise program would provide additional benefit to patients who underwent microdiscectomy for lumbar disc herniation. Instructions were given to all patients regarding lying, standing, sitting and walking.	3 months	ODI; BDIS; Lumbar Schober test; VAS; return-to-work status; generic functional status (SF-36).	Early postoperative exercise program starting immediately after surgery can improve pain, disability, and spinal function in patients who have undergone microdiscectomy.

(Continued)

Table 2 Continued.

Study	Study type	LOE	Participants, *n*	Short-study description	FUT	Scales/measures	Conclusions
Jentoft *et al.* (41)	PRCT	II	70	Compare two PT interventions (one group received information only and the other exercise in combination with information) following lumber disc surgery regarding effect on pain, functioning and fear of movement.	12 months	Numeric pain rating scale; ODI; Tampa Scale of Kinesiophobia (TSK-13); Fear Avoidance Beliefs Questionnaire.	Exercise in combination with information reduced leg pain and improved its function, which was statistically more evident over a period. Postoperative rehabilitation after lumbar disc surgery could include exercises in addition to information, but perhaps not for all patients, as both groups improved, and the difference between them was not clinically relevant.

BDIS, Beck Depression Inventory Score; FUT, follow-up time; LBP-RS, Low Back Pain Rating Scale; NT, no treatment; ODI, Oswestry Disability Index; PL, patient leaflet; PRCT, prospective randomized control trial; PRO, patient-reported outcomes; PT, physiotherapy; ST, sham therapy; VAS, visual analog pain scale.

superior to those initiated 4–6 weeks after surgery (6, 12, 18, 36, 40), nor they proved to be more cost-effective (6). Although there is still a lack of consensus, it is believed that the use of orthotic treatment after surgery does not bring benefits and may even delay rehabilitation (35). Therefore, patients who underwent lumbar discectomy should start their postoperative rehabilitation immediately after surgery, with patient education for good posture and gradual mobilization, and at 4–6 weeks after surgery start the therapeutic exercises program (19, 34).

Studies are needed to establish criteria for selecting patients that need rehabilitation, essentially those who maintain symptoms for long periods of time after surgery, while patients with complete resolution of symptoms in the postoperative period may not need rehabilitation (6, 12, 18, 39, 41). Some research has already been carried out in this regard, with studies acknowledging that the duration of preoperative leg pain and working ability, presence of comorbidities and some demographic factors (age and sex) are significantly associated with the duration of postoperative sick leave and returning to work period (18, 19, 42). The inclusion of all operated patients in the studies without the application of selection criteria may constitute a way of diluting the results and a source of biases (19).

The implementation of a rehabilitation program after lumbar discectomy appears to improve functional status in the short term nevertheless, long-term effects don't reach consensus (12, 34). Despite this, there are studies showing maintenance of results after 2 years (39), which can last for more than a decade (8, 40).

With the increasing use of minimally invasive techniques and their proven effectiveness, pilot studies have shown that the implementation of earlier rehabilitation programs after microdiscectomy has the potential of effectively improving outcomes (pain, disability and quality of life) and it is also associated with better return to work outcomes compared to more invasive techniques (42). Still, more studies with larger and cost-effective study groups are needed (43, 44).

Lumbar interbody fusion surgery

Lumbar interbody fusion is commonly performed in spondylolisthesis, degenerative disc disease and spinal stenosis and is generally accompanied by decompressive surgery (2, 15, 45, 46). Lately, the rate of lumbar interbody fusion is increasing, particularly in patients over 60 years of age (2, 5, 10, 45).

Studies report that 25–45% of patients remain symptomatic, with functional disability and maintain a poor quality of life (9, 45, 46), which could contribute to high reoperation rates (9, 46).

There is a great variability in the recommendations for postoperative patient management (1). Like other spine

Table 3 Summarized data from the included studies on postoperative treatment after lumbar fusion surgery.

Study	Study type	LOE	Partici-pants, *n*	Short-study description	Follow-up time	Scales/ measures	Conclusions
Lee *et al.* (13)	PCT	III	59 women	Evaluating changes in back muscle strength after PLIF and assess the effects of a postoperative exercise program on physical and mental health outcomes.	12 months	Back extensor strength; VAS scores in back pain; physical component summary and mental component summary.	Strength in back muscles decreased until 3 months postoperatively but significantly increased after that period. Patients who underwent postoperative rehabilitation program had significantly improved back strength, less pain and less functional disability at 12 months, postoperatively.
Archer *et al.* (5)	RCT	II	86	Determining the efficacy of a cognitive- CBPT program for improving outcomes in patients following laminectomy with or without arthrodesis for a lumbar degenerative condition. The intervention started 6 weeks after surgery (mostly by telephone in both groups).	6 months	Tampa scale for kenesiophobia; pain self-efficacy questionnaire; brief pain inventory; ODI; general health; performance-based tests.	Screening patients for fear of movement and using a targeted CBPT program results in significant improvement in pain, disability, general health and physical function after spine surgery for degenerative conditions.
Ilves *et al.* (14)	PLS	II	194	Investigating changes in trunk muscle strength 12 months after LSF compared to preoperative strength.	Preoperatively; 12 months postoperative	Isometric trunk extension and flexion strength (measured using a strain-gauge dynamometer in the standing position); amount of leisure time engaged in physical activity (minutes/wk), low back pain and leg pain intensities obtained using questionnaires.	Trunk muscle strength has increased over 12 months of postoperative follow-up; The strength gain was small and may not be clinically significant. The imbalance already found before surgery between the trunk extensors and flexors remained 12 months, postoperatively. Low back and leg pain intensities decreased significantly after surgery.
Monticone *et al.* (15)	PG RCT	II	130	Assessing the effect of a rehabilitation program including the management of catastrophizing and kinesiophobia on disability, dysfunctional thoughts, pain and the quality of life in patients after lumbar fusion surgery, comparatively with a standard exercise alone program.	12 months counting after the end of treatment.	ODI; Tampa Scale for kinesiophobia; pain catastrophizing scale; pain numerical rating scale; short-form health survey.	The cognitive-behavioral physical therapy program was superior to the exercise program in reducing disability, dysfunctional thoughts, and pain, and enhancing the quality of life of patients after lumbar fusion surgery; The effects lasted for at least 1 year after the intervention ended.
Wang *et al.* (9)	RTS	III	183	Investigating the clinical rehabilitation effect of lower-limb training on the patients that undergo oblique lumbar interbody fusion. The intervention group were trained with systematic lower-limb rehabilitation procedures over 3 months. Control group had no intervention.	3 months	Lower-extremity muscle force; VAS; lumbar Japanese orthopedic association score; ODI; incidence of deep venous thrombosis; patient satisfaction.	The lower-extremity rehabilitation exercise can effectively promote patient health recovery after surgery and also improve pain relief and functional outcomes; rehabilitation also decreases deep venous thrombosis events of the lower limbs.

(Continued)

Table 3 Continued.

Study	Study type	LOE	Partici-pants, *n*	Short-study description	Follow-up time	Scales/ measures	Conclusions
Yao *et al.* (49)	PRT	II	90	Evaluating the outcomes of bracing following TLIF.	12 months	VAS; ODI; fusion rates, complications and reoperation rates.	There was no benefit in patients wearing bracing after TLIF for up to 12 months. The fusion rate was not related to bracing.
Soliman *et al.* (51)	RCT	II	43	Investigating the outcomes of bracing after PSIF over 3 months postoperatively.	3 months	ODI; General Health Survey (SF-12); VAS	Postoperative bracing did not result in better improvement in quality of life or pain relief up to 3 months after PSIF.
Ilves *et al.* (17)	RCT	II	98	Investigating the effectiveness of the postoperative 12-month exercise program compared to usual care on disability and health-related quality of life in patients after LSF surgery.	12 months	ODI; HRQoL	The exercise intervention did not have an impact on disability or quality life beyond the improvement achieved by usual care. Disability remained at least moderate in considerable proportion of patients.
Low *et al.* (1)	QDAP	IV		Content analysis of the current postoperative aspects of rehabilitation (exercise prescription and return to normal activity) that are provided in patient information leaflets.			This study highlights a clear variation in the recommendations of exercise prescription, dosage and return to normal activities following lumbar spine surgery. Future work should focus on providing a consistent and patient-centered approach to recovery.
Elsayyad *et al.* (56)	RCT	II	60	Test the effect of adding NM vsMFR to SE on disability, pain and BROM in patients who had undergoneLSF	Assessed before starting the treatment, immediately after finishing and 1 month later.	ODI; VAS; BROM	Patients who received NM or MFR combined with SE demonstrated better improvement, in favor of the NM group, regarding disability and pain than patients who received SE alone after LSF. No differences were found among the groups regarding lumbar ROM.
Coronado *et al.* (54)	SART	II	112	Examine the association between goal attainment and patient-reported outcomes in patients who engaged in a 6-session, telephone-based, CBPT intervention after spine surgery.	12 months	GAS; ODI; 12-item short-form health survey; PROM information system; pain numeric rating scale.	Participants who met their goals as expected had greater physical function improvement at 6 months and 12 months. The study highlights goal attainment as an important rehabilitation component related to physical function recovery after spine surgery.

BROM, back range of motion; CBPT, cognitive-behavioral-based physical therapy; GAS, goal attainment scaling; HRQoL, health-related quality of life; LSF, lumbar spine fusion; MFR, myofascial release; NM, neural mobilization; ODI, Oswestry Disability Index; PCT, prospective clinical trial; PGRCT, parallel group randomized clinical trial; PLIF, posterior lumbar interbody fusion; PLS, prospective longitudinal study; PROM, patient reported outcome measurement; PRT, Prospective, randomized trial; PSIF, posterior spinal instrumented fusion; QDAP, quantitative data analysis procedure; RCT, randomized controlled trial; RTS, retrospective study; SART, secondary analysis of a randomized trial; SE, stabilization exercises; TLIF, transforaminal lumbar interbody fusion.

Table 4 Summarized more consensual information.

	Bracing	Postoperative intervention	Starting time after surgery
Cervical spine surgery	For 3 weeks after non-instrumented technique	No intervention proved to be superior to another. Cervico-scapulothoracic and upper extremity strengthening, endurance and stretching exercises as well as cognitive-behavioral therapy.	4–6 weeks after surgery
Lumbar disc surgery	Not recommended	Comprehensive physiotherapy interventions: patient education, endurance, stretching, motor control and strengthening exercises.	Immediately after surgery, with patient education The exercise rehabilitation program starts at 4–6 weeks after surgery.
Lumbar interbody fusion surgery	Not recommended	Cognitive-behavioral physical therapy: Most recommended: psychosocial, patient education, endurance, stretching, motor control and strengthening exercises. Insufficient evidence: soft-tissue mobilization, neural mobilization and joint mobilization.	Immediately after surgery with psychological intervention, patient education and gradual mobilization. The exercise rehabilitation program starts at 2–3 months postoperatively.

surgeries, no standardized rehabilitation program has been defined for patients after lumbar fusion surgery (2, 13, 46), much due to a lack of studies with moderate-to high-quality evidence but also because of the sparse research on this subject (Table 3) (2, 45, 46).

The use and effectiveness of bracing after lumbar spine fusion remain controversial (47, 48, 49, 50). Some surgeons prescribe mostly rigid lumbosacral orthosis based on their personal experience and beliefs that it can improve lumbar stabilization and pain in the first 3 months postoperatively (13, 47, 48, 50). In this regard, recent studies claim that postoperative bracing is not useful neither has effect in postoperative outcomes comparatively to no bracing (48, 49, 50, 51, 52), because solid internal immobilization can be ensured with modern instrumentation; thereby patients can begin gradual mobilization as symptoms allow them to (2, 47, 48).

There is no consensus about the best time to start rehabilitation nor even about its intensity or duration (10, 13). Early exercise programs starting at 6 weeks after surgery did not prove to be superior than starting at 12 weeks after surgery (2). Some advocate that starting rehabilitation at 2–3 months postoperatively align better with bony tissue healing and have better outcomes in pain and disability than early rehabilitation (2).

Patients who undergo lumbar spinal fusion show a more severe muscular deterioration with muscle denervation because of a background of long-standing and disruptive back pain, muscle damage related to the surgical approach – specially in posterior lumbar interbody fusion (PLIF) – and usually a longer period of postoperative inabilitation than patients who undergo simple lumbar discectomy or decompression (2, 13, 14, 15). Therefore, the implementation of a program of soft-tissue mobilization, neural mobilization, endurance exercises, back stretching exercises, neutral spine control exercises, lumbar muscle strengthening exercises and balancing of core musculature seems to be more effective than no rehabilitation on improving significantly back muscle strength, pain and disability (2, 13, 53).

Patients with these degenerative pathologies develop high levels of functional limitation, fear of movement and pain catastrophizing (5, 15, 45). In that way, studies have shown the effectiveness and importance of using exercise rehabilitation protocols combined with cognitive-behavioral therapy and patient goal attainment-based therapy, showing significant improvements in disability, back and leg pain, fear avoidance behavior, mental health and quality of life (1, 2, 5, 13, 15, 45, 54).

The scientific evidence is insufficient to recommend specific rehabilitation protocols cognitive-behavioral physical therapy programs should start immediately after surgery, with psychological intervention with personal goal attainment, patient education and gradual mobilization. Formal spine exercise rehabilitation should then begin at 2–3 months postoperatively, with soft-tissue mobilization, neural mobilization, joint mobilization and with more evidence support: back endurance, stretching, motor control and strengthening exercises (2, 54). These rehabilitation programs seem to be well tolerated and safe for the patients (13).

The extent of the rehabilitation is also a point of controversy because it is difficult to generalize a specific period due to the great variability among patients such as patients' ages, other orthopedic problems, more psychological barriers (greater fear avoidance and/or depression), greater disability and preoperative deconditioning, different ability to exercise safely and independently, this means, these patients may need a closer rehabilitation monitoring and a more personalized rehabilitation program adjusted to their evolution, without a specific duration (2, 5, 55). Further investigation is necessary to better study the influence that each of these variables has on patient recovery and to evaluate its long-term effects on outcomes (5).

Conclusions

- Although rehabilitation is largely recommended after both cervical and lumbar spine surgery (Table 4 summarizes more consensual information), there is still lack of powerful evidence with most of the research focusing on improving and validating surgical techniques.
- A better understanding of the mechanisms by which the disease, the surgery and the therapeutic exercises affect spine is needed in order to develop an effective rehabilitation program.
- Lumbar discectomy is the most performed procedure and is also the one that presents the most amount of research regarding postoperative rehabilitation. Despite that, there is not yet any strong evidence to build guidelines. Therefore, more research is needed, specifically regarding rehabilitation after lumbar fusion surgery.
- Is consensual that in all spine surgeries more investigation is needed to guarantee durability of the effect, evaluate cost-effectiveness and intervention quality, safety and tolerance and predictors of outcomes for postoperative rehabilitation.
- We understand that rehabilitation has benefits on patient recovery after spine surgery, although further investigation, with larger prospective multicentric studies, is needed to achieve a standardized postoperative rehabilitation approach.

ICMJE conflict of interest statement
We declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

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