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Systematic Review

The Predictive Value of Fear Avoidance Beliefs for Outcomes Following Surgery for Lumbar Degenerative Disease: A Systematic Review and Best Evidence Synthesis

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Background: Currently, evidence regarding fear avoidance beliefs as potential predictors for lumbar surgery outcomes seems insufficient and strong conclusions are not yet available.

Objective: This systematic review aimed to evaluate the predictive value of preoperative fear avoidance beliefs for postoperative pain intensity, functional status, and health-related quality of life following surgery for lumbar degenerative disease.

Study Design: Systematic review and best evidence synthesis.

Methods: An extensive search was performed in PubMed/Medline, EMBASE, PsycINFO, CINAHL and the Cochrane library for articles published up until October 2021. Two independent reviewers performed the screening, data extraction, and quality assessment, with a third independent reviewer consulting to resolve any disagreement. Observational studies that included patients undergoing surgery for lumbar degenerative disease, as well as evaluated fear avoidance beliefs (i.e., pain-related fear, pain catastrophizing, pain anxiety) in relation to a surgical outcome measure (i.e., pain intensity, functional status and health-related quality of life) were included in the review. The CHARMS- and QUIPS-tools were used for data extraction and quality assessment, respectively. A best evidence synthesis was performed resulting in conclusions regarding strong, moderate, conflicting, and limited levels of evidence.

Results: A total of 24 studies (n = 17,881) were included in this review. Following best evidence synthesis, 3 included studies reported no significant predictive value of preoperative pain-related fear for postoperative pain intensity resulting in moderate evidence for this relationship. Moderate evidence was also found indicating no significant predictive value of preoperative pain-related fear for postoperative functional status, as 6 out of 8 relevant studies reported this result. Only one study reported on the predictive value of preoperative pain catastrophizing for postoperative health-related quality of life, resulting in limited evidence for the absence of this predictive relationship. All other relationships were found to have conflicting evidence.

Limitations: To evaluate surgical outcome, only patient-reported outcome measures as used by spine registries were included. Thus, our findings cannot be extrapolated to all surgery outcomes following lumbar degenerative disease and should only be interpreted in relation to postoperative pain intensity, functional status, or health-related quality of life.

Conclusion: Best evidence synthesis showed moderate evidence indicating that preoperative pain-related fear is not a significant predictor for postoperative pain and function following surgery for lumbar degenerative disease. Additionally, limited evidence was found for a lack of predictive value of preoperative pain catastrophizing for postoperative health-related quality of life. As current evidence regarding the predictive value of preoperative fear avoidance beliefs following such a surgery is mixed, further research is required before more definitive conclusions can be made.

Key words: Lumbar surgery, pain catastrophizing, pain-related fear, anxiety, fear avoidance, lumbar degenerative disease, pain intensity, function, quality of life

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Currently, it is estimated that 10% to 40% of patients undergoing lumbar surgery continue to experience pain and disability following surgery (1-3). Patients left with residual pain following lumbar surgery experience greater levels of pain, lower health-related quality of life (HRQoL), higher levels of disability, as well as a higher rate of unemployment, compared to patients diagnosed with other chronic pain conditions (4). Additionally, the economic burden of such an unfavorable outcome is described as being higher than that of low back pain (1,4). More knowledge regarding modifiable risk factors and predictors related to surgical outcomes might be key aspects in the prevention of an unfavorable outcome, as well as in the development of targeted perioperative treatment methods (2,5-7).

The fear avoidance model explains how an acute painful experience can be interpreted in 2 ways. Either it is perceived as nonthreatening, which can lead to continued daily activities and functional recovery, or it can be misinterpreted as threatening, leading to a vicious circle which in turn can lead to the development of chronic pain in the long term (8). The dysfunctional misinterpretation of pain, or pain catastrophizing, has already been shown to be associated with persistent pain and disability following lumbar surgery (9-11). Pain catastrophizing can give rise to pain-related fear, which can be described as the fear arising when pain-related stimuli are perceived as a main threat (8). In the model proposed by Leeuw et al (8), which is based on the models of Vlaeyen & Linton (12) and Asmundson et al (13), a pain anxiety pathway (i.e., the anxious anticipation of a possible painful experience) is added to the model (8,12,13). As these fear avoidance beliefs (e.g., pain catastrophizing, pain-related fear, and pain anxiety) are important components in the development of chronic pain, they also may be important factors in the development of persistent pain, disability, and diminished quality of life following surgery.

Previous systematic reviews already discussed the relationship between preoperative fear avoidance factors and postsurgical outcomes (5,10,14,15). However, so far the evidence regarding fear avoidance beliefs as potential predictors for lumbar surgery outcomes seems positive, albeit insufficient (5,10,14-16). Moreover, the rating of the level of evidence in these earlier reviews was unclear and strong conclusions regarding the prognostic factors for outcomes following lumbar surgery are not yet available (5,10,14-16). Also, the number of studies including fear avoidance beliefs has been growing rapidly, motivating an update regarding this topic (17-24). Indeed, additional knowledge about the influence of such beliefs on surgical outcomes will be beneficial to better understand unfavorable outcomes following lumbar surgery and could lead to the prevention of such outcomes in future patients. Therefore, this review aims to provide an updated overview of the predictive value of fear avoidance beliefs for outcomes following surgery for lumbar degenerative disease.

Methods

This systematic review was conducted following the Preferred Reporting Items for Systematic reviews and Meta-Analyses guidelines (PRISMA-statement 2020) (25). Additionally, it was registered with the PROSPERO database (registration number: CRD42020130626). None of the funders played a role in the design, conduct, or reporting of this study.

Data Sources and Searches

First, an initial search in PubMed/Medline was executed, followed by analysis of the words contained in the title, abstract, and index terms describing the articles. Next, an extensive search using all the identified keywords, index terms, and their synonyms was performed across all included databases for articles published up until March 2020. An update of the search was performed for articles published up until October 2021. Databases used for the extensive search include PubMed/Medline, EMBASE, PsycINFO, CINAHL, and the Cochrane library. The full population, intervention, comparison, outcome, time, setting (PICOTS) and search string can be found in Appendix 1. Lastly, the reference lists of all studies that were identified for full-text reading were hand-searched for further relevant studies.

Study Selection

Two reviewers independently screened all retrieved articles' title and abstract. Next, full-text articles were reviewed to check whether they met the inclusion criteria. If needed, any disagreement between the 2 reviewers regarding (potential) eligibility of studies was resolved through consultation with a third independent reviewer during a consensus meeting.

Studies were included if they met the following inclusion criteria that follows.

Population

This review considered studies that included individuals aged 18 or older who received lumbar surgery following a diagnosis of lumbar degenerative disease. Lumbar degenerative disease includes conditions such as spinal stenosis, disc herniation, spondylolisthesis, and disc degeneration, and is often associated with low back pain and lower limb pain or weakness (26). Indications for surgery include clinical factors, such as mechanical low back pain (i.e., deep, agonizing pain, exacerbated by loading and relieved by unloading) and severe preoperative disability in combination with failed conservative treatment, or radiological factors, such as imaging revealing spinal stenosis in combination with evidence of instability and imaging revealing a degenerative deformity (27). No specific criteria for surgical technique were included. We excluded patients with systemic pathologies (e.g., osteoporosis, autoimmune and oncological conditions) or congenital disorders (e.g., scoliosis).

Research Designs

This review considered observational studies evaluating fear avoidance beliefs related to outcomes following lumbar surgery in adult patients. This includes prospective or retrospective cohort and case-control studies using an epidemiological design, as well as observational data drawn from randomized controlled trials.

Outcome Measures

Outcome measures included pain intensity (e.g., visual analog scale (VAS)), functional status (e.g., Oswestry Disability Index) and HRQoL (e.g., Short Form Health Survey (SF-36; SF-12)), EuroQol 5 dimensions (EQ-5D) at 3 months or later following surgery (28).

Prognostic Factors

The prognostic factors of interest for this review are those fear avoidance beliefs related to the updated fear avoidance model by Leeuw et al (8). This includes factors such as pain catastrophizing, pain-related fear (i.e., kinesiophobia, fear of work-related activities, fear of physical activity) and pain anxiety.

Only studies written in English were included; no restrictions on the publication year were applied. Studies that failed to meet any of the above described inclusion criteria were excluded from the review. Reviews, meta-analyses and case reports were not included in this systematic review, as well as editorials or other articles in popular media.

Data Extraction

A modified version of the checklist for critical appraisal and data extraction for systematic reviews of prediction modelling studies prognostic factors (CHARMS-PF) was used to extract relevant data from the included articles (29). This extraction was done independently by the 2 primary reviewers, after which the extracted data was then compared and checked for accuracy.

Quality Assessment

The Quality In Prognosis Studies tool (QUIPS) was used to assess methodological quality in all included studies (30,31). This tool is divided into 6 domains: study participation, study attrition, prognostic factor measurement, outcome measurement, study confounding, and statistical analysis and reporting. All aspects of the domains are rated on reporting (yes, no, partially, or unsure). Following the recommendation by Grooten et al

(32), all aspects were discussed and a priori agreement criteria were established before assessment. Based on the rating of all corresponding aspects, QUIPS domains were rated either high, moderate, or low in terms of risk of bias. Additionally, all studies received an overall rating of risk of bias depending on the rating of their domains. After discussion, the authors agreed to the following criteria for overall rating: studies received an overall rating of "low risk of bias" when either all domains were rated "low risk" or only one domain was rated "moderate risk." A rating of "high risk of bias" was assigned when ≥ one domain was rated "high risk" or when ≥ 3 domains were rated "moderate risk." Only studies with 2 domains rated as "moderate risk" received an overall rating of "moderate risk of bias."

The 2 primary reviewers performed the quality assessment independently. Whenever a disagreement regarding domain scoring occurred, the third independent reviewer performed the quality assessment as well, and the disagreement was discussed among the 3 reviewers. Following an initial pilot version of quality assessment, agreement criteria were further clarified. Furthermore, a meeting with the reviewers was organized after every assessment of a series of 4 to 6 studies to limit the discrepancies between reviewers and maximize agreement.

Data Synthesis and Analysis

A meta-analysis was planned whenever at least 2 studies provided data on the same prognostic factor in relation to the same surgical outcome. However, the methodological differences between the included studies were too large to allow performing a relevant meta-analysis. Therefore, we opted to perform a best evidence synthesis for each association between a prognostic factor (i.e., pain-related fear, pain catastrophizing, anxiety) and a surgical outcome measure (i.e., pain intensity, functional status, HRQoL). A best evidence synthesis is described as a qualitative analysis of clinically homogenous studies, while ranking the evidence according to predetermined levels (33,34). Following discussion among the reviewers, it was decided that due to the strict eligibility criteria of this review, the clinical homogeneity of the included papers was sufficient to perform a best evidence synthesis. The levels of evidence used for this synthesis can be found in Table 1 (33,35).

Studies were excluded from the best evidence synthesis when the instrument used to measure the prognostic factor or outcome measure was not clinically comparable to others. For example, the symptoms' domain of the Spinal Stenosis Measure cannot clinically be compared to the VAS, as it includes other symptoms regarding pain (e.g., pain frequency). Similarly, when only results were available for a composite score, including the outcome measure of interest, the study was excluded from the synthesis. Additionally, when data regarding the prognostic factor in the regression analysis was missing, the study was excluded from the best evidence synthesis, such as whenever the prognostic factor of interest was excluded in a stepwise regression (e.g., only correlation results remain).

Results

Study Selection

The initial database search resulted in 605 records retrieved from PubMed, PsycINFO, CINAHL, Embase, and the Cochrane library (Fig. 1). After removing duplicates, an additional 343 articles were removed based on title or abstract. Out of the 53 articles selected for full text assessment, 6 did not have an available full text and were removed from further screening. Another 23 studies were not considered eligible for inclusion, thus resulting in 24 studies included from database searches. However, 2 out of these 24 studies were missing valuable data on the methodology used regarding the prognostic factor of interest. Following contact with the respective authors, these 2 studies were excluded from the review, as no additional data could be provided. Thus, only 22 studies were included from database searches (11,17-23,36-49).

Reference lists of included studies were checked and resulted in 116 additional records. Following removal of duplicates and initial screening, 16 records were assessed for eligibility based on the full text. Two studies from reference list checks were considered eligible for inclusion (50,51), resulting in a total of 24 studies included in this systematic review.

Study Characteristics

A total of 23 cohort studies could be identified, while one study was described as a "retrospective study with comparative design"(43). Fourteen studies reported on surgical outcome measures related to pain intensity. Six out of 14 studies used change in pain intensity between baseline and follow-up as the dependent variable in the regression analysis (19,21,37,39,45,50), while 4 studies focused on pain intensity at follow-up (11,20,42,43). Four more studies included pain intensity as part of a composite score (17,38,48,51).

Out of the 19 studies that included functional status as a surgical outcome measure, 11 focused on the change in functional status (17,19,21,24,37,40,45-48,50), while 6 other studies focused on functional status at follow-up (11,18,36,42,43,49). Two additional studies included functional status as part of a composite score (38,51). Six studies used outcome measures related to HRQoL, with 3 studies focusing on the change in HRQoL (19,23,44), while 3 others focused on HRQoL at follow-up (11,22,42). Twelve studies examined pain-related fear as a potential predictor for postsurgical outcome (11,17,22,24,37,40,42,43,46-48,51). The predictive value of pain catastrophizing was assessed in 8 studies (11,22,24,39,42,43,48,49), while 13 studies included anxiety in their analyses (17-21,23,36,38,39,44,45,48,50). More details regarding study characteristics can be found in Table 2.

The sample size of all included studies ranged from 25 to 14,485, with a total of 17,881 patients participating in these studies. The mean age of patients ranged from 40 to 75, although 2 studies only reported a median age (ranging from 39 to 40) (39,43). Overall, an equal amount of women and men patients participated in the included studies, as 50.98% of all patients was reported as women. However, one study did not specify patients' characteristics (50), and could not be included in overall demographic calculations.

Thirteen studies investigated the predictive value of fear avoidance beliefs in patients with spinal ste-

Table 1. *Levels of evidence for best evidence synthesis (33,35).*

Levels of Evidence	Criteria
Strong evidence	Consistent results in ≥ 2 low risk of bias studies, with generally consistent findings in ≥ 75% of studies
Moderate evidence	One low risk of bias study and ≥ one high risk of bias studies provide consistent findings, or consistent findings reported in ≥ 2 high risk of bias studies with consistent results in ≥ 75% studies
Conflicting evidence	Multiple studies (either high or low risk of bias) with consistent results in < 75% studies
Limited evidence	Single study findings from either a high risk or low risk of bias study

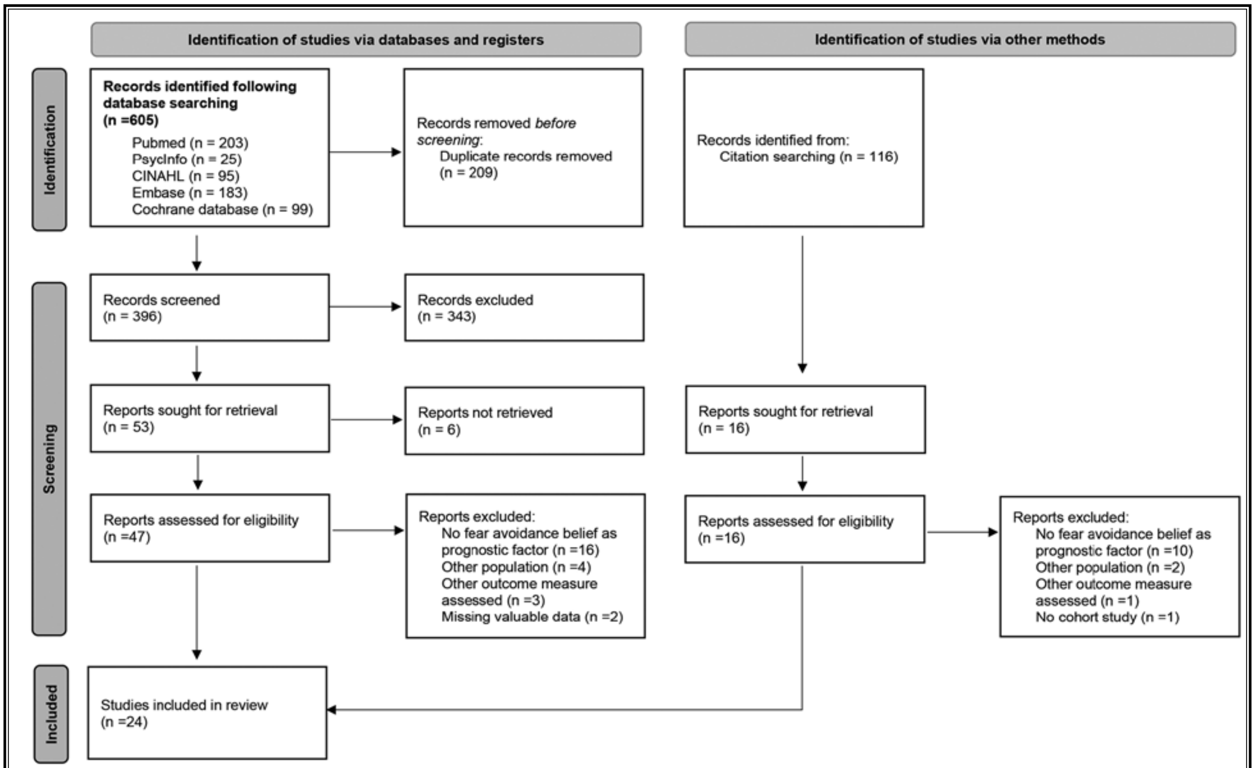

Fig. 1. *PRISMA flowchart (25) outlining the screening and selection process including reasons for exclusion and record counts at each step.*

Table 2. *Characteristics of studies investigating the predictive value of fear avoidance beliefs for surgical outcome following lumbar degenerative disease.*

Study	Study Design	Sample	Population	Predictors	Outcomes	Follow-Up	Quips
Abbott et al 2011 (11)	Prospective cohort study	n = 107 Mean age = 50.6 ys (SD = 7.8) 61.7% women	Spinal stenosis, degenerative or isthmic spondylolisthesis or degenerative disc disease	TSK; CSQ-Cat	VASBack; ODI; EQ-5D index	2-3 ys	High
Burgstaller et al 2017 (17)	Prospective cohort study	n = 243 Mean age = 75.0 ys 51.3% women	Lumbar spinal canal stenosis	FABQ-Activity; HADS-Anxiety	Δ SSM-function; Δ SSM-symptom	12 mos	High
Carreon et al 2016 (36)	Cohort study	n = 312 Mean age = 58.5 ys (SD = 15.2) 56% women	Lumbar degenerative disorder	EQ-5D-Anxiety	ODI	12 mos	High
den Boer et al 2006 (37)	Prospective cohort study	n = 277 Mean age = 43 ys 50% women	Lumbosacral radicular syndrome caused by prolapsed or sequestered disc	TSK	Δ VAS; Δ RMDQ	6 mos	High
Dobran et al 2017 (18)	Prospective cohort study	n = 25 Mean age = 70.4 ys 44% women	Lumbar spinal stenosis	SCL-90-R	ODI	12 mos	High
Gilmore et al 2019 (19)	Prospective cohort study	n = 171 51% 18-65 ys 49% women	Disc prolapse, degenerative disc disease, lumbar spinal stenosis, degenerative spondylolisthesis	GAD-7	Δ NRSBack; Δ NRSLeg; Δ ODI; Δ SF-36-PC	6 mos	High
Graver et al 1995 (38)	Prospective cohort study	n = 122 Mean age = 40.8 ys (SD = 3.8) 46% women	Intervertebral lumbar disc herniation	HADS-Anxiety	COS	12 mos	High
Hegarty et al 2012 (39)	Prospective cohort study	n = 53 PPSP group: Median age = 40 ys; 55% women nPPSP group: Median age = 39 ys; 42% women	Intervertebral lumbar disc herniation	PCS; HADS-Anxiety	Δ VAS	3 mos	High
Hellum et al 2012 (40)	Prospective cohort study	n = 88 Mean age = 40.9 ys (SD = 7.1) 48.8% women	Low back pain with radiographic signs of degeneration	FABQ-Work; FABQ-Activity	Δ ODI	2 ys	High
Jakobsson et al 2019 (24)	Prospective cohort study	n = 100 Mean age = 46.6 ys (SD = 7.9) 54% women	Motion-elicited low back pain with degenerative changes in 1 - 3 segments	TSK; PCS	Δ ODI	6 mos	High
Johansson et al 2010 (42)	Prospective cohort study	n = 59 Mean age = 40 ys (SD = 8) 40% women	Lumbar disc herniation	TSK; CSQ-Cat	VASBack; VASLeg; ODI; EQ-5D index	12 mos	High
Johansson et al 2016 (43)	Retrospective study with comparative design	n = 56 No complaint group: Median age = 40 ys; 15% women Complaint group: Median age = 40 ys; 53% women	Disc herniation	TSK; CSQ-Cat	VASLeg; ODI	3 mos; 2 ys	High

Table 2 (continued). ***Characteristics of studies investigating the predictive value of fear avoidance beliefs for surgical outcome following lumbar degenerative disease.***

Study	Study Design	Sample	Population	Predictors	Outcomes	Follow-Up	Quips
Kim et al 2015 (49)	Cohort study	n = 138 Low PCS group: Mean age = 64.3 ys (SD = 11.1); 51.5% women High PCS group: Mean age = 67.2 ys (SD = 10.7); 80% women	Spinal stenosis	PCS	ODI	12 mos	High
Knafo et al 2021 (46)	Prospective cohort study	n = 63 Mean age = 63.1 ys (SD = 1.9) 57.1% women	Lumbar disk herniation, lumbar stenosis, degenerative spondylolisthesis	FABQ-Work; FABQ-Activity	Δ ODI	6 mos	High
Laufenberg-Feldmann et al 2018 (20)	Prospective cohort study	n = 106 Mean age = 58.8 ys (SD = 16.5) 48.1% women	Lumbar disc herniation	GAD-7	NRS	6 mos	High
Lee et al 2016 (44)	Prospective cohort study	n = 376 Mean age = 69 ys 60.6% women	Spinal stenosis, degenerative spondylolisthesis, intervertebral disc herniation, degenerative lumbar kypho-scoliosis	EQ-5D-Anxiety	Δ EQ-5D index; Δ EQ-5D VAS	12 mos	High
Lee et al 2017 (21)	Retrospective cohort study	n = 206 Mean age = 62.4 ys (SD = 8.7) 66.5% women	Spinal stenosis, degenerative spondylolisthesis, spinal stenosis with spondylolisthesis	HADS-Anxiety	Δ VAS; Δ ODI	2 ys	High
Mannion et al 2007 (51)	Cohort study	n = 163 Mean age = 61.4 ys (SD = 14.3) 58% women	Spinal stenosis, discopathy, facet syndrome, segmental stability	FABQ-Work; FABQ-Activity	Core index	6 mos	High
McIlroy et al 2021 (47)	Retrospective cohort study	n = 14,485 Mean age = 68 ys (SD = 10.5) 50.8% women	Lumbar spinal stenosis	FABQ-Work; FABQ-Activity	Δ ODI (Walking ability)	6 mos; 12 mts	High
Schade et al 1999 (50)	Prospective cohort study	n = 42 NDA NDA	Disc herniation	PGWBI-Anxiety	Δ VAS; Δ RMDQ	2 ys	High
Trief et al 2000 (45)	Prospective cohort study	n = 102 Mean age = 47.3 ys (SD = 14.9) 49% women	Back pain	STAI-Trait; MSPQ	Δ Back pain(5-point Likert scale); Δ Leg pain (5-point Likert scale); Δ DPQ	12 mos	High
Tripp et al 2017 (22)	Retrospective study	n = 214 Mean age = 59.2 ys (SD = 14.9) 52.8% women	Disc herniation, stenosis, spondylolisthesis, deformity, other degenerative condition	TSK; PCS	SF-12-PC; SF-12-MC	6 mos	High

Table 2 (continued). ***Characteristics of studies investigating the predictive value of fear avoidance beliefs for surgical outcome following lumbar degenerative disease.***

Study	Study Design	Sample	Population	Predictors	Outcomes	Follow-Up	Quips
Wagner et al 2020 (23)	Prospective cohort study	n = 180 Fusion group: Mean age = 63 ys; 66.0% women No fusion group: Mean age = 63 ys; 54.1% women	Spinal stenosis, disc herniation, instability, spondylolisthesis	STAI-State; STAI-Trait	Δ EQ-5D index; EQ-5D VAS; SF-36-PC; SF-36-MC	12 mos	High
Weiner et al 2021 (48)	Prospective cohort study	n = 193 Mean age = 65.9 ys (SD = 9.7) 3.1% female	Lumbar spinal stenosis with neurogenic claudication	FABQ; CSQ-Cat; GAD-7	Δ SSM-function; Δ SSM-symptom	12 mts	High

Δ indicates change in outcome between baseline and time of follow-up. Core index, Composite core index score (including back & leg pain intensity, back function, symptom-specific well-being, general well-being, disability); COS, Clinical overall score (including pain intensity, clinic and neurological examination, functional status and analgesics); CSQ-Cat, Coping Strategies Questionnaire Catastrophizing; DPQ, Dallas Pain Questionnaire; EQ-5D-Anxiety, EuroQol-5 dimension Anxiety Score; EQ-5D index, EuroQol-5 dimension index measure; EQ-5D VAS, EuroQol-5 dimension Visual Analog Scale; FABQ, Fear Avoidance Belief Questionnaire; ; GAD-7, General Anxiety Disorder-7; HADS, Hospital Anxiety and Depression Scale; MSPQ, Modified Somatic Perception Questionnaire; mos, months; NDA, No Data Available; nPPSP, non-Persistent Postsurgical Pain; NRS, Numeric Rating Scale; ODI, Oswestry Disability Index; PCS, Pain Catastrophizing Scale; PGWBI-Anxiety, Psychological General Well-Being Index Anxiety Score; PPSP, Persistent Postsurgical Pain; QUIPS, Quality of Prognosis Studies; RMDQ, Roland Morris Disability Questionnaire; SCL-90-R, Symptom Checklist 90 Revised; SD, Standard Deviation; SF-12-MC, Short Form 12-item Health Survey Mental Component Score; SF-12-PC, Short Form 12-item Health Survey Physical Component Score; SF-36-MC, Short Form 36-item Health Survey Mental Component Score; SF-36-PC, Short-Form 36-item Health Survey Physical Component Score; SSM, Spinal Stenosis Measure; STAI, State Trait Anxiety Inventory; TSK, Tampa Scale for Kinesiophobia; VAS, Visual Analog Scale; ys, years

nosis (11,17-19,21-23,44,46-49,51). Conditions related to disc protrusion (e.g., disc herniation, disc prolapse) were the second most commonly researched with 12 studies focusing on these conditions (19,20,22,23,37-39,42-44,46,50). Spondylolisthesis (11,19,21-23,44,46), degenerative disc disease (11,51), and segmental instability (23,51) were researched in 7, 2, and 2 studies, respectively. Another 2 studies included patients with low back pain who showed degenerative changes in several segments (24,40). Facet syndrome (51), general back pain (45), lumbar degenerative disorder (36), degenerative kyphoscoliosis (44), and deformity (22) were each included in one study. Lastly, one study included a group of patients who had degenerative conditions other than disc herniation, stenosis, spondylolisthesis, and deformity (22).

In all included studies, various comparative prognostic factors (e.g., age, gender) were added to the multivariable regression analyses. However, as a best evidence synthesis does not take into account the comparative prognostic factors, description of these factors was not deemed relevant.

Methodological Quality

Following assessment of methodological quality using QUIPS, all studies were identified as having high risk of bias. Results of the QUIPS assessment are detailed in Appendix 2.

Synthesis of Results

Results of the best evidence synthesis are reported in Table 3.

Pain Intensity

Following best evidence synthesis, this review found moderate evidence that preoperative pain-related fear has no significant predictive value for postoperative back or leg pain intensity in patients with lumbar degenerative disease. Though 7 studies were relevant (11,17,37,42,43,48,51), 4 studies were excluded from the synthesis (17,42,48,51). Out of the excluded studies, one study found preoperative work-related fear to be a significant negative predictor for the core index (i.e., a composite score including pain intensity, back function, disability, symptom-specific, and general well-being) following spinal surgery, while no significant association was found for fear regarding physical activity (51). Two other excluded studies found no significant predictive value for pain-related fear with a postoperative composite score including pain intensity (i.e., Spinal Stenosis Measure – Symptoms) in patients with lumbar spinal stenosis (17,48). A third

Table 3A. ***Results of the best evidence synthesis on the predictive value of fear avoidance beliefs for postoperative pain intensity following surgery for lumbar degenerative disease.***

Fear Avoidance Belief		Study	Study Result (Significance level; Confidence interval)		Level of Evidence
Pain-related fear	TSK	Abbott et al 2011 (11)		0 ($P = 0.743$)	Moderate evidence
	TSK	den Boer et al 2006 (37)		0 ($P \geq 0.05$)	
	Factor 1, behavioral variables (including coping self-statement, coping catastrophizing and fear avoidance)	Johansson et al 2016 (43)	At 3 mos: At 24 mos:	0 ($P = 0.36$) 0 ($P = 0.18$)	
Catastrophizing	CSQ-Cat	Abbott et al 2011 (11)		+ ($P = 0.002$)	Conflicting evidence
	Factor 1, behavioral variables (including coping self-statement, coping catastrophizing and fear avoidance)	Johansson et al 2016 (43)	At 3 mos: At 24 mos:	0 ($P = 0.36$) 0 ($P = 0.18$)	
Anxiety	GAD-7	Laufenberg-Feldmann et al 2018 (20)	As continuous factor: As dichotomous factor:	0 ($P = 0.50$; 95% CI (-0.36 to 0.74)) 0 ($P = 0.43$; 95% CI (-0.63 to 1.46))	Conflicting evidence
	HADS-Anxiety	Lee et al 2017 (21)		+ ($P = 0.002$)	

Study result: += positive predictive value (increase in preoperative fear avoidance belief indicates increase in postoperative pain intensity); 0 = no predictive value; - = negative predictive value (increase in preoperative fear avoidance belief indicates decrease in postoperative pain intensity). Significance level is indicated by both *P*-value and 95% confidence interval (95% CI) whenever possible. CSQ-Cat = Coping Strategies Questionnaire Catastrophizing; GAD-7 = General Anxiety Disorder-7; HADS = Hospital Anxiety and Depression Scale; TSK = Tampa Scale for Kinesiophobia; mos = months

study was excluded due to lack of data (42). For this synthesis, no specific distinction was made between back and leg pain intensity, as was also the case in 2 of the included studies (11,37). However, it should be mentioned that one study only included leg pain intensity as an outcome measure (43).

Conflicting evidence was found regarding the predictive value of preoperative catastrophizing for postoperative pain intensity in patients with lumbar degenerative disease. Whereas 5 studies were considered for this synthesis (11,39,42,43,48), 2 studies were excluded as no data regarding their results were available (39,42). A third excluded study found no significant predictive value of catastrophizing for the postoperative score of the Spinal Stenosis Measure – Symptoms in patients with lumbar spinal stenosis (48). While one included study only included back pain intensity (11), the other study used leg pain intensity as an outcome measure (43). For this synthesis, no distinction was made between back and leg pain intensity.

Best evidence synthesis showed conflicting evidence for the predictive value of preoperative anxiety for postoperative pain intensity in patients with lumbar degenerative disease. Although 9 studies were relevant (17,19-21,38,39,45,48,50), 7 were excluded from the synthesis: 5 due to lack of data (17,19,39,45,50), and 2 because of the use of a composite outcome measure (38,48). One excluded study did find preoperative anxiety to be a negative predictor for the clinical overall score (i.e., a composite score including pain, clinical testing, function, and analgesics) following lumbar disc surgery (38). The second study that used a composite score did not find a significant predictive value for preoperative anxiety with the postoperative score of the Spinal Stenosis Measure – Symptoms in patients with lumbar spinal stenosis (48). Both included studies did not make a distinction between back and leg pain intensity in their analyses. However, it should be mentioned that one focused on pain during movement (20), while the other questioned patients on the change in general pain intensity since the surgery (21). Details regarding these syntheses for pain intensity can be found in Table 3A.

Functional Status

Moderate evidence was found indicating that preoperative pain-related fear has no significant predictive value for postoperative functional status in patients with lumbar degenerative disease. Though 12 studies were relevant, 3 studies were excluded from the synthesis (11,17,24,37,40,42,43,46-48,51). For 2 of the studies, no data of interest were available (24,42). The third excluded study used the composite core index as is described in an earlier paragraph (51). Addition-

Table 3B. *Results of the best evidence synthesis on the predictive value of fear avoidance beliefs for postoperative functional status following surgery for lumbar degenerative disease.*

Fear Avoidance Belief		Study	Study Result (Significance level; Confidence interval)		Level of Evidence
Pain-related fear	TSK	Abbott, et al, 2011 (11)		0 (P = 0.436)	Moderate evidence
	FABQ-Activity	Burgstaller, et al, 2017 (17)	As dichotomous factor:	0 (95% CI (0.64 to 1.92))*	
	TSK	den Boer, et al, 2006 (37)		- (P < 0.05)	
	FABQ-Work	Hellum, et al, 2012 (40)		- (P = 0.007; 95% CI (1.2 to 2.4))*	
	Factor 1, behavioral variables (including coping self-statement, coping catastrophizing and fear avoidance)	Johansson, et al, 2016 (43)	At 3 mos: At 24 mos:	0 (P = 0.250) 0 (P = 0.371)	
	FABQ-Work	Knafo, et al, 2021 (46)		0 (P = 0.4; 95% CI (0.96 to 1.11))*	
	FABQ-Activity			0 (P = 0.5; 95% CI (0.94 to 1.13))*	
	FABQ-Work	McIlroy, et al, 2021 (47)	At 6 mos: At 12 mos:	0 (P = 0.412; 95% CI (0.98 to 1.01))* 0 (P = 0.512; 95% CI (0.98 to 1.03))*	
	FABQ-Activity		At 6 mos: At 12 mos:	0 (P = 0.136; 95% CI (0.99 to 1.01))* 0 (P = 0.776; 95% CI (0.97 to 1.01))*	
	FABQ	Weiner, et al, 2021 (48)		0 (P = 0.82; 95% CI (0.86 to 1.03))*	
Catastrophizing	CSQ-Cat	Abbott, et al, 2011 (11)		- (P = 0.041)	Conflicting evidence
	PCS	Jakobsson, et al, 2019 (24)		- (P = 0.030; 95% CI (0.038 to .728))	
	Factor 1, behavioral variables (including coping self-statement, coping catastrophizing and fear avoidance)	Johansson, et al, 2016 (43)	At 3 mos: At 24 mos:	0 (P = 0.36) 0 (P = 0.18)	
	PCS	Kim, et al, 2015 (49)		0 (P = 0.395; 95% CI (0.956 to 1.018))*	
	CSQ-Cat	Weiner, et al, 2021 (48)		0 (P = 0.69; 95% CI (0.95 to 1.08))*	
Anxiety	EQ-5D-Anxiety	Carreon, et al, 2016 (36)		0 (P = 0.482)	Conflicting evidence
	SCL-90-R-Anxiety	Dobran, et al, 2017 (18)		- (P = 0.031)*	
	HADS-Anxiety	Lee, et al, 2017 (21)		- (P = 0.014)	
	STAI-State	Wagner, et al, 2020 (23)		0 (P = 0.634)	
	STAI-Trait			0 (P = 0.894)	
	GAD-7	Weiner, et al, 2021 (48)		0 (P = 0.1846; 95% CI (0.92 to 1.02))*	

Study result: +=positive predictive value (increase in preoperative fear avoidance belief indicates increase in postoperative functional status); 0=no predictive value; - =negative predictive value (increase in preoperative fear avoidance belief indicates decrease in postoperative functional status). Significance level is indicated by both p-value and 95% confidence interval (95% CI) whenever possible. * indicates results of a logistic regression. CSQ-Cat=Coping Strategies Questionnaire Catastrophizing; EQ-5D-Anxiety=EuroQol-5 dimension Anxiety Score; FABQ=Fear Avoidance Belief Questionnaire; GAD-7=General Anxiety Disorder-7; HADS=Hospital Anxiety and Depression Scale; PCS=Pain Catastrophizing Scale; SCL-90-R=Symptom Checklist 90 Revised; STAI=State Trait Anxiety Inventory; TSK=Tampa Scale for Kinesiophobia; mos=months

ally, it should be mentioned that one of the included studies only used walking ability (as measured by the Oswestry Disability Index) as an outcome measure for functional status (47).

For preoperative catastrophizing, conflicting evidence was found regarding its predictive value for postoperative functional status in patients with lumbar degenerative disease. Six relevant studies were found (11,24,42,43,48,49); one (42) was excluded due to lack of data.

Conflicting evidence was also found for the predictive value of preoperative anxiety for postoperative functional status in patients with lumbar degenerative disease. Ten studies were considered for this synthesis (17-19,21,23,36,38,45,48,50). However, 5 of those studies were excluded, 4 due to lack of data (17,19,45,50),

Table 3C. ***Results of the best evidence synthesis on the predictive value of fear avoidance beliefs for postoperative health-related quality of life following surgery for lumbar degenerative disease.***

FEAR AVOIDANCE BELIEF		STUDY	STUDY RESULT (Significance level; Confidence interval)		LEVEL OF EVIDENCE
Pain-related fear	TSK	Johansson, et al, 2010 (42)		- (*P* = 0.027; 95% CI (1.2 to 35.3))*	Conflicting evidence
	TSK	Tripp, et al, 2017 (22)	For SF-12-PC:	0 (*P* =0.16; 95% CI (-0.31 to 0.05))	
Catastrophizing	CSQ-Cat	Abbott, et al, 2011 (11)		0 (*P* = 0.396)	Limited evidence
Anxiety	EQ-5D-Anxiety	Lee, et al, 2016 (44)	For EQ-5D index: For EQ-5D VAS:	- (*P* = 0.002)* 0 (*P* = 0.063)*	Conflicting evidence
	STAI-State	Wagner, et al, 2020 (23)	For EQ-5D VAS: FOR SF-36-PC:	0 (*P* = 0.324) 0 (*P* = 0.066)	
	STAI-Trait		For EQ-5D VAS: FOR SF-36-PC:	- (*P* = 0.025) - (*P* = 0.041)	

Study result: +=positive predictive value (increase in preoperative fear avoidance belief indicates increase in postoperative quality of life); 0=no predictive value; - =negative predictive value (increase in preoperative fear avoidance belief indicates decrease in postoperative quality of life). Significance level is indicated by both P value and 95% confidence interval (95% CI) whenever possible. * indicates results of a logistic regression. CSQ-Cat=Coping Strategies Questionnaire Catastrophizing; EQ-5D-Anxiety=EuroQol-5 dimension Anxiety Score; EQ-5D index=EuroQol-5 dimension index measure; EQ-5D VAS=EuroQol-5 dimension Visual Analogue Scale; SF-12-PC=Short Form 12-item Health Survey Physical Component Score; SF-36-PC=Short Form 36-item Health Survey Physical Component Score; STAI=State Trait Anxiety Inventory; TSK=Tampa Scale for Kinesiophobia

and one due to the use of a composite score as the dependent variable (38). The latter did find preoperative anxiety to be a negative predictor for the clinical overall score following lumbar disc surgery (38). Table 3B details the results of the syntheses for functional status.

Health-related Quality of Life

Best evidence synthesis showed conflicting evidence for the predictive value of preoperative kinesiophobia for postoperative measures related to HRQoL in patients with lumbar degenerative disease. Two out of 4 relevant studies were excluded from the synthesis (11,22,42,51). One study was excluded due to lack of data(11), while the second study used the composite core index as the dependent variable (51). The latter study is described in more detail above. One included study used the EQ-5D index as the dependent variable (42), while the other study focused on the physical component of the SF-12 (22). As such, 2 additional conclusions can be made regarding this synthesis. First, it showed limited evidence that pain-related fear has a significant negative predictive value for postoperative HRQoL in general. Second, limited evidence was found that this predictor has no predictive value for the physical health component of postoperative HRQoL.

Limited evidence was found regarding the predictive value of preoperative catastrophizing for postoperative HRQoL in patients with lumbar degenerative disease, as only one study reported no significant predictive value (11). Two other studies were considered for this synthesis, but were excluded due to lack of data (22,42).

Conflicting evidence was found for the predictive value of preoperative anxiety for postoperative measures related to HRQoL in patients with lumbar degenerative disease. Though 3 studies were considered for this synthesis (19,23,44), one study was excluded due to lack of data (19). However, one included study used both the EQ-5D index and the EQ-5D VAS as a dependent variable for regression analyses (44). For both outcome measures, a different conclusion was found (i.e., significant negative predictive value and no predictive value). Similarly, the second included study used the EQ-5D VAS and the physical component of the SF-36 as dependent variables, as well as the state- and trait-domain of the State Trait Anxiety Inventory as different independent variables (23). Though in the second study, a different conclusion was made for each independent variable (i.e., significant negative predictive value and no predictive value). Overall, the evidence remains conflicted regarding HRQoL in general, as well as for the physical health component of postoperative HRQoL. All details regarding these syntheses can be found in Table 3C.

Discussion

This systematic review aimed to examine the predictive value of preoperative fear avoidance beliefs for outcomes following surgery for lumbar degenerative disease. A total of 24 eligible studies were retrieved and reviewed to help answer this research question. Following best-evidence synthesis, moderate evidence was found indicating that preoperative pain-related fear has no significant predictive value for postoperative pain intensity or functional status in patients with lumbar degenerative disease. For all other relationships between potential predictors and surgical outcome measures, only conflicting or limited evidence was found (Fig. 2).

The moderate evidence regarding the lack of significant predictive value of preoperative pain-related fear for postoperative pain intensity and functional status seemingly disagrees with conclusions regarding the negative influence of fear and avoidance beliefs in the systematic review by Alodaibi et al (10). However, it should be noted that the latter solely focused on lumbar disc herniation surgery, while our review included a much wider patient population. Additionally, Alodaibi et al (10) did not make any distinction among pain, disability, or return to work as surgical outcome measures, and only described the associations between preoperative fear and avoidance beliefs and surgical outcomes found in the included studies (10). Moreover, our conclusions regarding pain-related fear contradict findings from systematic reviews in other surgical populations, which indicate that pain-related fear negatively influences functional outcomes following knee surgery (52,53). However, these reviews were unable to formulate definitive conclusions regarding the predictive relationship between preoperative fear and postoperative pain (52,53).

Thus, to the best of our knowledge, our review is the first to provide moderate evidence indicating no significant predictive value of pain-related fear for postoperative pain and function in patients with lumbar degenerative disease. Remarkably, only conflicting evidence regarding the predictive value of pain-related fear for postoperative HRQoL was found in patients with lumbar degenerative disease. No comparison with other surgical populations was possible, as the current systematic review is the first to specifically report on the predictive value of preoperative pain-related fear for postoperative HRQoL.

For both pain catastrophizing and anxiety, only conflicting or limited evidence was found for their predictive relationship with surgical outcomes. These findings oppose earlier descriptive reviews, which report on the predictive value of pain catastrophizing and anxiety for lumbar surgery outcomes (5,10,14-16). For example, a recent review by Costelloe et al (16) identified both pain catastrophizing and anxiety as predictors for postoperative pain following spine surgery. Earlier, Alodaibi et al (10) also studied the predictive value of these fear avoidance beliefs for surgical outcomes following lumbar disc herniation. Although some associations were described, it was ultimately concluded that more research is needed to formulate a clear conclusion regarding pain catastrophizing and anxiety as potential predictors (10).

Also, den Boer et al (5) and Celestin et al (14) reported on psychological factors (e.g., anxiety, coping) as predictors for surgical outcomes following lumbar surgery. Indeed, the former described evidence for anxiety as a predictor for lumbar disc surgery outcomes, while the latter suggested the negative influence of preoperative psychological factors for treatment outcomes. However, it should be noted that Celestin et al (14) combined results of studies investigating both lumbar surgery and the implantation of a spinal cord stimulator. Though both procedures can be effective, lumbar surgery can present a larger burden for the patient at the time of the procedure due to its more invasive process. Nevertheless, as spinal cord stimulation will have a continuous effect following the implantation, patients might have increased anxiety levels, as well as other fear avoidance beliefs, before the procedure.

Lastly, Wilhelm et al (15) included pain catastrophizing as a potential predictor in their review and found a negative association with postoperative pain intensity and disability scores following lumbar spinal fusion. Although catastrophizing was identified as a negative predictor, the authors ultimately concluded that the current evidence is insufficient and further research is still necessary (15).

Moreover, none of these reviews included a detailed best evidence synthesis or meta-analysis. As such, our results following a best evidence synthesis provide additional insight in the (lack of) predictive value of fear avoidance beliefs for lumbar surgery outcomes. Nevertheless, overall conclusions remain inconclusive as the evidence appears conflicted or limited. Thus, more research is required to gain further understanding on the predictive value of fear avoidance beliefs for surgical outcomes following lumbar degenerative disease.

A variety of measurement instruments were reported for fear avoidance beliefs and surgical out-

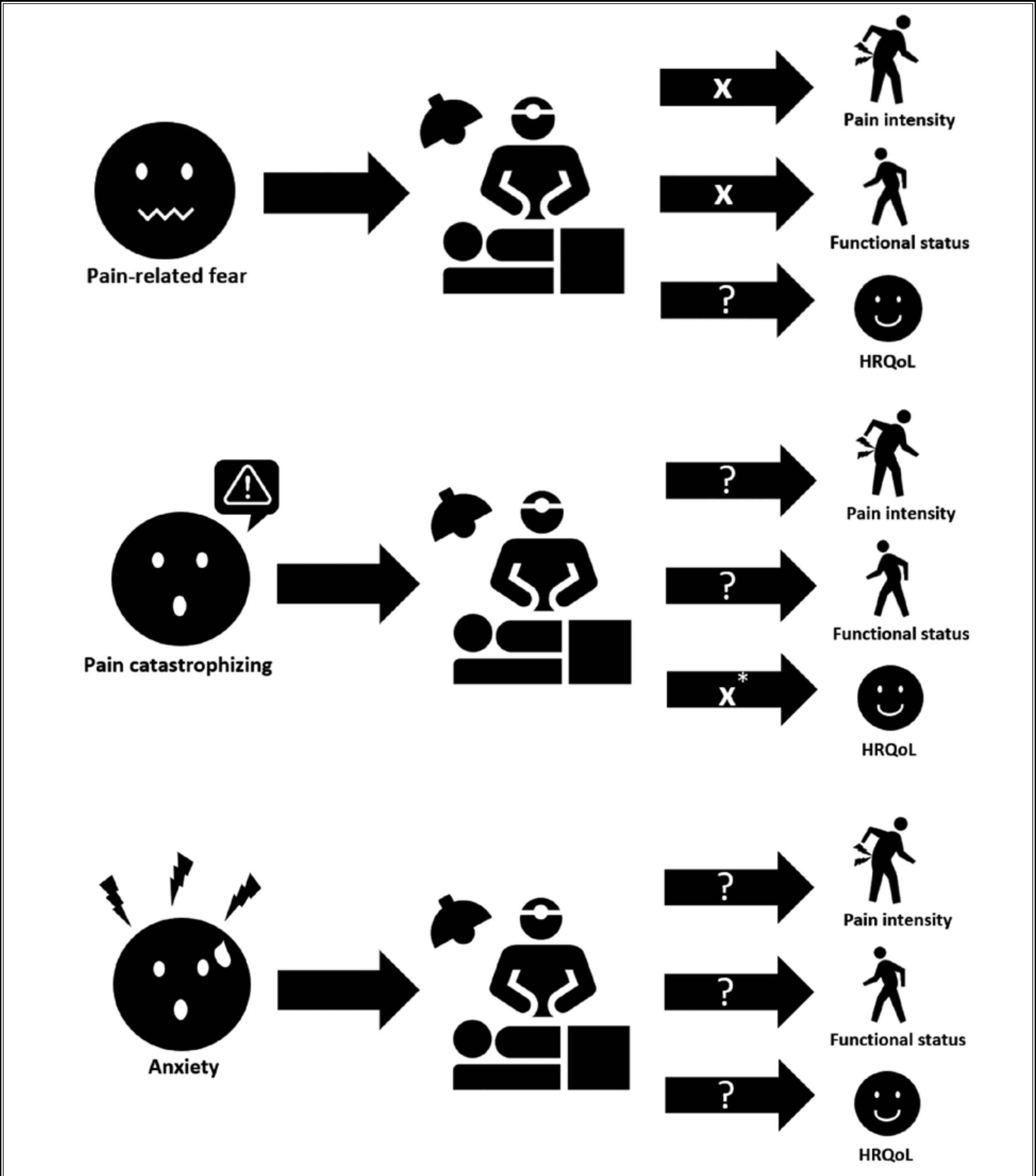

Fig. 2. *Results of the best evidence synthesis regarding the predictive value of preoperative fear avoidance beliefs for outcome measures following surgery for lumbar degenerative disease indicating moderate evidence for no predictive value (x), conflicting evidence (?) and limited evidence for no predictive value (x*) per relationship.*

come measures. For example, the EQ-5D (11,23,42,44), the SF-12 (22) and the SF-36 (23) were used to assess HRQoL in studies included in the best evidence synthesis. However, it should be noted that utility scores, such as the EQ-5D index measure, are related to a general value of HRQoL, while the physical component score of the SF-12 and SF-36 focus specifically on the physical health aspect of a patient's quality of life. Moreover, measures such as the EQ-5D index and the physical component score of the SF-12 are multidimensional, including multiple HRQoL-domains, while the EQ-5D VAS is a unidimensional score solely indicating a patient's general well-being. Nevertheless, previous research has indicated that measures such as the physical component score of the SF-12 were correlated with the EQ-5D physical dimensions, as well as the EQ-5D index score and EQ-5D VAS (54). Although direct comparison might not be possible among all these outcome measures, results of these measures do give an indication of a similar concept of HRQoL. Therefore, combining results of these instruments might be warranted to formulate a general conclusion regarding HRQoL.

Similar remarks can be made regarding the measurement instruments reported for fear avoidance beliefs. The Tampa Scale for Kinesiophobia (11,22,37,42,43) and the Fear Avoidance Belief Questionnaire (17,40) were used to assess pain-related fear in the studies included for synthesis, while the Pain Catastrophizing Scale (22,24,49) and the catastrophizing domain of the Coping Strategies Questionnaire (11,43) were used to assess pain catastrophizing. Regarding anxiety, 5 different instruments were used in the included studies: the State Trait Anxiety Inventory (23), the Hospital Anxiety and Depression Scale (21), the anxiety domain of the EQ-5D (36,44), the anxiety symptom domain of the Revised Symptoms 90-item Checklist (18) and the General Anxiety Disorder-7 (20). Although all these instruments assess specific subconcepts (e.g., kinesiophobia, state anxiety), they all evaluate beliefs and cognitions related to a specific fear avoidance belief (55-58). Given that all these questionnaires are considered validated instruments for assessing pain-related fear, pain catastrophizing, or anxiety, results of these instruments were combined according to their corresponding fear avoidance belief (18,55-61).

Limitations

Some limitations should be considered when interpreting this systematic review. First, our research question was based on factors related to the fear avoidance model by Leeuw et al (8) therefore the results cannot be extrapolated to factors related solely to other fear avoidance models.

Next, although the definition of anxiety was often not specified as related to pain in the included studies, we opted to include all outcome measures related to anxiety. As none of the eligible studies mentioned "pain anxiety" specifically, we felt it was justified to broaden our definition to anxiety symptoms in general as indeed all studies examined anxiety in relation to pain or disability.

Lastly, to evaluate surgical outcomes, we focused solely on patient-reported outcome measures as used by spine registries and recommended for low back pain (28,62). Thus, our findings cannot be extrapolated to all surgery outcomes following lumbar degenerative disease and should be interpreted in relation to postoperative pain intensity, functional status, or HRQoL. Moreover, the selected surgical outcome measures rely heavily on the biological aspect of a biopsychosocial perspective on treatment outcome, and thus not always reports on all aspects patients might find important (63). As such, future research should include different outcome measures representing the full biopsychosocial perspective on treatment outcomes. Additionally, qualitative research could be used to gain more insight into patients' experiences following surgery and create a (more) complete overview of their surgical outcomes (64).

Conclusion

This systematic review focusing on the predictive value of fear avoidance beliefs found moderate evidence indicating that preoperative pain-related fear has no predictive value for postoperative pain intensity or functional status in patients with lumbar degenerative disease. Additionally, limited evidence was found for a lack of predictive value of preoperative pain catastrophizing for postoperative health-related quality of life. No other predictors for postoperative surgical outcomes in patients with lumbar degenerative disease could be identified following a best-evidence synthesis. As currently the evidence for the predictive value of preoperative fear avoidance beliefs in patients with lumbar degenerative disease is still mixed, further research is required.

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Appendices available at www.painphysicianjournal.com

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Appendix 1.

PICOTS

This systematic review aims to examine whether fear avoidance beliefs predict surgical outcome in patients following spinal surgery for lumbar degenerative disease.

The following framework (PICOTS) was used to perform this systematic review:

Population: Patients aged 18 or older who received surgery following a diagnosis of lumbar degenerative disease (e.g., spondylolisthesis, spinal stenosis, disc herniation, degenerative disc disease). We excluded systemic pathologies, such as osteoporosis, autoimmune and oncological conditions, or congenital disorders (e.g., scoliosis).

Indexed prognostic factors: Preoperative pain-related cognitions and emotions related to the fear avoidance model, or fear avoidance beliefs, by Leeuw et al (8), including pain catastrophizing, pain-related fear (e.g., kinesiophobia, fear of (re)injury, fear of work-related activities) and pain anxiety (e.g., pain vigilance).

Comparative prognostic factors: When reported in the studies, we took into account the following factors: factors related to symptom severity, preoperative symptom duration, preoperative mental health factors, preoperative disability, preoperative health-related quality of life, work-related factors, factors related to earlier treatments, physical factors, patients' expectations, comorbidities, surgical factors, as well as demographic factors.

Outcome: Pain intensity, functional status and health-related quality of life.

Time: Follow-up measurements starting ≥ 3 months postsurgery.

Setting: Primary and secondary care settings.

Search strategy

Population:

"Lumbosacral region/surgery"(MeSH)
OR "Lumbar vertebrae/surgery"(MeSH)
OR "Low Back Pain/surgery"(MeSH)
OR "Radiculopathy/surgery" (MeSH)
OR "Lumbar surgery"
OR "Lumbar spine surgery"
OR "Lower back surgery"
OR ("Low Back Pain" AND "Surgery")
OR ("Lumbar radiculopathy" AND "Surgery")
OR ("Lumbar spinal stenosis" AND "Surgery")
OR ("Lumbar stenosis" AND "Surgery")
OR ("Lumbar disc herniation" AND "Surgery")
OR ("Lumbar" AND "degenerate*" AND "Surgery")

Index prognostic factors:

("Risk factors"(MeSH)
OR "Prognosis"(MeSH)
OR "Risk factors"
OR "Prognos*"
OR "Predict*"
OR "factor"
OR "Independent")
AND
("Catastrophization"(MeSH)
OR "Anxiety"(MeSH)
OR "Fear"(MeSH)
OR "Catastrophization"
OR "Anxiety"
OR "Fear"
OR "Pain catastrophizing"
OR "Hypervigilance"
OR "Pain vigilance"
OR "Pain-related fear"
OR "Kinesiophobia"
OR "Fear of movement"
OR "Fear of re-injury"
OR "Anxiety"
OR ("Fear" AND "Avoidance"))

Outcome

"Failed Back Surgery Syndrome"(MeSH)
OR "Pain, Postoperative"(MeSH)
OR "Patient reported outcome measures"(MeSH)
OR "Treatment outcome" (MeSH)
OR "Treatment failure" (MeSH)
OR "Quality of life" (MeSH)
OR "Failed Back Surgery Syndrome"
OR "Postoperative pain"
OR "Chronic pain"
OR "Persistent pain"
OR "Pain intensity"
OR "Disability"
OR "Function"
OR "Physical function"
OR "Mental function"
OR "Quality of life"
OR "Patient reported outcome measure"
OR "Treatment outcome"
OR "Treatment failure"
OR "Surgical outcome"

Appendix 2: *Results of QUIPS-assessment per domain*.

Domain		Abbott et al (11)	Burgstaller et al (17)	Carreon et al (36)	den Boer et al (37)	Dobran et al. (18)	Gilmore et al (19)
1.	Study participation	High	Moderate	High	High	High	Low
2.	Study attrition	High	High	High	Low	High	Low
3.	Prognostic factor measurement	Low	Low	High	Moderate	High	High
4.	Outcome measurement	Moderate	High	High	Low	High	Low
5.	Study confounding	Moderate	High	High	Low	High	Low
6.	Statistical analysis and reporting	Low	Low	Moderate	Moderate	High	Low
	Overall rating of risk of bias	High	High	High	High	High	High

Domain		Graver et al (38)	Hegarty et al (39)	Hellum et al (40)	Jakobsson et al (24)	Johansson et al (42)	Johansson et al (43)
1.	Study participation	High	Moderate	High	High	Moderate	Moderate
2.	Study attrition	High	Low	High	Low	High	High
3.	Prognostic factor measurement	High	High	High	Low	Moderate	High
4.	Outcome measurement	Moderate	High	Moderate	Moderate	High	High
5.	Study confounding	High	High	High	Low	High	Moderate
6.	Statistical analysis and reporting	Moderate	Low	Moderate	Low	High	Moderate
	Overall rating of risk of bias	High	High	High	High	High	High

Domain		Kim et al (49)	Knafo et al (46)	Laufenberg-Feldmann et al (20)	Lee et al (44)	Lee et al (21)	Mannion et al (51)
1.	Study participation	High	High	High	High	Moderate	High
2.	Study attrition	High	High	High	High	Moderate	High
3.	Prognostic factor measurement	Moderate	Low	Low	High	High	Low
4.	Outcome measurement	Moderate	High	Low	High	Low	Low
5.	Study confounding	High	Moderate	Moderate	High	Moderate	Low
6.	Statistical analysis and reporting	Low	Low	Low	Moderate	Moderate	Low
	Overall rating of risk of bias	High	High	High	High	High	High

Domain		McIlroy et al (47)	Schade et al (50)	Trief et al (45)	Tripp et al (22)	Wagner et al (23)	Weiner et al (48)
1.	Study participation	Low	High	High	High	Moderate	High
2.	Study attrition	High	High	High	High	High	High
3.	Prognostic factor measurement	High	High	Low	Low	High	Low
4.	Outcome measurement	Low	High	Low	Low	High	Low
5.	Study confounding	Low	High	Low	Low	High	Low
6.	Statistical analysis and reporting	Low	High	Low	Low	Moderate	Moderate
	Overall rating of risk of bias	High	High	High	High	High	High