THE INFLUENCE OF THE FEAR-AVOIDANCE MODEL FACTORS

ON PATIENTS SCHEDULED TO UNDERGO

LUMBAR DISC HERNIATION SURGERY

by

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ABSTRACT

Although the prognosis of patients with a lumbar disc herniation (LDH) diagnosis is generally favorable, 20% to 30% continue reporting pain, disability, and unfavorable outcome regardless of treatment received. The Fear Avoidance Model (FAM) is one among the most known models in low back pain (LBP) to explain chronic pain and disability. However, factors in this model have been mostly examined in nonspecific LBP to describe the development of chronic symptoms. The purpose of this dissertation was to study the influence of FAM factors on patients' poor outcomes following LDH surgery.

We systematically searched for studies that measured any FAM factors to prospectively assess LDH surgical outcomes. We identified 13 prospective studies that used different FAM measures to predict LDH postoperative pain, disability, or sick leave. Quality assessment of the included studies was performed and reported. Heterogeneity between studies in terms of FAM predictors, outcome measures, analyses, and in other aspects were found. While pain and depression were the most measured FAM factors, some factors were not adequately assessed. There seems to be different prognostic value between preoperative leg pain and back pain. Fear, avoidance, anxiety, and pain coping seem to have negative impact on LDH surgical outcomes.

We also analyzed prospective data for LDH patients undergoing discectomy surgery to study specific FAM measures and their impact on post discectomy leg pain,

back pain, and disability. Fear-avoidance, pain catastrophizing, physical activity level, functional disability, and other FAM factors were measured preoperatively. The FAM measures demonstrate significant associations with each other and with preoperative functional disability. These FAM measures also explained significant amounts of the 10-week outcomes' variances. The most influential FAM factors in our data were depression and work-related fear. Many findings in this analysis were supported by previous research.

In general, FAM factors seem to have a similar impact on LDH patients (pre- and postoperatively) as on nonspecific LBP patients. LDH patients with preoperative higher levels of back pain, fear-avoidance beliefs, anxiety, pain catastrophizing, passive pain coping, and depression were more likely to have unfavorable surgical outcomes. Screening for FAM factors in LDH patients and managing them accordingly during conservative therapy, before surgery, and throughout the postoperative rehabilitation is, therefore, needed to improve outcomes and minimize health care costs.

I dedicate this dissertation to my wise father, supportive mother, and to my lovely wife. Their support, patience, sacrifice, and prayers helped me throughout these years. I also want to dedicate this dissertation to my wonderful son, Abdullah, and my precious daughter, Sarah. They filled my heart with joy during tough times. Additionally, this dissertation is dedicated to my brothers and sisters who supported me and wished me all the best. Last but not least, this dissertation is dedicated to my magnificent adviser, Julie Fritz. Her respectable manners, constant guidance, and limitless support were unbelievable.

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LIST OF ABBREVIATIONS

LBP……………………………………..Low Back Pain
LP………………………………………Leg Pain
CLBP……………………………………Chronic Low Back Pain
LDH……………………………………..Lumbar Disc Herniation
BPS……………………………………...The Biopsychosocial Model
FAM…………..……………………..The Fear Avoidance Model
PA………………………………………Physical Activity
Preop……………………..……………Preoperative (i.e., before the surgery)
Postop…………………….…………..Postoperative (i.e., after the surgery)
VAS……………………………………..The Visual Analog Scale
NPRS……………………………………The Numeric Pain Rating Scale
ODI……………………………………...The Oswestry Disability Index
ZDS……………………………………...The Zung Depression Scale
BDI……………………………………....The Beck Depression Index
FABQ……………………………………The Fear-Avoidance Belief Questionnaire
TSK……………………………………...The Tampa Scale for Kinesiophobia
CSQ……………………………………...The Coping Strategies Questionnaire
PCI………………………………….….The Pain Coping Index
MSPQ……………………………………The Modified Somatic Perception Questionnaire
MCID…………………………………….The Minimal Clinical Importance Difference
FU…………………….………………….Follow-up
RCT………………………………………Randomized Control Trial
SLR……………………………….……..Straight Leg Raising test
MRI…………………………………..….Magnetic Resonance Imaging
CT……………………………………..….Computed Tomography
CI………………………………………...Confidence Interval
SD………………………………………..Standard Deviation
VIF………………………………………Variance Inflation Factor
QA……………………………………….Quality Assessment

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CHAPTER 1

INTRODUCTION

Pain is one of the main reasons for seeking medical care. In the United States, more than 100 million adults are affected with chronic pain or pain that last more than 3 to 6 months [1]. The annual US spending on this epidemic is estimated to be more than 500 billion dollars [2]. Low back pain (LBP) and arthritis are the two most common types of chronic pain [3]. Lifetime prevalence of LBP has been estimated to reach up to 80% [4-6]. In two national surveys, it was found that more than one quarter of U.S. adults (age 18 and over) reported LBP in the past 3 months [7]. Hence, LBP has been ranked the fifth most common reason for all physician visits [8].

Lumbar Radiculopathy, or Sciatica

Lumbar radiculopathy, or sciatica, is one of the most common forms of LBP [9]. This condition is characterized by pain that radiates down the leg along the course of the sciatic nerve, the major nerve that supplies the lower extremity below the knee, suggesting nerve root irritation. Muscle weakness, diminished reflexes, or sensory disturbances may also be present. The most common cause of sciatica is lumbar disc herniation (LDH) [9, 10]. Sciatica prevalence, reported from different studies, ranges from 1.2% to 43% [11]. Although the natural course of sciatica is favorable with about 60% of patients recovering in the first two months, persistent symptoms are present in 20% to 30% of the patients [12].

Surgical Option for LDH

As most sciatica patients cope with their pain or find relief with conservative treatment, a surgical option to remove the herniated disc is chosen by 5% to 15% of patients who cannot control their symptoms [13]. Although the surgical option can give patients faster relief of leg pain in the first couple of months than conservative treatment, the positive effect typically diminishes after 1 to 2 years [14]. Additionally, long-term outcomes of LDH surgeries are not satisfying for many patients. After 7 to 20 years following discectomy, more than one third of the patients had unsatisfactory outcomes and 28% of them complained of persistent back and leg pain [15]. Parker et al. (2010) found that over 30% of patients experienced moderate to severe back pain after first time discectomy led some patients to undergo subsequent fusion surgery [16]. The risk of further surgeries and additional health care costs are high in this case. Among over 35,000 patients with sciatica who have undergone first time discectomy surgery, 14% had at least one additional surgery on the back and these patients were associated with high risk of further surgeries and substantial health care cost [17, 18].

LDH Surgery's Direct and Indirect Costs

Surgeries to remove the disc herniation are associated with considerable direct and indirect costs. In 2003, annual Medicare spending on lumbar discectomy exceeded 300 million dollars [19]. In addition, costs associated with preoperative and postoperative diagnostic and therapeutic charges are substantial [16, 20]. These costs are divided between outpatients' visits, diagnostic imaging, injection procedures, medication charges, postoperative rehabilitation, complication managements, and absenteeism from work. The trends of spending on back pain and sciatica health care are on the rise, however, this expenditure has not yielded better patient outcomes [21, 22].

Patient Selection

The most important issue related to discectomy success is always the appropriate patient's selection. Current practices spend excessive time looking at biological causes of pain, but overlooked other potential reasons. Recent studies and clinical observations have started to challenge the idea that sciatica is merely a result of disc compression on the nerve root [10]. Psychological and social aspects have been found to be as important as the clinical findings to predict postsurgical outcomes [15, 23, 24]. Likewise, many studies found psychosocial factors to be important in predicting LDH surgery outcomes [25, 26]. Identifying patients who might be impacted with psychological factors and managing the influence of these factors accordingly is important at three stages of care: conservative management, before surgery, and throughout the postsurgical rehabilitation. Detecting patients in advance who are less likely to benefit from LDH surgery or to benefit from rehabilitation would be valuable and essential.

The Biopsychosocial Model

The Biopsychosocial Model (BPS) (Figure 1.1), as opposed to the classical medical model, considers not just biological, but also psychological, and social elements of health to help understand chronic pain and persistence of symptoms [27]. The health-illness continuum, according to this model, is a result of the interaction between physical, psychological, and social influences. In the presence of physical pathology, psychological and socioeconomical factors modulate the experience of pain and other symptoms, which can be reflected by patients' complaints [28]. By adopting this model, one can understand why some patients, who have the same exact lesion, report different levels of pain and disability. Additionally, this model explains why some patients recover while others

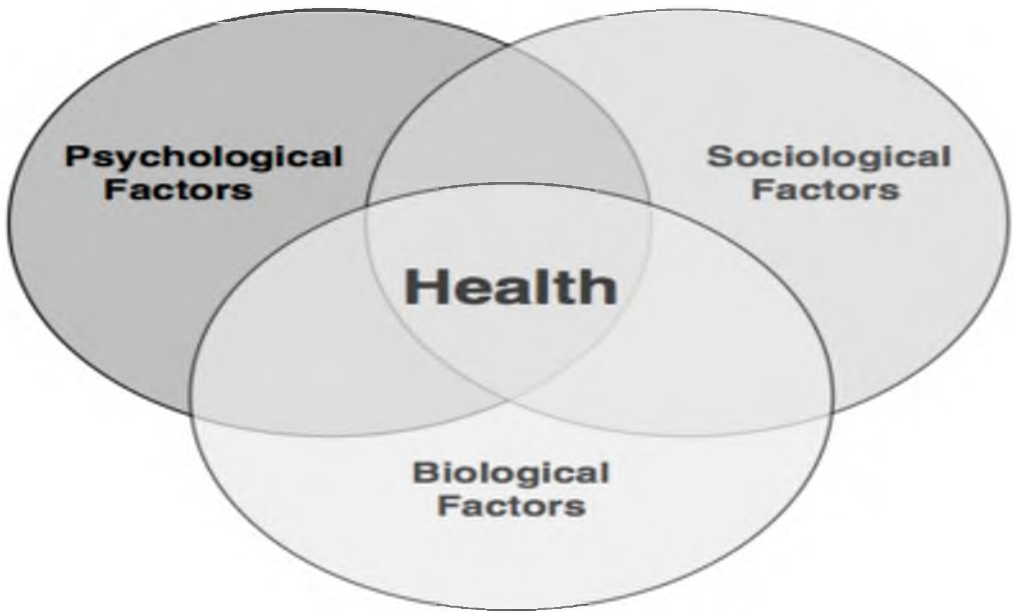

Figure 1.1 The Biopsychosocial Model

complain of chronic symptoms.

Back Pain and the BPS Model

Gordon Waddell, the Scottish orthopedic surgeon, was among the pioneers to apply the BPS model to the back pain illness, which has helped to progress and to change the way one thinks about this disorder [29]. He questioned the traditional idea that LBP is simply the result of an injury that involves the spinal nerves or other structures in the back. Waddell explains why LBP should not be viewed as a purely medical case [30]. Psychological and social factors, according to Waddell, play an important role with patients who do not recover within the expected period [31]. On the basis of Waddell and other investigators' work, the Fear Avoidance Model (FAM) has been proposed [32-36]. This model employs pain catastrophizing and fear with a number of other constructs to explain how some individuals with LBP transition from acute to chronic pain and disability.

The Fear Avoidance Model (FAM)

Consisting of cognitive, emotional, behavioral, physical, and biological processes, the FAM has become one of most accepted models to explain musculoskeletal chronic symptoms (Figure 1.2) [33, 37, 38]. In a simple way, the FAM describes how negative cognitive interpretation of pain (pain catastrophizing) triggers fears, which in turn affect the attention process (hypervigilance) and trigger maladaptive behaviors. Just after the injury, avoidance behaviors are considered adaptive, but in the long run they lead to disuse, disability, and depression. This process initiates a vicious circle that leads to chronic pain and persistence of symptoms. Individuals who confront and think of pain as a nonthreatening feeling, on the other hand, are expected to stay active and cope with pain, which gradually leads to recovery. Factors in this model (pain severity, pain catastrophizing, fear-avoidance, anxiety, depression, physical activity, disability and deconditioning) have been examined in many studies and found to be associated with poor outcomes [33, 37]. Nonetheless, most of these studies have examined FAM factors in nonoperative and nonspecific LBP samples. Viewing LDH symptoms as a pure specific diagnosis that does not relate to any of FAM factors can be misleading. Each one of the FAM factors seems to have an association with LDH surgical outcomes.

Pain Severity

Pain experience is the main symptom that relates to negative interpretation and prompts maladaptive behaviors. It was found to be associated with escape and avoidance and to have an important role in disability [37]. In the case of LDH patients, some evidence shows different prognostic roles between LBP and leg pain [39, 40]. However, these two kinds of pain are often used interchangeably to predict LDH surgical outcomes [25].

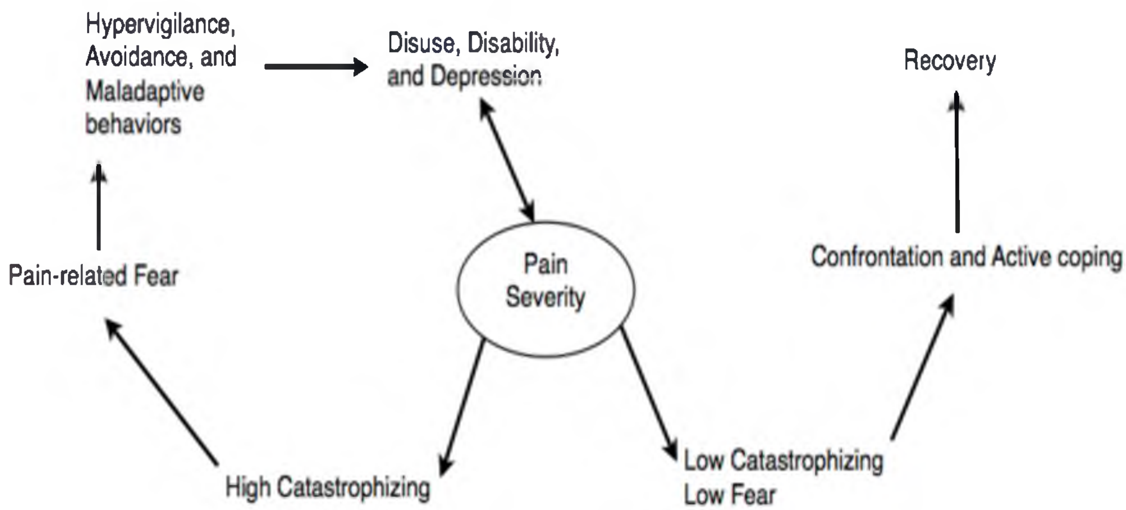

Figure 1.2 The Fear Avoidance Model (adapted from Vlaeyen et al. [33])

Sciatica is distinguished from nonspecific LBP by unilateral leg pain greater than LBP [10]; yet, many patients with predominant LBP are diagnosed with sciatica and are considered candidates for LDH surgery. Kleinstueck et al. (2011) found that patients undergoing LDH surgery with predominantly back pain had worse outcomes than patients with predominantly leg pain [40]. In their multivariate regression analysis, higher baseline back pain was a significant predictor of poor 12-months postoperative outcomes. Surgeons may overdiagnose patients with LDH if they have predominant LBP that does not radiate below the knee and with no neurological signs [41]. Baseline back pain and leg pain below the knee in patients with potential LDH seem to have a different impact on the postsurgical outcomes and should be viewed differently.

Pain Catastrophizing

The negative cognitive interpretation of pain, anticipated or actual pain, as threatening is a key part of the FAM [37, 42, 43]. Called pain catastrophizing, this tendency to exaggerate bodily sensation has been linked to a number of pain-related outcomes in individuals with various health conditions [42, 44, 45]. In a population-based cohort, high level of catastrophizing and kinesiophobia predicted future LBP and disability [44]. In addition, catastrophizing has been associated with chronicity in postsurgical outcomes [46, 47]. However, few studies have employed this construct to predict poor outcomes in patients undergoing LDH surgery [47, 48]. Although the effect of pain catastrophizing on outcomes is evident and consistent in musculoskeletal surgery [47], it is still not clear how this plays a role in LDH surgical outcomes.

Fear-Avoidance Beliefs and Anxiety

Fear, anxiety, hypervigilance, and avoidance are emotional or behavioral factors that are closely related to each other. Either an emotional reaction of a present threat (fear) or a future affective-state of a vague danger (anxiety) may result in excessive attentional bias (hypervigilance) and avoidance of pain or activities that are expected to cause pain [37]. Pain-related fear is believed to be a protective mechanism right after an injury to shift attention toward the damage. However, when pain becomes chronic and is no longer explained by tissue damage, fear-avoidance behaviors can be dysfunctional [37]. Growing evidence supporting the idea that pain-related fear may be more important in predicting disability than pain itself [36, 49, 50]. A high level of fear-avoidance was found to be associated with and predictive of chronic LBP and disability [44, 51]. On the other hand, reduction of the fear level may increase participation in daily activities and reduce disability [52, 53]. Although fear-avoidance is not normally assessed in sciatica patients, it was found to be a prognostic risk factor for nonsuccess [54]. In addition, few studies examined pain-related fear in surgically treated sciatica patients and found it to be predictive of postoperative pain, disability, and low quality of life [48, 55].

Disuse and Deconditioning

According to the FAM, negative cognitive interpretation of injury and fear-avoidance behaviors can lead to the decline of usual physical activities. Gradually, as a result, deterioration and deconditioning of one's fitness and muscular system may start to take place [37, 56]. Disuse (i.e., decline in Physical Activity (PA) and/or improper use of musculoskeletal system) may result in what is called "disuse syndrome" (Figure 1.3) [56]. That is, long-term inactivity could lead to interaction of physiological and functional deconditioning, psychological issues, and social changes. However, evidence on disuse and deconditioning in chronic LBP (CLBP) patients is still inconclusive [56-58]. In cross-sectional studies, CLBP patients were found to have lower and altered levels of PA and this was associated with pain catastrophizing and fear-avoidance beliefs [59, 60]. Smeets et al. (2009) found that patients with CLBP have lower levels of fitness; however, this was not associated with FAM variables [61]. In a recent systematic review and meta-analysis, a moderate and negative relationship was found between PA and disability in CLBP patients [62]. Physiologic change and muscle atrophy in CLBP have also been reported. A smaller cross-sectional area or muscle atrophy of the multifidus muscle, which is an important muscle for back stability, was found in CLBP patients [63-65]. In sciatica patients, multifidus muscle changes seem also to be associated with chronic symptoms both in operative and nonoperative populations [66, 67]. More research on disuse and deconditioning and the relationship with clinical outcomes is warranted to know the actual role of these factors.

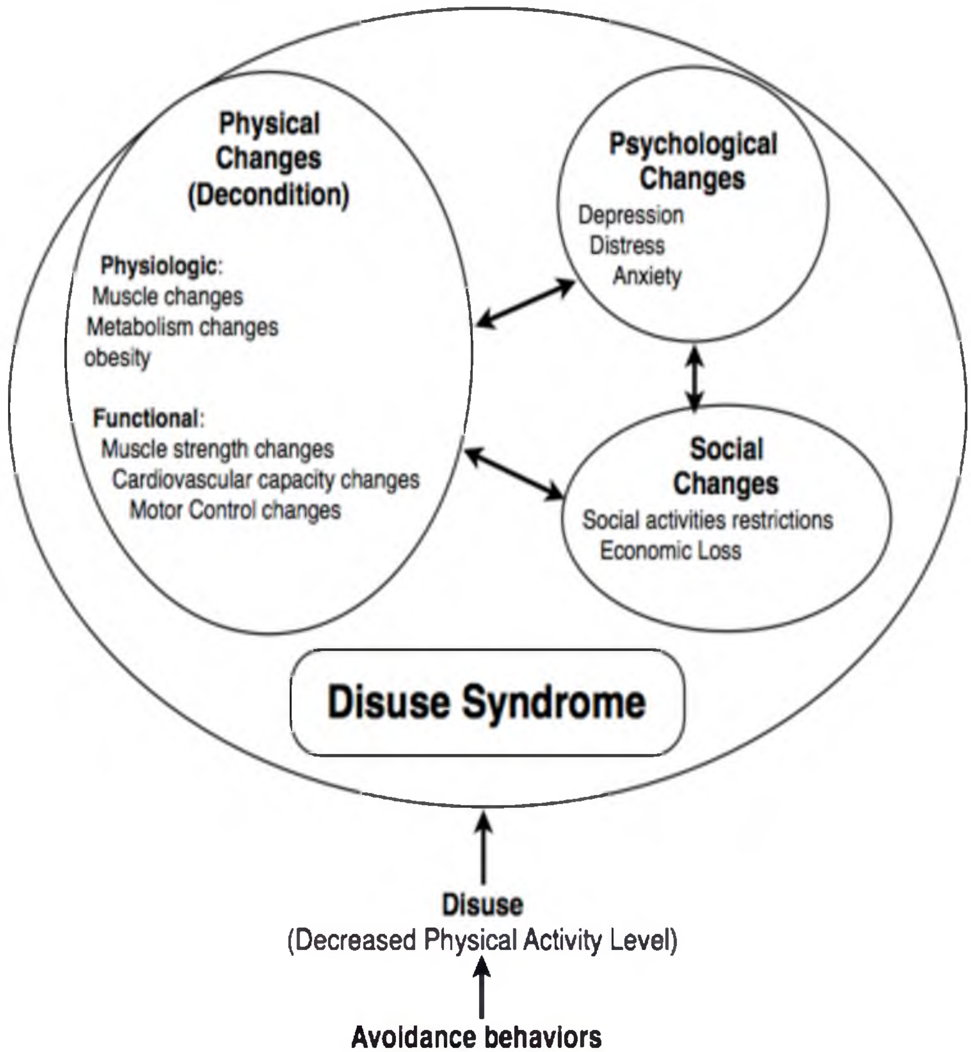

Figure 1.3 Disuse syndrome, adapted from Verbunt et al. (consequences of inactivity) [56]

Depression

Constant decline in fitness and muscles deconditioning may lead to perpetuating of pain, regression in productivity and subsequently to depression [56]. Higher prevalence of depression among individuals with chronic pain is now evident [68, 69]. A review on depression-pain comorbidity has found that depression impact on pain was common in back pain studies [70]. Depression was associated with a number of poor outcomes and unfavorable prognoses. Patients with pain and comorbid depression experienced more intense pain, longer symptoms, higher disability, higher unemployment, lower satisfaction, higher health care utilization, and had less chance of recovery [70]. Increased CLBP prevalence could be associated with increased prevalence of depression [71]. Depression was found to be a risk factor for onset of a new episode of LBP as well as for developing CLBP [72, 73]. Changes in pre treatment depression accounted for post treatment changes in pain intensity and disability in CLBP patients [74]. The level of depression also predicted postoperative outcomes for LDH patients [75, 76].

Disability

Disability or limited functional execution of daily life activities, in patients with CLBP, is a result of multifactorial causes. Biological, psychological, and social factors play a role in this functional disability. The association between FAM factors and disability has become evident in subjects with CLBP [36, 37, 44, 49-53, 62, 70, 74]. Nonetheless, functional disability measures can also be used to predict LDH surgical outcomes. LDH patients with higher preoperative functional disability levels seem to have worse outcomes from surgery [55, 75]. Ability to know the exact role of preoperative functional disability on a LDH surgical outcome is needed to improve patient selection for surgery. It is not clear yet if functional disability would still be a prognostic factor after accounting for other FAM factors.

Conclusion

FAM has become an accepted model to explain chronic musculoskeletal symptoms, especially in CLBP cases. Factors in this model show constant association and influence on pain intensity, functional disability, and other unfavorable outcome measures. However, most of the research that has examined FAM factors has focused on nonspecific LBP. In addition, few studies have used this model to explain worse surgical outcomes in patients with specific-LBP. There is a strong theoretical basis that this model also applies to LDH patients [37, 77].

Ability to show that physical, psychological, and social factors play an important role in some cases of failed back surgery and that this model explains postoperative outcomes for patients with specific LBP (i.e., LDH) will help improve LDH diagnostic and selection criteria. In addition, this knowledge can be valuable for both presurgical LDH conservative treatment and postoperative rehabilitation, where some cases continue experiencing persistence of pain and chronic symptoms.

Therefore, the aim of this dissertation was to explore how FAM factors (according to the measures that we used) relate to each other preoperatively for patients with LDH planned to undergo decompression surgery. More importantly, we wanted to investigate how these preoperative FAM factors (back pain, leg pain, catastrophizing, fear-avoidance, anxiety, depression, physical activity and disability) predict leg and back pain intensity, and functional disability after surgery. Our approach to acquire these goals included:

1. Conducting a systematic review to identify prospective studies that have examined any preoperative FAM factors (back and leg pain, catastrophizing, fear-avoidance, anxiety, depression, physical activity and disability) to predict LDH surgical outcomes.
2. Analyzing data of a prospective study that preoperatively assessed some of the FAM measures for LDH patients undergoing lumbar discectomy surgery. (Outcome measures included were leg pain, back pain, and functional disability.)

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CHAPTER 2

DO PREOPERATIVE FEAR AVOIDANCE MODEL FACTORS PREDICT OUTCOMES AFTER LUMBAR DISC HERNIATION SURGERY? A SYSTEMATIC REVIEW

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Abstract

Background and Purpose

Lumbar Disc Herniation (LDH) surgery is usually recommended when conservative treatments fail to manage patient's symptoms. However, many patients undergoing LDH surgery continue to report pain and disability. Preoperative psychological factors have shown to be predictive for postoperative outcomes.

Our aim was to systematically review studies that prospectively looked at the prognostic value of factors in the Fear Avoidance Model (FAM), including back pain, leg pain, catastrophizing, anxiety, fear-avoidance, depression, physical activity and disability, to predict postoperative outcomes in patients undergoing LDH surgery.

Methods

We performed a systematic literature review of prospective studies that measured any FAM factors preoperatively to predict postoperative outcomes for patients undergoing LDH surgery. Our search databases included PubMed, CINAHL, and PsycINFO. We assessed the quality of each included study using a certain list. Results related to FAM factors in the included studies were summarized.

Results

Thirteen prospective studies met our inclusion criteria. Most studies were considered high quality. Heterogeneity was present between the included studies in many aspects. Several studies included baseline pain, disability and depression FAM factors. In, general, depression, fear-avoidance behaviors, passive pain coping, and anxiety FAM

factors seem to have negative influence on LDH surgical outcome. Baseline back pain and leg pain appear to have a different prognostic value on the LDH surgical outcomes.

Conclusion

FAM factors seem to influence LDH surgical outcomes. Patients with high levels of depression, anxiety and fear-avoidance behaviors are more likely to have poor LDH outcomes. On the other hand, high levels of leg pain, but not back pain seem to be predictor for favorable LDH surgery outcome. More research is needed to determine the exact role of each FAM factor on LDH surgical outcome and the value for screening of these factors.

Introduction

Lumbar discectomy or surgery to remove a Lumbar Disk Herniation (LDH) that compresses a nerve root is usually recommended when 6 to 8 weeks of conservative treatments fail to relieve sciatica symptoms. In the U.S., Medicare spending (in 2003) on discectomy/laminectomy surgeries exceeded 300 million dollars [1]. However, long-term surgical outcomes for more than one third of the patients undergoing discectomy were not satisfactory and more than one quarter continued to have significant residual pain after surgery [2, 3]. Additionally, reoperation rate after lumbar discectomy ranges from 9% to 25% [3-5]. Careful selection and screening for prognostic factors is crucial to minimize substantial costs and unfavorable outcomes.

The Fear Avoidance Model (FAM) is composed of physical, cognitive, emotional, and behavioral constructs that have been found to be associated with future disability and pain persistence [6, 7]. Several studies have found that these factors predicted the development of Low Back Pain (LBP) as well as the transition and maintenance of chronic LBP [8-11]. According to FAM, an individual with catastrophic cognition about pain tends to interpret pain experience as threatening to his/her health and productivity. This cognitive interpretation, in turn, triggers fear and avoidance behaviors of activities that are perceived by the patient to be related to pain. As the patient continues with such maladaptive beliefs and behaviors, disuse, disability, and depression subsequently develop.

Examining the prognostic value of FAM factors has been mostly conducted in nonoperative and nonspecific LBP population. Preoperative biopsychosocial factors, in general, have been shown to be predictive of postsurgical outcomes [12-15]. Nevertheless, studies that measured specific preoperative FAM factors to predict LDH surgical-outcomes are scarce. Additionally, evidence about which FAM measures are more predictive of LDH postsurgical outcomes is not yet clear. Therefore, our aim in this systematic review was to identify prospective studies that have included FAM measures preoperatively to predict LDH postoperative outcomes and to find which FAM measures have prognostic value for surgical outcomes in this population.

Methods

We performed a systematic search in relevant databases including Medline (PubMed 1980-2012), PsycINFO (EBSCO 1980-2012), and CINAHL (EBSCO 1981-2012), and we manually searched related reviews and studies' reference lists. We used a wide range of keywords to ensure including most of the studies that pertained to our aim. In our search, we combined keywords related to back pain and/or sciatica, disc herniation, surgery to remove herniation, and FAM factors with "AND" search query (detailed search's keywords is displayed in Appendix A). We included studies if they fit our inclusion criteria (Table 2.1).

We included only full report studies with enough description of the methods to allow our review. We did not have language or sample size restrictions. Because operational procedures have changed, we limited our search to studies published after 1980.

Search and Extraction Procedure

Two independent reviewers (FA and KM) conducted the review search. The initial step included screening titles and abstracts followed by screening of the full text of potentially eligible studies. Disagreements between the two reviewers (FA and KM) about the study's eligibility were resolved by consensus in a meeting with a third reviewer (JF). Each one of the included studies was assessed for the association between the included preoperative FAM variables and the postoperative outcomes. We examined primarily multivariate analyses that were used to test FAM predictors. We considered preoperative predictors to be a measure of FAM factors if they related to back pain, leg pain, pain catastrophizing, pain coping, fear, avoidance, anxiety, functional disability, depression, or physical activity. Postoperative outcomes that we considered were pain intensity, functional disability, and ability to return to work (or a composite measure that included any one of the aforementioned outcomes).

Quality Assessment

The same two reviewers (FA and KM) assessed each included study's methodological quality using a list of criteria (Table 2.2) to evaluate prognostic studies as

Table 2.1 The systematic review inclusion criteria

Inclusion criteria
1. Prospective design (i.e., observational study or a secondary analysis of a randomized control trial-RCT).
2. Study should have included any of the FAM measures preoperatively (back pain, leg pain, pain catastrophizing, pain coping, fear, avoidance, anxiety, functional disability, depression, or physical activity) to predict postoperative pain, disability, or return to work outcome (or a composite measure that included anyone of the aforementioned outcomes).
3. All included patients were scheduled to undergo surgery to remove LDH causing symptoms related to sciatica (i.e., either discectomy or microdiscectomy).
4. LDH had to be confirmed by clinical diagnostic test (MRI, CT, or myelography) or by operative findings (i.e., bulging/protrusion, prolapse, extrusion, or sequestration).
5. All preoperative FAM measures have been taken within 6 weeks prior to surgery.
6. Follow-up outcome measures were taken at least 3 months after surgery.
7. Did not include patients with other diagnoses (e.g., stenosis, spondylolistesis, or arthritis).

Table 2.2 The quality assessment criteria

Domain	Criteria
Sample	1- Source of the sample were clearly defined
	2- Enough description of the sample
Prognostic variables	3- Clear definition and description of the used prognostic factor
	4- Measured appropriately (reliable and valid)
Follow-up	5- Completeness rate (>80%)
	6- Adequate description of the completeness
Outcome	7- Clear definition and description of the used outcomes
	8- Measured appropriately (reliable and valid)
Analysis	9- Enough description of the analysis
	10- Appropriate analysis
Confounding	11- Account for potential confounders with appropriate analysis

reported by Hayden et al. (2006) [16]. To determine agreement between reviewers for quality criteria, we calculated interrater agreement on each quality assessment criterion for each study using weighted Kappa statistics (with 95% CI).

Each criterion was given a score of two if it was satisfied in the study, one if it was partially achieved, and we gave no point if the criterion was not achieved or if it was not clear. The total possible score for each study based on these 11 criteria was 22. Studies that scored 18 or higher (>80%) were considered high quality studies, and studies with a score less than 18 were considered low quality studies.

Results

Out of 2480 citations, we screened the full text of 36 potentially eligible studies. Thirteen studies that met our inclusion criteria were included [17-29]. A flow diagram, illustrating the process of the review is presented below (Figure 2.1). A summary table of the characteristics of each included study is shown in Appendix B and Appendix C. The most common reasons for excluding studies after a full text screening were: study had a different aim and did not use appropriate analyses, study design was not prospective, or study was part of another included study.

Heterogeneity of the Included Studies

Heterogeneity was present between included studies in terms of which FAM predictor measures were evaluated, outcome measures, follow-up periods, and analyses that were used to test predictors and control for potential confounding variables. Therefore, it was not appropriate to conduct a meta-analysis. Instead, we reviewed and summarized the results of the included studies.

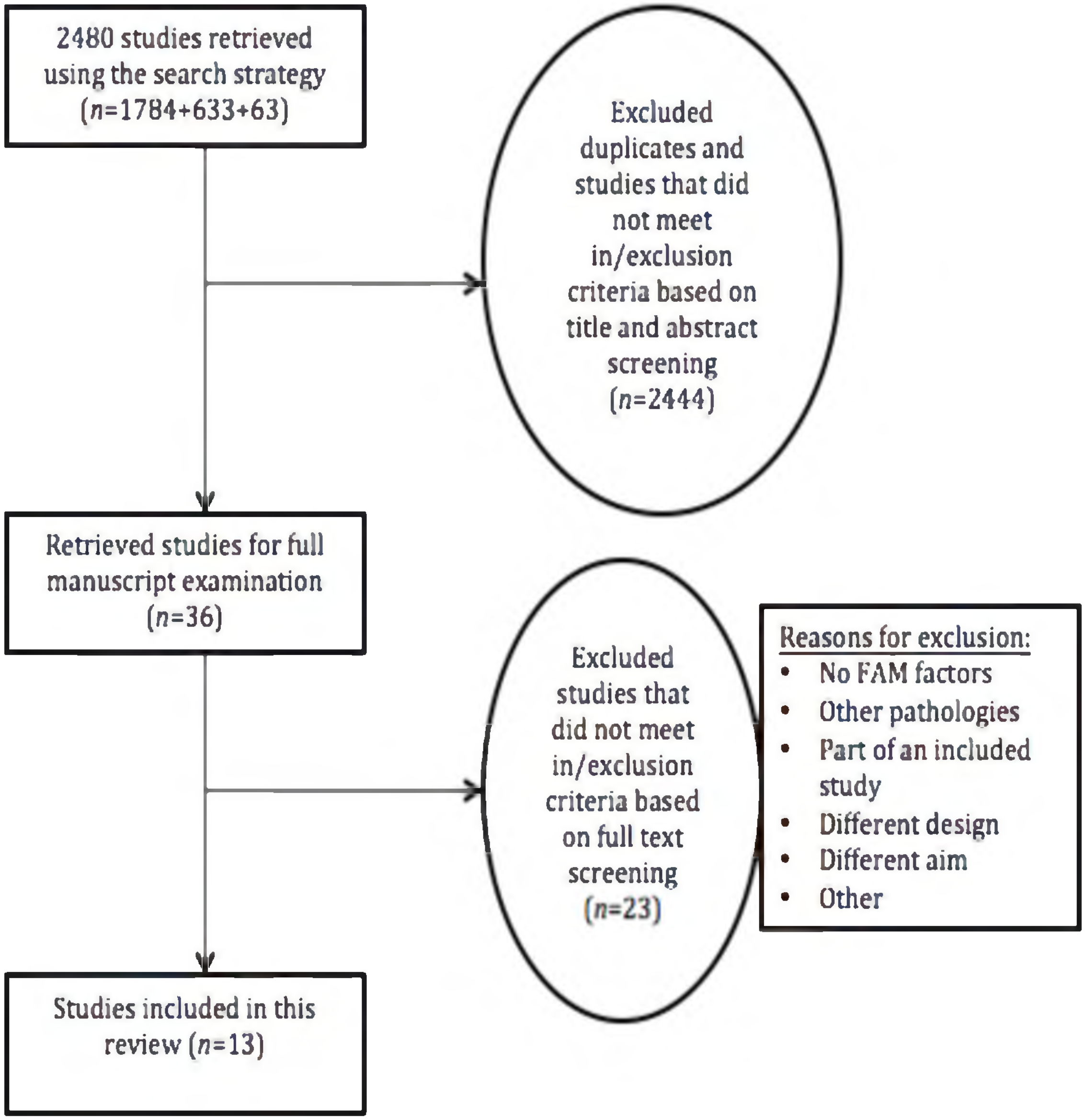

Figure 2.1 Search process flow diagram

Description of the Included Studies

All of the included studies aimed primarily to examine the predictive value of one or more FAM measures for LDH surgical outcomes. All of the studies included subjects with LDH diagnosis who were candidates for surgery to remove the herniated disc. All of the included studies took place in Europe. Sample sizes that were included in the studies ranged from 46 [21] to 342 [19] and follow-up (FU) sample sizes were over 80% in all studies except one that did not report the FU size [22]. The FU periods ranged from 6 months to 7 years in two studies [20, 27]. The surgical procedures performed in the studies were either discectomy or microdiscectomy. Although most studies used regression analyses to test prediction models of outcomes, two studies used discriminant analysis [18, 19] and one used cluster analysis [23]. Six studies had an adjustment for baseline leg pain, back pain, or functional disability in their prediction models [19, 21, 24, 27-29], while five studies had an adjustment for other potential variables [17, 20, 22, 25, 26]. One study was originally a randomized clinical trial that did not find a significant difference between the two used rehabilitation programs [26]. Another study used data that were prospectively collected on consecutive patients undergoing discectomy [29].

Quality Assessment (QA)

Out of the 143 total QA items evaluated across the included studies, the two reviewers (FA and KM) agreed on 122 items (85.3%). Overall interrater agreement of the QA between the two raters was good[30] kappa = 0.66 (p<.001), 95% CI (0.53, 0.79). Interrater agreement on the Individual QA criteria ranged from fair to very good (Kappa values, 0.20-1.00). Disagreements between the two reviewers were resolved by consensus with the third reviewer (JF). A QA table of the included studies is attached (Appendix D).

The QA score for each of the included studies ranged from 13 to 21 (out of 22). Four studies that scored lower than 18 (80%) on the QA were considered low quality studies [17, 18, 22, 23].

FAM Predictors

Different studies used different measures to capture FAM factors. Frequently used FAM measures were the McGill questionnaire and visual analog scale (VAS) for pain, the Tampa Scale for Kinesiophobia (TSK)[31] for fear-avoidance beliefs, the Roland Morris Disability Questionnaire for disability, the Zung Depression Scale (ZDS)[32], and the Beck Depression Inventory (BDI)[33] for depression.

Pain

Seven studies examined pain, of which three measured back pain and leg pain independently to predict LDH surgical outcomes [19, 27, 29]. In general, pain was always associated with LDH postoperative outcome. When used independently, however, leg pain and back pain seemed to have different prognostic values. Patients with higher baseline leg pain had better surgical outcomes [19, 27]. On the other hand, higher baseline back pain predicted worse surgical outcomes [19, 29].

Catastrophizing, Coping, Anxiety, and Fear-Avoidance

Four studies examined pain coping or pain catastrophizing, four examined anxiety, and four studies examined fear and avoidance beliefs. Half of the studies that measured pain coping preoperatively (two studies) reported association with postoperative outcomes [18, 24]. Similarly, two studies that measured anxiety have found it to be associated with LDH surgical outcomes [17, 25]. Three out of four studies that measured fear and avoidance beliefs found them to be associated with LDH surgical outcomes [19, 24, 26].

Physical Activity (PA), Disability, and Depression

Among all included studies in this systematic review, PA level was measured in only one study [26]. PA level was addressed through a question; however, this study did not report PA level to be associated with LDH surgical outcome. Functional disability, on the other hand, was examined preoperatively in five studies. Three of them found disability to be associated with surgical outcomes [19, 21, 24]. The most measured FAM factor between all of the included studies was depression. Seven out of 10 studies that measured depression preoperatively found it to be associated with LDH postoperative outcomes [17, 19, 21-23, 27, 28].

Discussion

Our aim was to systematically find and review prospective studies that included any preoperative FAM factors to predict LDH surgical outcomes. We found 13 prospective studies that fit our inclusion criteria. Most of these studies were considered high methodological quality level except four. In general, many preoperative FAM measures seem to be associated with and influence LDH postoperative outcomes. In fact, some results indicate that psychological factors may have stronger association with outcomes than biomedical factors and these findings are in agreement with previous research that have included nonoperative patients with nonspecific LBP [8, 34, 35]. Overall, LDH outcome appears to be dependent on what outcome measure was used and many of these measures appear to be related to FAM factors.

Many studies used leg pain and back pain interchangeably to predict outcomes. However, studies that evaluated these two kinds of pain separately to predict outcomes found leg pain and back pain to have different prognostic values. Patients with high leg pain but with no or minimal back pain had better outcomes. Fear and avoidance behaviors were measured in four studies, three of them found association between these FAM factors and LDH surgical outcomes. TSK was used to measure fear and avoidance beliefs in two studies. This variable (i.e., TSK) was a predictor for LDH postoperative pain [24], disability [24], and quality of life [26] outcomes. Pain catastrophizing and physical activity level were the least employed FAM measures to predict LDH surgical outcomes. On the other hand, depression was measured in 10 studies, 7 of them found baseline depression to be associated with LDH postoperative outcomes. Frequently used depression measures were ZDS and BDI.

There was clear heterogeneity of the included studies in many aspects. Studies included in this systematic review differed in the exact FAM measures employed, the statistical analyses performed, the variables adjusted for covariates in the prediction models, and the outcome measures used. Moreover, sample sizes and follow-up periods in these studies varied considerably. Therefore, the results of this systematic review should be interpreted carefully considering each individual study's predictors, outcomes, and results. Although we considered most of the related databases, one limitation of this systematic review could be that we missed potential studies in other databases. Although few studies were included in this review, this is the first systematic review that looked at the influence of FAM factors on outcome in the operative and specific LBP subgroup (i.e., LDH) population. FAM factors appear to impact surgical outcomes on patients with LDH. Future prospective studies should confirm these findings and examine the prognostic value of more FAM measures in patients with operative and specific LBP cases. Pain catastrophizing and physical activity should be examined more in future studies because they have been found to be associated with nonspecific LBP subgroup's outcome but were rarely examined in postoperative patients. Patients' selection for conservative or operative management should take into account leg pain as well as back pain, depression and fear-avoidance beliefs.

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Appendix A: The Systematic Review

Search Strategy (Keywords)

The systematic review search strategy (keywords)

- Search performed using the following keywords strategy:

    1. Studies examining LBP identified using: low back pain, backache, lumbago, "lumbar radiculopathy", sciatica, back pain, dorsalgia, and "leg pain," combined with "OR" statements.

    2. Studies related to the disc herniation identified using: Disc, bulge, protrusion, prolapse, herniation, slipped, combined with "OR" statements.

    3. Studies that included patients undergoing LDH surgery identified using: surgery, operation, operative, preoperative, postoperative, postsurgical, discectomy, microdiscectomy, combined with "OR" statements.

    4. Studies that included FAM predictors identified using: pain, catastrophizing, catastrophising, affectivity, sensitivity, anxiety, vigilance, hypervigilance, attention, fear, kinesiophobia, avoidance, depression, physical activity, disuse, deconditioning, disability, and coping, combined with "OR" statements.

All the steps were then combined with "AND"

Appendix B: Included Studies Summary Table 1 (Aim, Sittings, Sample, Follow-up, and Baseline Measures)

Study	Aim	Sittings (date, location, surgery)	Sample (size, age, gender, criteria)	Follow-up (size at FU)	Baseline pain or disability
Sorensen and Mors 1989	To test the prognostic value of social, psychological, and medical factors for postsurgical outcome.	Between January 1, 1985 to November 30, 1985 Department of Neurosurgery at the University Hospital, Aarhus, Denmark Surgical procedure: Discectomy	57 patients Neither age nor sex was reported? Inclusion criteria: surgery was indicated according to the usual principles of the department and the patient's acceptance of participation in the study. Exclusion criteria: previous operation for lumbar disk herniation and/or acute indication for operation.	6 and 24 months FU 1 died in the 24-month FU	No report of baseline measures except that (72% of the patients = VAS>50mm)

Study	Aim	Sittings (date, location, surgery)	Sample (size, age, gender, criteria)	Follow-up (size at FU)	Baseline pain or disability
Fulde et al. 1995	To investigate the predictive usefulness of defense mechanisms, coping strategies, and depression, for poor operation outcome	No dates reported Department of Neurosurgery at the Endoklinik, Hamburg, Germany Surgical procedure: discectomy	52 consecutive patients (28 men) Mean age = 41.4 (*SD* = 11.5) Inclusion Criteria: Diagnosed with LDH and undergoing surgery	6 months 48 patients (92%) completed the 6 months FU	Not reported

Study	**Aim**	**Sittings (date, location, surgery)**	**Sample (size, age, gender, criteria)**	**Follow-up (size at FU)**	**Baseline pain or disability**
A. Junge et al. 1995	To determine which of the somatic subjective symptoms, objective signs, sociodemographic, and psychological factors influence the outcome of lumbar disc surgery, and to develop screening checklist to distinguish bad and good surgery outcome.	No dates were reported 6 centers in Germany and Switzerland (Neurosurgery and orthopedic surgery departments) Surgical procedure: Standard discectomy	400 consecutive patients (19 were reoperated and excluded) 381 patients (229 men) Mean age = 44.7 (*SD* =11.2 y/o) Inclusion Criteria: Age less than 69 years, German as a native language, Indication for LDH surgery, and no previous disc or back surgery.	6 and 12 months FU 342 (89%) completed the 6 months FU 328 (86%) completed the 12 months FU	Mean pain (VAS) = 6.5 (*SD* = 2.87 BDI = 7.46 (*SD* = 5.72)

Study	Aim	Sittings (date, location, surgery)	Sample (size, age, gender, criteria)	Follow-up (size at FU)	Baseline pain or disability
Schade et al. 1999	To investigate the predictive value of three classes of variables (medical data including demographics, low-back pain history, physical findings and MRI-identified morphological abnormalities, general psychological factors and psychosocial aspects of work) for discectomy outcome.	March 1991 to Oct 1993 (original study: Boos et al. 1995) Sittings was not reported Surgical procedure: discectomy	46 consecutive patients (34 men) with a symptomatic LDH 35.2 y/o (range 20-50) (Boos et al. 1995) Inclusion Criteria: a scheduled discectomy, age 20–50 years, continued employment at the time of surgery, no previous back surgery, failed adequate trial of conservative treatment (6–8 weeks), and availability for an additional clinical and MRI examination prior to the surgery Exclusion criteria: not Swiss residentship, rapid progressive severe motor deficit or cauda equina.	2 year FU (23-30 months) 42 of the 46 patients (91.3%) completed the 2 year follow-up	Presented in bar chart

Study	**Aim**	**Sittings (date, location, surgery)**	**Sample (size, age, gender, criteria)**	**Follow-up (size at FU)**	**Baseline pain or disability**
V.GRAVER et al. 1999	To evaluate the long-term (7 years) results, and the predictive value of general background variables, psychological traits, fibrinolytic activity for surgical outcome. In addition, To reassess psychological traits and relate the findings to the long-term clinical outcome.	From August 1988 until March 1990 All operations were at the Department of Neurosurgery, Ullevaal University Hospital, Norway. Surgical procedure: discectomy	122 consecutive patients (56 women) 7-year follow-up →114 (93%) Mean age = 40.5 y/o 96 (42 women) attended the clinical evaluation (constitute the main sample in the study) 18 other patients (12 women) only mailed the questionnaire Inclusion Criteria: clinical symptoms and corresponding neuroradiological findings of nerve root compression due to lumbar disc herniation, with little or no associated osteodegenerative changes Ex criteria: other diseases of the lumbosacral spine, previous low back surgery, and over 70 y/o.	1 and 7 year (range 6- 7.5 years) follow-up 7-year follow-up →114 (93%)	LBP = 55.6 (*SD* = 24.1) LP = 61.5 (*SD* = 22.8)

Study	Aim	Sittings (date, location, surgery)	Sample (size, age, gender, criteria)	Follow-up (size at FU)	Baseline pain or disability
Kohlboek et al. 2004	To assess the prognostic power of somatic, psychologic, and social predictors for the 6-month outcome of lumbar discectomy.	Between July 2001 and February 2002 Neurosurgery Department of Salzburg, Austria Surgical procedure: microdiscectomy	58 consecutive patients Mean age = 47 years (*SD* = 11.73) Inclusion criteria: 1) clinical symptoms, corresponding neurodiagnostic findings and pain duration of more than 6 weeks; 2) no red flags (serious spinal pathology) or other diseases of the lumbosacral spine (e.g. instability, spondylolisthesis); 3) no previous back surgery; 4) German as native language; and 5) age less than 70 years. Six patients were excluded due to acute surgery, and another four patients refused to participate in this study.	6 months follow-up 48 patients (83%) (29 men) completed the 6 months follow-up	Neither preoperative pain, nor disability score were reported. Mean duration of pain was 10-weeks (*SD* = 15.12), and patients reported an average number of similar pain episodes of 3.37 (*SD* = 6.50).

Study	**Aim**	**Sittings (date, location, surgery)**	**Sample (size, age, gender, criteria)**	**Follow-up (size at FU)**	**Baseline pain or disability**
L. Arpino et al. 2004	To examine the role of depressive condition in the outcome after LDH surgery.	Between Sept 2001 and may 2002 Neurosurgery Dept. at the University of Naples Italy Surgical procedure: microdiscectomy	73 (25 women) consecutive patients Mean age of 43.5 y/o *SD* = 15.3 y Inclusion criteria (no criteria were reported but just this 2 statements): LDH candidates. Diagnosis was based on clinical and neuroradiological evaluations including lumbar spine radiography and MRI.	3 and 12 months post operatively FU sample size was not reported	Baseline pain = 6.4 (range = 1.4–10.0)

Study	Aim	Sittings (date, location, surgery)	Sample (size, age, gender, criteria)	Follow-up (size at FU)	Baseline pain or disability
Den Boer et al. 2006	To clarify the role of preoperatively assessed cognitive-behavioral factors ((i.e., pain related fear of movement/ (re) injury, passive pain coping, and negative outcome expectancies) in postop disability and pain-intensity in patients who underwent surgery for LDH.	No reported dates Four Dutch hospitals (their names reported in the study) Surgical procedure: Standard discectomy	310 patients 277 had complete data, 50% were female Mean age = 43 (range 17-77) Inclusion Criteria: First time lumbar disc surgery, age older than 16 years, failure of conservative treatment, and an ability to understand and read Dutch Exclusion criteria: co-morbidity influencing daily activities and.	6 weeks and 6 months postop 277 (89%) had complete data	VAS pain = 47.3 (*SD* = 21.6) Ronald disability = 15.3/24 (*SD* = 4.1)

Study	Aim	Sittings (date, location, surgery)	Sample (size, age, gender, criteria)	Follow-up (size at FU)	Baseline pain or disability
Silverplats et al. 2010	To examine the long term outcome of lumbar disc herniation surgery and to investigate if any demographics, psychological, social or physiological factors could predict the surgical outcome.	Between September 1996 and March 2002 Location was not reported in the study but in the author info-Sweden) Surgical procedure: discectomy or microdiscectomy	183 consecutive patients 171 patients met inclusion criteria Mean age of 39, *SD* = 11 years 76 (44%) of the patients were women Inclusion Criteria: first time surgically treated patients with a CT or MRI-verified one-level disc herniation on L4–L5 or L5–S1 level that correlated with the patients' symptoms Exclusion criteria: Patients with previous surgery on the herniated disc segment or with other spinal disorders	2 year and long follow-up (mean = 7.3, *SD* = 1.0) (Range = 5.1 – 9.3 years) 154 (90%) at 2-year follow-up 140 (81%) at long term follow-up	VAS leg pain Mean = 59, *SD* = 19 VAS back pain Mean = 50, *SD* = 23 ODI mean = 53

Study	Aim	Sittings (date, location, surgery)	Sample (size, age, gender, criteria)	Follow-up (size at FU)	Baseline pain or disability
Johansson et al. 2010	To analyze the predictive value of cognitive and behavioral factors for pain, disability and quality of life 1 year after lumbar disc surgery.	Between March 2003 and March 2005 Two orthopedic departments in Sweden, one university department (*n*=41) and one community hospital (*n*=18) Surgical procedure: Standard discectomy	Consecutive patients 59 patients met inclusion criteria Mean age = 40, *SD* = 8 y/o, 40% female In Criteria: First time lumbar disc surgery, 18 to 60 y/o, MRI-confirmed lumbar disc herniation Ex criteria: co-morbidity influencing daily activities and not being fluent in the Swedish language.	1 year 55 (93%) at 1year follow-up	Median baseline: Leg pain (0–100) = 72 Back pain (0–100) = 70 ODI-Swedish version (0-100) = 38

Study	Aim	Sittings (date, location, surgery)	Sample (size, age, gender, criteria)	Follow-up (size at FU)	Baseline pain or disability
D'Angelo et al. 2010	To evaluate anxiety and depression as prognostic factors for radicular and back pain after 1 year postop in patients with lumbar disc herniation.	Between April 2006 and November 2007 Study took place in Neurosurgery Department of "Casa Sollievo della Sofferenza" Hospital, San Giovanni Rotondo (Italy) Surgical procedure: microdiscectomy	142 patients met criteria, 108 included in the statistical analysis (64 men) Mean age=45.9, *SD* = 12.2 y/o Inclusion Criteria: LDH and persistent radicular pain with or without LBP despite nonsurgical treatment for at least 6 weeks, evidence of nerve root irritation with a positive Lasègue sign and/or a corresponding neurological deficit. Neuroradiological examination with confirmed disc herniation at a level and side corresponding to the clinical symptoms Exclusion criteria: younger than 18 years old, previous lumbar surgery, cauda equine syndrome, or other diseases of the lumbosacral spine, pregnancy, or preexisting psychiatric diseases	1, 3, 6, 12-month follow-up 108 patients completed the 12 month measures and included in the statistical analysis (64 men) 25 (17.6%) did not adhere to the psychometric evaluation during the 12-month study period and were excluded	VAS mean = 8 ZDS mean = 12

Study	Aim	Sittings (date, location, surgery)	Sample (size, age, gender, criteria)	Follow-up (size at FU)	Baseline pain or disability
Kleinstueck et al. 2011	To examine how the relative severity of LBP influences the outcome of lumbar decompression surgery for lumbar disc herniation.	Between March 2004 to April 2008 The data were taken using the framework of the Spine Society of Europe (SSE) Spine Tango Spine Surgery Registry together with the author local spine surgery outcomes database Surgical procedure: Standard discectomy	Consecutive patients 308 patients met criteria (177 men) Mean age= 48, *SD* = 13 In Criteria: The patients had to have a good understanding of written German or English or (after 2006) French, Spanish, Italian or Portuguese, have a 1-year follow-up questionnaire, and satisfy the study's surgical admission criteria (single level LDH no additional pathology, posterior decompression by means of discectomy or sequestrectomy, with no additional fusion or stabilization)	12 months 92% of patients who were sent the 12-month completed the 12 months FU "Although all 308 patients had a 12-month questionnaire, 46 of them had no baseline questionnaire due to administrative errors (*n* = 5) or because the patient was admitted on an emergency basis (*n* = 36)"	Baseline leg pain = 6.9, *SD* = 2.5 Back pain = 4.4, *SD* = 3.0 Main problem: back pain (14.6%) Leg pain (55.1%) Neurological disturbances (30.3%)

Study	Aim	Sittings (date, location, surgery)	Sample (size, age, gender, criteria)	Follow-up (size at FU)	Baseline pain or disability
Chaichana et al. 2011	1- To determine the role that preoperative depression and somatic anxiety have on long-term back and leg pain, disability, and quality of life (QOL) for patients undergoing single-level lumbar discectomy. 2- To assess whether depression and somatic measures were associated with the achievement of an MCID in all outcome measures.	No dates reported 2 medical institutions Surgical procedure: microdiscectomy	67 patients (42 men) Mean age = 41+-10 y/o Inclusion Criteria: diagnosis of sciatica or persistent LBP, failed 6-week minimum of conservative therapy, and neurological deficit. MRI-confirmed LDH corresponding with patient symptoms. Exclusion criteria: previous back surgeries, multilevel disc herniation, foraminal or extraforaminal herniation, extraspinal cause of sciatica, active medical or workers' compensation lawsuit, preexisting spinal pathology, unwilling to participate in follow-up procedures, notable nonintervertebral disc abnormalities including spondylolysis, spondylolisthesis, inflammatory arthritis, or metabolic bone disease, or chronic back pain unrelated to their recent development of LDH	3, 6, 9, and 12 months after surgery 1-year no loss to FU (*n* = 67)	Preop VAS-BP mean = 6.1, *SD* = 5.6 VAS-LP mean = 6.1, *SD* = 5.6 ODI mean = 49.9, *SD* = 17.6 ZDS mean = 18.5, *SD* = 10.6

Appendix C: Included Studies Summary Table 2 (Predictors,

Outcomes, Analysis, Results, Findings,

and Comments)

Study	Predictors	Outcome	Analysis	Results/findings-comments
Sorensen and Mors 1989	Pain (VAS) Pain drawing (rating chart) Minnesota Multiple Personality Inventory (MMPI) including Depression scale Sex Age Employed Duration of sick leave Duration of back illness Duration of education Social support Myelography and surgical findings Rahe’s and Holme’s Life events (short version)	Poor or good operation outcome Poor = state of health about the back "poor" (patients stated their health about the back as poor, fair or quite good), pain drawing on VAS >= 50, and no job function (not employed). Every operation outcome other than "'poor surgical outcome'" is defined as good surgical outcome The total surgical outcome of each patient from the 2 follow-up stated as: 2 = good outcome both 6 and 24 months postoperative. 1 = poor outcome either 6 or 24 months postoperative. 0 = poor outcome on both FU	Multiple linear regression (Variables were entered to the regression analysis one by one, and only withheld a variable if it increased the regression coefficient significantly with $p < 0.05$)	At the 24-month follow up, 25% of patients reported that there back health is “poor” In the univariate analysis, pain, pain drawing, anxiety and depression (MMPI) were found significant predictors. Main finding of the multivariate regression results were: Ad-scale (MMPI) and being employed or not, together explained 42% of the difference in surgical outcome. None of the included FAM variables were entered in the multiple regression analysis. Variables were entered to the regression analysis one by one, and only withheld a variable if it increased the regression coefficient significantly with $p < .05$

Study	Predictors	Outcome	Analysis	Results/findings-comments
Fulde et al. 1995	Beck Depression Inventory (BDI) Coping strategies questionnaire consisted of 5 scales (Avoidance of movement, other avoidance, search for social support, distraction, and nonverbal pain expression). Defense mechanism questionnaire consisted of 5 scales (renationalization, denial, turning against the object, regression, avoidance of social contact).	Poor operation outcome (All 3 criteria: use of analgesics because of pain, frequent visits to the doctor because of pain, and failure to return to work).	Stepwise discriminant analysis (5 coping items + 5 defense items + 1 depression item have been used in this analysis).	8 patients (16,7%) matched all three "poor" outcome criteria. 5 out of 6 items (regression, rationalization, avoidance of social contact, nonverbal pain expression, search for social support) correctly predicted 87.5% of the poor surgical outcome and 80% of the good surgical outcome group (2 from the coping strategies and 3 from the defense mechanisms). 39/48 (81.3%) of the patients' outcomes were correctly predicted using the 5 variables found relevant. Depression was not found to be predictive of the poor outcome. The BDI did not correlate with any other variable at baseline.

Study	Predictors	Outcome	Analysis	Results/findings-comments
A. Junge et al. 1995	Hannover mobility questionnaire (HMQ) Beck depression questionnaire (BDQ) Pain behavior (5 scales: search for social support, avoidance of movement, general avoidance, distraction/relaxing, nonverbal expression) Sociodemographic: Gender Job level Desire for disability pension Duration of reduced working ability Duration of acute back pain Intensity of LBP (VAS) Suffering from complaints Number of other pain location	12-month outcome 1- LBP >= 6 on VAS and 2- Reduced working ability of more than half a year or no return to previous job and 3- Regular visit to the treating physician or hospital stay Bad = 2 criteria if back pain was 4; or all 3 criteria	Multivariate canonical discriminate analysis of the 12-months outcome (good-bad)	At the 12-months FU, 169 (51.5%) were in the good outcome group, 93 (28.4%) in the moderate outcome group, and 66 (20.1%) in the bad outcome group No significance differences in outcome between 6 and 12 months FU About 80% of the patients were classified correctly by the statistical model Pain history (physical mobility, duration of reduced working ability and of acute back pain, intensity of LBP, suffering from complaints, number of other pain location contributed to correct outcome 73.8% Psychodiagnostic parameters (search for social support, avoidance of movement, distraction, other pain behavior and depression) contributed to correct outcome 62.9% Medical parameters (pain radiation to leg, additional back Dx, imaging finding, and SLR) contributed to correct outcome 57.7%

	Predictors (Continuous)	**Outcome** (Continuous)	**Analysis** (Continuous)	**Results/findings-comments** (Continuous)
A. Junge et al. 1995	Pain radiation to leg Additional back Diagnoses Imaging finding SLR	Moderate = one of the criteria above; or 2 if LBP is between 0 and 3 Good outcome = none of the abovementio ned criteria		The strongest predictors were physical mobility (HQM), number of pain location in the body before surgery, duration of reduced working ability, duration of acute back pain, and suffering from complaints (VAS). Low job level, HPQ (search for social support), and intensity of acute back pain were also predictive of bad outcome. The study found that patients with no reduced mobility, no back pain, and no other painful spots in the body but with disabling leg pain with radicular tension signs and differences in jerk reflexes and/or muscular palsy had the best surgical outcome. Those with long-lasting preoperative working disability, primary back pain, other painful sources in the body, and low job level and low education level were found more likely to have bad surgery outcome. Depression and pain behavior are important predictors if the postoperative outcome was only pain. However, psychological factors lost their importance when all 3-outcome criteria considered.

Study	Predictors	Outcome	Analysis	Results/findings-comments
Schade et al. 1999	Medical data (including demographics, LBP history, physical findings, MRI-identified morphological abnormalities) Psychological general well-being index (Depression, Anxiety, self-control, well-being, general health, and vitality) Psychosocial factors (Job satisfaction and social support Preoperative pain (McGill pain questionnaire, VAS) (Control variable) Preoperative disability (RMDQ) (Control variable)	Low Postop pain (VAS) Disability (Ronald Morris) Return to work (Time in months) Surgical outcome (4 items about pain, work, medication, and physical limitations)	Stepwise multiple regression analyses performed separately for each of the three variable sets (medical data, general psychological factors and psychosocial aspects of work). Then the significant variables of the three categories were combined in an overall regression model with 'preoperative pain and/or preoperative disability in daily activities' entered first in the regression model. Then, medical data were entered followed by general psychological variables, and work-	The final regression model to predict pain relief demonstrated MRI identified neural compromise (.28, $p < .1$) and social support by the spouse (-.39, p < .01) (and control variable preop pain, -.42, $p < .01$) as significant predictors of pain relief at 2 year follow-up (adj $R^2 = .3$, $p < .01$). The final regression model to predict disability showed that MRI-identified neural compromise (-.44, $p < .05$) and work-related resignation (.4, $p < .001$) (and control variable preop disability, .39, $p < .05$) were significant predictors of subjective disability at 2 year follow-up (adj $R^2 = .46$, $p < .0001$). The final regression model to predict return to work showed that depression (.43, $p <$,01) and occupational mental stress (.28, $p < .01$) (and control variable preop pain disability, .35, $p < .05$) were significant predictors of return to work at 2-year follow-up (adj $R^2 = .31$, $p < .001$). The final regression model to predict surgical outcome showed that the extent of herniation (.48, $p < .001$) and depression (-.46, $p < .001$) (and control variable preop pain/disability, -.46, $p < .01$) were significant predictors of a good result after lumbar discectomy.

	Predictors (Continuous)	**Outcome** (Continuous)	**Analysis** (Continuous)	**Results/findings-comments** (Continuous)
Schade et al. 1999			related psychosocial factors.	Among all FAM factors in this study, preoperative pain, disability, and depression showed significant prediction of postop pain, disability, or RTW.

Study	Predictors	Outcome	Analysis	Results/findings-comments
V.Graver et al. 1999	Psychological traits: Modified Somatic Perception Questionnaire (MSPQ) and Hospital Anxiety and Depression Scale (HAD) Fibrinolytic activity Perioperative variables (One vs. two operated discs) (Partial vs. full laminectomy Background variables were controlled for (age, BMI, smoking, and alcohol consumption)	Clinical overall score (COS): from 96 patients, preop and 1 year postop: 1-pain (average VAS) 2-physical signs (e.g., SLR) 3-functional (ODI) 4-type and dosage of analgesics registered Low back pain (VAS) Leg pain (VAS)	Four multivariate regression analyses: 7-year outcome (COS, LBP, and leg pain) Controlling for background variables (age, BMI, smoking, and alcohol consumption)	Gender (being female) significantly predicted poor COS, low back and leg pain MSPQ, but not HAD, was significantly predictive of COS, low back and leg pain The 7-year outcome was worse than the 1-year outcome for leg pain, back pain and disability and just back pain was significantly worse. The 7-year psychometrical scores were significantly associated with the 7-year COS, HAD-anxiety ($F = 24.80$, $p < .001$, $R^2 = 0.21$), HAD-depression ($F = 31.79$, $p < .001$, $R^2 = 0.26$) and MSPQ ($F = 49.89$, $p < .001$, $R^2 = 0.35$). 6% had reoperation, 23% did not RTW, and 12% were partially satisfied or not satisfied 7 years postop

Study	Predictors	Outcome	Analysis	Results/findings-comments
Kohlboek et al. 2004	Medical factors (SLR, duration of pain, and radicular distribution of pain) Psychological factors: 1-Pain (NPRS from 1 to 7) 2-Depression (ADS-L) 3-pain interference with ADL Pain disability index (PDI) 4-Qualitative assessment of pain (McGill pain Q) 5-Job strain (1-10). 6-Coping strategies (KSI) Sociodemographic variables: (educational and social status, occupational characteristics, and duration of inability to work)	Pain maintenance: (one question about current pain; yes/ no) Number of pain location (11 body regions) Pain intensity (NPRS 1-10) Functional status (Hannover Mobility Questionnaire (HQM) Return to work (Y/N) Health-Related Quality of life (MOS SF-36)	The six outcome criteria were classified into one outcome variable by hierarchical cluster analysis (Ward' s method)	6 months postop outcome clustering yields 3 groups (success-14 patients, socially unintegrated-14 patients, and poor outcome group-21 patients) 44% (21) of the patients did not benefit from surgery when subjective outcome criteria were considered. This group had 5/10 NPRS 6 months postop. SLR (the only significant one among medical factors), depression and sensory pain description (from the psychological variables) were significant in predicting the 6 months outcome group and all together classified 83% of outcome group. Depression was the most important predictor among the psychological measures. The greater the degree of preoperative depression, the worse the 6-month postoperative outcome. The combination of medical, psychological, and social variables yielded the best prediction of the outcome classification. SLR correctly classified 40% of outcome group Depression correctly classified 48% of outcome group.

Study	Predictors	Outcome	Analysis	Results/findings-comments
L. Arpino et al. 2004	Depression (ZDS) Age, sex, level of disc herniation were controlled for	Pain (VAS) at 12 months	Multiple regression analysis	No sig differences in outcome between 6 and 12 FU. Depression was the only significant predictor (none of the controls) for the 12 months postop pain ($t = 7.120$, $p < .001$). About half of the patients (36) were depressed (ZDS >= 35) preoperatively. 4 patients developed depression 3 and 12 months after surgery. 28/36 of the patients stayed depressed pre- and 12 months postoperatively. After controlling of patients with absolute depression, patients with relevant depressive Symptoms ($n = 4$) had higher VAS at baseline ($F = 6.7$, $p < 0.02$), 3 ($F = 179.6$, $p < .001$), and 12 months postoperatively ($F = 219.2$; $p < .001$). (ANOVA analysis).

Study	Predictors	Outcome	Analysis	Results/findings-comments
Den Boer et al. 2006	Entered in the 3rd step in regression: Fear of movement (TSK-AV-adjusted version) taken 1 day preop) Passive pain coping (PCI taken 1 day preop) Negative expectancy (4 item-scale taken 1 day preop) Adjusted variables were entered in the 1st step in regression: Disability (RDQ) – Dutch version Preop Pain (VAS) Demographics (age, gender, education level) Entered in the 2nd step in regression:	Disability (RDQ) Pain (VAS)	Multiple regression analyses were used to study the contribution of cognitive-behavioral factors, after controlling for preop disability, preop pain, age, gender, and educational level (entered at step 1) and pain 3 days postop (entered at step 2).	Improvement after surgery was less obvious 6 months than 6 weeks. Significant difference in disability but not pain. 6 months postop, 31% of the patients still experienced high level of disability (RDQ >= 8/24) and 25% of severe pain (VAS >= 30/100). Independent predictors of high disability at 6 weeks and 6 months postop were negative outcome expectancies (t = 2.62, $p < .01$; t = 3.25, $p < .01$), more pain-related fear of movement/(re) injury (t = 3.15, $p < .01$; t = 3.14, $p < .01$), and passive pain-coping strategies (t = 2.4, $p <.05$; t = 3.49, $p< .01$). Independent predictors of higher pain at 6 weeks and 6 months postop were more negative outcome expectancies (t = 3.16, $p < .01$, t = 4.05, $p < .001$), more pain-related fear of movement/(re) injury (t = 2.92, $p < .01$; t = 2.07, $p < .05$), and passive pain-coping (t = 2.19, $p < .05$; t = 2.62, $p < .01$). Higher levels of preop disability, preop pain, pain 3 days postop, negative outcome expectancies, fear of movement, passive pain-coping, older age, female gender, and lower level of significantly predicted more disability at follow-up assessment.

	Predictors (Continuous)	**Outcome** (Continuous)	**Analysis** (Continuous)	**Results/findings-comments** (Continuous)
Den Boer et al. 2006	3-day postop pain (VAS)			3-day postop pain (control variable) significantly predicted both pain and disability 6 weeks and 6 months postoperatively. Higher levels of preop pain, pain 3 days postop, more preop neurological deficits, negative outcome expectancies, fear of movement, older age, and female gender, significantly predicted more pain intensity at follow-up assessment (6 weeks or 6 months). Pain-coping strategies predicted 6-month disability but not future pain.

Study	Predictors	Outcome	Analysis	Results/findings-comments
Silverplats et al. 2010	Baseline back pain (VAS) Baseline leg pain (VAS) Duration of leg pain Baseline depression (ZDS) Baseline disability (ODI) Gender, Age, Smoking habits, Level of disc hernia, Use of analgesics, Time on sick leave	Satisfaction with surgical treatment (primary dichotomized outcome) Macnab postop classification (excellent/good or fair/poor) at 2 year F/U (primary dichotomized outcome) Change in back pain, change in leg pain, working capacity, analgesics, sleeping pills (secondary outcomes at 2-year FU)	Logistic regression with all predictors that showed a potential influence in the bivariate analyses (i.e. predictors that showed a $p < 0.20$). Logistic regression models were also analyzed with a forward (likelihood ratio) stepwise selection procedure, aiming at finding the most influential predictor.	16 patients had undergone at least one re-operation on the lumbar spine. 33% had fair or poor on the primary on the primary objective outcome (2 year postop) 33% (2-year FU) 28% (7 year FU) were partially or not satisfied with surgical outcome. Higher baseline leg pain was the only significant predictor of the improvement in postop leg pain ($p < 0.039$). Depression was the only significant predictor of the improvement in back pain ($p < 0.049$). The main finding of the study, and the predictor of the primary and many of the secondary outcomes, was length of sick leave. Sick leave correlated with duration of leg pain, which might gave nonsignificant results for duration of leg pain. Neither baseline back pain nor baseline disability was significant predictors of any of the surgical outcome.

Study	Predictors	Outcome	Analysis	Results/findings-comments
Johansson et al. 2010	Leg and back pain (VAS) Fear avoidance behavior (TSK) Coping/catastrophizing (CSQ) Expectation to return to work 3 months after surgery Age, gender, educational level, sick leave, work load, physical activity level, and duration of current leg and back pain	Leg and back pain (VAS) Disability (ODI) Quality of life (EQ-5D) Sick leave	Multiple backward logistic regression to examine prognostic of preop fear-avoidance, coping, and expectation to RTW to dependent variables (pain, disability, and QOL). Subsequent Multiple Logistic regression analysis included independent variables that fulfilled the multicollinearity restriction (correlation coefficient $r < 0.4$) and had p-value of < 0.1 in the first regression analysis. Variables entered in the final regression model were age, gender, work load, duration of leg pain, coping catastrophising, fear avoidance beliefs and expectations of chance to RTW within 3 months after surgery. Age, gender, educational level, workload, leg pain, and rehabilitation group were controlled for.	9 (16%) patients remained on sick leave 12 months postop. The strongest predictor for low quality of life 12 months after surgery was high scores of fear avoidance beliefs (OR = 6.6, $p < 0.027$). Fear avoidance was not included as predictor of other outcomes. Other FAM variables did not reach significance. The main finding was that expectation to return to work within 3 months postop (one question: In your estimation, what are the chances that you will be working in 3 months?) was significant predictor for all outcomes. Female was predictor of worse QOL after 1 year LDH surgery (OR = 6, p <0.03).

Study	Predictors	Outcome	Analysis	Results/findings-comments
D'Angelo et al. 2010	State (y1) and Trait (y2) Anxiety Inventory (STAI) Depression (ZDS) (All variables with $p < .10$ at univariate analysis were entered in the multiple linear regression)	Pain (VAS)	Multiple linear regression analysis The variables with $p < .10$ from the univariate analysis were entered in the multiple linear regression analysis	12 months postop, 38 (35%) reported only radicular leg pain, and 25 (23%) reported both radicular leg and back pain. In the univariate analysis, the presence of preoperative pain was significantly correlated with state anxiety ($p < .0001$), trait anxiety ($p < .0001$), and inability to work ($p < .0001$). From the regression analysis, preop trait anxiety was the main predictor of the severity of pain (VAS score) both before ($p < .001$) and after surgery ($p < .001$). 59 (54.6%) of patients showed trait anxiety before surgery, and 12 (11,1%) showed depression. A significant increase ($p < .004$) in current depression (ZDS > 49/80) was found before and 12 months after surgery; From 12 (11%) to 25 (23%). Depression was present in patients showing trait anxiety and persistent pain after surgery. The persistence of pain during the follow-up was significantly associated with the presence of pain at each previous follow-up. (Regression analysis result).

Study	**Predictors**	**Outcome**	**Analysis**	**Results/findings-comments**
Kleinstueck et al. 2011	Entered in the 2nd step in regression: LP LBP LP-LBP (LP intensity minus the preoperative LBP intensity) (Leg/buttock and back pain intensity, each measured separately on a 0–10 graphic rating scale) Adjusted variables were entered in the 1st step in regression: Age, Gender, Comorbidity, Multidimensional Core Outcome Measures Index (COMI) questionnaire: questions about pain (leg/buttock and back pain intensity measured with 0-10 graphic rating scale), function, symptom specific well-being, general quality of life, and social and work disability.	COMI Question about global outcome (GO) of surgery "how much did the operation help your back problem?" (5-likert scale dichotomized into Good or poor)	Multivariate stepwise regression analysis was used to predict the 12-month postop COMI score. The preop COMI score, age, gender, and comorbidity were entered in the first step (adjusted variables), and in the 2nd step: preop LP, LBP and LP-LBP (as potential predictors, using forward selection). Multivariate stepwise logistic regression analysis to predict the 12-month postop GO of surgery (good or poor). The baseline age, gender, and comorbidity were entered in the first step (adjusted variables), and in the 2nd step: preop LP, LBP and LP-LBP (as potential predictors, using forward selection).	12 months dichotomized GO→ 249/308 (81.1%) patients had a ''good'' outcome, and 58/308 (18.9%) had a ''poor'' outcome. In the multiple regression, After controlling of age, gender, comorbidity, and COMI, preop LBP were the most significant predictor of the 12-month COMI score ($b = 0.204$, $p = .001$). Higher preop LBP predicted worse outcome (i.e., COMI). In the multiple logistic regression, After controlling of age, gender, comorbidity, and COMI, baseline LBP was the only significant predictor of the 12-month the global outcome (OR = 0.821, $p < .004$). Higher preop LBP predicted worse outcome (i.e., less chance of getting good outcome).

Study	Predictors	Outcome	Analysis	Results/findings-comments
Chaichana et al. 2011	Depression (ZDS) Somatization (MSPQ) (Controlling for patient age, weight, and preoperative VAS-BP, VAS-LP, ODI, or SF-36 PCS score)	VAS-BP VAS-LP ODI SF-36 PCS (QOL) MCID for each outcome	Regression analysis to predict the 1-year outcome. Multiple linear regression analysis to examine the relationship between preoperative ZDS and MSPQ scores and the 12-month improvement in VAS-BP, VAS-LP, ODI, and SF-36 PCS scores. (Controlling for patient age, weight, and preoperative VAS-BP, VAS-LP, ODI, or SF-36 PCS score). Logistic regression analysis to examine the relationship between preoperative ZDS and MSPQ scores and the 12-month improvement in VAS-BP, VAS-LP, ODI, and SF-36 PCS that achieved the MCID. (Controlling for patient age, weight, and preoperative VAS-BP, VAS-LP, ODI, or SF-36 PCS score).	10% (7 patients) were depressed preop (ZDS>33) In the multivariate linear regression analysis, increase in preop ZDS score or MSPQ were associated with less improvement in VAS-BP score ($p = .02$, $p = .005$), less improvement in VAS-LP score ($p = .03$, $p = .001$), less improvement in ODI score ($p < .001$, $p = .001$), and less improvement in SF-36 PCS score ($p < .001$, $p = .001$). In the multivariate logistic regression analysis, each 1-point increase in preop ZDS score or MSPQ were associated with (12%, 21%) and (11%, 13%) less likelihood of achieving an MCID in ODI ($p = .006$, $p = .002$) and SF-36 PCS ($p = .04$, $p = .03$) at 1 year postoperatively, respectively. Neither the preop ZDS nor MSPQ were significant predictors of failure to reach an MCID in the VAS-BP ($p = 0.85$, $p =.77$) or VAS-LP ($p = .96$, $p =.64$) score. The results suggest that depression and somatic awareness may not impact the amount of pain relief reported after discectomy, but rather impacted QOL and functional disability in the LDH patients.

Appendix D: Quality Assessment Table

Study	Sample		Prognostic factors		Follow-up	
	Source of sample clearly defined	Enough description of the sample	Clear definition/description of the used prognostic factor	Measured appropriately (reliability, validity)	Completeness rate (>80%)	Adequate description of completeness
Fulde et al. 1995	P	P	Y	Y	Y	N
A. Junge et al. 1995	P	Y	Y	Y	Y	Y
Schade et al. 1999	P	Y	Y	Y	Y	N
V.GRAVER et al. 1999	Y	Y	Y	Y	Y	Y
Kohlboek et al. 2004	Y	Y	P	Y	Y	N
L.Arpino et al. 2004	Y	P	Y	Y	N	N
Den Boer et al. 2006	P	Y	Y	Y	Y	Y
Silverplats et al. 2010	P	Y	Y	Y	Y	N
JOHANSSON et al. 2010 (A)	Y	Y	Y	Y	Y	Y
D'Angelo et al. 2010	Y	Y	Y	Y	Y	P
Kleinstueck et al. 2011	Y	Y	Y	P	Y	N
Chaichana et al. 2011	P	Y	Y	Y	Y	Y
Sorensen and Mors 1989	Y	P	P	Y	Y	Y

Study	Outcome		Analysis			Score out of (22) Y=2, P=1, N=0
	Clear definition/description of the used outcome	Measured appropriately (reliability, validity)	Enough description	Appropriate analysis	Account for confounding with appropriate analysis	
Fulde et al. 1995	Y	N	P	Y	N	13
A. Junge et al. 1995	Y	N	Y	Y	Y	19
Schade et al. 1999	Y	Y	Y	Y	Y	19
V.GRAVER et al. 1999	Y	P	P	Y	P	19
Kohlboek et al. 2004	Y	P	P	P	Not clear	14
L.Arpino et al. 2004	Y	Y	P	Y	P	15
Den Boer et al. 2006	Y	Y	Y	Y	Y	21
Silverplats et al. 2010	Y	Y	Y	Y	Y	19
JOHANSSON et al. 2010	Y	Y	P	Y	P	20
D'Angelo et al. 2010	Y	Y	P	Y	P	19
Kleinstueck et al. 2011	Y	Y	Y	Y	Y	19
Chaichana et al. 2011	Y	Y	Y	Y	Y	21
Sorensen and Mors 1989	Y	N	Y	P	P	16

CHAPTER 3

EXAMINING THE FEAR-AVOIDANCE MODEL IN PATIENTS SCHEDULED TO UNDERGO LUMBAR DISC HERNIATION SURGERY: A SECONDARY ANALYSIS OF A PROSPECTIVE STUDY

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Abstract

Background and Purpose

Although the prognosis of sciatica and Lumbar Disc Herniation (LDH) patients is favorable for the most part, some patients continue to report pain and persistence of symptoms even after discectomy surgery. The Fear Avoidance Model (FAM) has been shown to be associated with chronic pain and disability mostly in nonoperative and non-specific low back pain (LBP) individuals. Therefore, our aim was to examine the relationship between specific preoperative FAM variables in LDH patients scheduled to undergo discectomy surgery. In addition, we want to assess the prognostic value of these FAM variables for predicting the 10-week outcomes following discectomy surgery.

Methods

This is a secondary analysis of a prospective study with 61 subjects scheduled to undergo first time discectomy surgery. Baseline relationships between FAM measures including: leg pain, back pain, pain catastrophizing, fear avoidance beliefs, depression, functional disability, and physical activity level were assessed preoperatively. Multilevel regression analyses were used to examine the predictive value of the preoperative FAM variables for the outcomes of the 10-week leg pain, back pain, and disability, after controlling for age, gender, and patients' surgical expectations.

Results

Many of the included FAM measures were associated at baseline with disability and pain. In addition, depression and work-related fear and avoidance beliefs were

significant predictors of the 10-week LDH postsurgical leg pain, back pain and functional disability.

Conclusion

FAM factors seem to play a similar role in patients who have undergone surgery for LDH as has been identified in nonspecific and nonoperative LBP population. Screening for these factors in LDH patients and managing them accordingly may improve outcomes.

Introduction

Patients with sciatica, potentially due to lumbar disc herniation (LDH), have in general good prognosis regardless of management type. However, persistence of pain and chronic symptoms developed in 10% to 40% of the LDH patients [1]. Sciatica and LDH diagnoses are often regarded as a specific low back pain (LBP) subgroup. This classification gives the impression that this subgroup has one exact reason for the pain and/or other symptoms (in this case, usually disc compression on nerve root), and recovery will result from removing this cause. Surgical procedures to remove the disc herniation are often used when conservative management fails to relieve the patient's pain. However, other elements need to be considered when dealing with sciatica patients.

Psychosocial factors were found to be associated with poor outcomes and persistence of pain in operative and nonoperative LDH patients [2-7]. The Fear Avoidance Model (FAM) is one of the common models in LBP that describes how psychological factors play a role in persistence of pain and disability [8]. The FAM includes certain cognitive, behavioral, physical, and emotional factors that have been found to be associated with chronic LBP [9]. However, most of the research that has examined FAM factors studied chronicity in nonspecific and nonoperative populations [9]. Current evidence indicates that FAM factors may have a similar impact on specific LBP subgroup and can be used to predict unfavorable surgical outcomes [7, 9-12].

Preoperative pain, pain-related fear, avoidance and maladaptive behaviors, anxiety, depression, and functional disability are among the FAM factors that have been examined in previous studies to predict LDH surgical outcomes. Jung et al. (1995) examined a number of medical and psychological measures in patients undergoing discectomy surgery [6]. Results found that preoperative back pain, depression, maladaptive pain behaviors, and baseline functional disability predicted unfavorable surgical outcomes. Likewise, Den Boer et al. (2006) found that baseline cognitive and behavioral factors were associated with both 6 weeks and 6 months discectomy surgical outcomes [13]. After controlling for potential confounders, their multiple regression analyses revealed that higher levels of preoperative pain, pain related-fear, functional disability, and passive pain-coping behavior predicted LDH postoperative pain and disability.

Although preoperative FAM factors seem to have an impact on outcomes in patients undergoing LDH surgery, a number of important FAM factors and measures have not been studied adequately in this subgroup of patients. Pain catastrophizing and physical activity level are two FAM factors that have been associated with chronic non-specific LBP and disability but needed to be examined more in patients undergoing LDH surgery [14-16]. Moreover, the Fear Avoidance Beliefs Questionnaire (FABQ) is an important FAM measure that has been shown repeatedly to be associated with the transition to chronic LBP and disability mostly in nonspecific LBP cases [17-19]. However, the FABQ has not been adequately examined as a predictor of chronicity in patients undergoing LDH surgery. Therefore, the aim in this analysis was to examine specific preoperative FAM measures and evaluate their association with leg pain, back pain, and disability outcome following surgery for LDH.

Methods

Participants and Study Design

This was a secondary analysis of a randomized control trial comparing two rehabilitation programs after discectomy surgery [20]. Patients between 18 and 65 years old with confirmed LDH by CT or MRI were included in the study. All patients had to be scheduled to undergo first time one-level discectomy to remove the herniated disc. Subjects were excluded from the original study if they had medical co-morbidities or conditions that prevented them from participation in an exercise program.

Recruitment of the participants took place between April, 2009 and July, 2012 from orthopedic and neurologic surgeon offices located in Salt Lake City, Utah. Baseline measures were taken within 2 weeks before the surgery. After 2 weeks following the surgery, subjects were randomized to one of two 8-week rehabilitation programs (general stabilization or specific motor control exercises). Both programs included aerobic and general trunk strengthening exercises. In addition to these exercises, one group performed specific motor control exercises in the first 2 to 3 weeks of the rehabilitation program. Specific exercises were implemented to train individuals to control the action of their lumbar multifidus and transverse abdominis muscles. Both groups received the same education on best care and equal time of exercising. After 10 weeks following the surgery, a “blind” examiner assessed the outcome measures. The original study did not find statistical significant differences in the clinical outcomes between the two postoperative rehabilitation programs after the surgery [20].

Baseline Measures (predictor)

Within 2 weeks before surgery, the patients' demographics were recorded (including information about age, BMI, and gender). Patients were asked to rate their expectation about surgery from completely agree to completely disagree that "surgery will help" using a 5-point Likert-type scale. Patients also completed several self-report measures related to FAM. Details about examined FAM measures in the study are provided below.

Leg and low back pain severity were assessed using a separate Numeric Pain Rating Scale (NPRS), commonly used to rate musculoskeletal pain. Patients rated their leg and back pain on an 11-point scale from zero (no pain) to 10 (worst imaginable pain). Pain measures were taken for current, best, and worst pain in the past 24 hours. The three scores were then averaged to represent each patient's average pain. NPRS has been shown to be reliable, valid, and responsive for individuals with LBP and for postoperative population [21, 22].

Pain catastrophizing was measured using the 13-item Pain Catastrophizing Scale (PCS)[23]. Each item asks about negative thoughts and feeling related to pain (e.g., "It's terrible and I think it's never going to get any better") and is rated from zero (not at all) to 4 (all the time). This scale captures three different components of pain catastrophizing (helplessness, rumination, and magnification). The PCS is a valid and reliable measure for both genders and different ages [24-28]. The PCS has also been found to be an important risk factor of persistent postoperative pain [29-31].

Fear-avoidance beliefs were measured using the Fear Avoidance Beliefs Questionnaire (FABQ)[17]. This widely used measure of pain-related fear and consequent avoidance assesses the impact of the injury on beliefs and behaviors. The questionnaire is composed of two subscales; one measures the potential influence of fear-avoidance beliefs on general physical activity (four statements) and one on work-related activity (seven statements). Each statement (e.g., “My work may harm my back”) has seven ratings, from (completely disagree) to (completely agree). FABQ has been found to have appropriate psychometric properties and to be an important predictor of the transition from acute to chronic LBP [19, 32].

Depression was measured with the Beck Depression Inventory II (BDI) [33]. The BDI is a self-report inventory with 21 questions that measure depression symptoms. Each answer is scored from 0 to 3 giving a total possible score of 63. According to the BDI-II manual, a total score of 0 to 13 represents no depression; 14 to 19, mild depression; 20 to 28, moderate depression; and, more than 28 represents severe depression symptoms. The BDI has good psychometric prosperities and has been shown to have good predictive validity in patients with chronic pain [34, 35].

Physical activity (PA) level was measured using the short form of the International Physical Activity Questionnaire (IPAQ)[36]. IPAQ is a self-report questionnaire that asks questions about the activity level in the last 7 days. Questions ask about walking as well as moderate and vigorous physical activities. Individuals are classified according to their answers into one of three categories (low, moderate, or high activity level group). This PA measure has acceptable psychometric properties and has been translated to many languages [36]. In this study, we dichotomized PA level into active (high or moderate activity level group) or inactive (low activity level group).

Functional disability was measured using the modified Oswestry Disability Questionnaire (ODI) [37, 38]. The ODI is composed of 10 questions that rate functional disability in different activities during the day. Each answer is scored from 0 to 5. Higher scores indicate greater disability. The ODI has been shown to be valid, reliable and has a high level of responsiveness [38, 39].

Outcome Measures

At the 10th postoperative week follow-up, leg pain, back pain, and disability were assessed with the same baseline measures (i.e., NPRS and ODI).

Statistical Analysis

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS 20.0, Chicago, IL). We screened the data for deviation from normality and linearity. Overall, most measures appear to be normally distributed and the predictors seem to have linear relationships with the outcomes. To summarize and describe the sample, descriptive statistics of the demographics, baseline FAM variables, and the 10-week outcomes were performed. These included mean and standard deviation (*SD*) or frequency counts for categorical data (e.g., gender).

To examine the bivariate relationships among baseline FAM variables as well as between baseline FAM variables and the 10-week outcomes, the Pearson product-moment correlation coefficient (r) was used. Subsequent partial correlation analysis, adjusting for age and gender, were performed to assess and control for the potential influence of these two variables.

Hierarchical multiple regression analyses were conducted to examine the prognostic value of FAM variables for the 10-week postoperative outcomes (leg pain (NPRS), back pain (NPRS), and disability (ODI)) after controlling for potential confounding variables (age, gender, and surgery expectation). The control variables were entered in the first step and the FAM variables were entered in the second step. Each hierarchical regression analysis was followed by a stepwise multiple regression analysis to study the most influential FAM variables. The stepwise regression analyses were adjusted for age, gender, and surgical expectation (entered in the first step).

To examine for potential multicollinearity problem (i.e., insufficient unique variance due to high correlation between predictors), we assessed the variance inflation factors (VIF). Any VIF value over 5 [40] or 10 [41] may indicate a multicollinearity problem. All VIFs' values in this analysis were under 3.0.

In this study, we included 61 patients at baseline and of those 61 patients, 55 had complete 10-week postoperative outcomes. This yielded more than five events per each of the eight examined variables. It has been shown that five events per variable (EPV) are enough to avoid overfitting and to produce similar results as compared to the strict 10 EPV rule [42]. In, addition, we had 80% power to detect a correlation (r) of 0.4 with only 46 cases in a two-tailed test at a significance level of 0.05 (calculated from G.power software [43]).

All analyses were based on two-tailed *p*-value tests and the significance level was set at (0.05). Listwise (in partial correlation and regression analyses) and pairwise deletion (in bivariate correlation analysis) were used in the case of missing values.

Results

Surgical Procedure

All patients underwent open discectomy (except one patient who had minimally invasive endoscopic discectomy). Thirty-nine patients (64%) had their surgery at the L5-S1 level, 15 (25%) at the L4-5 level, and 4 patients (7%) at the L3-4 level.

Patients' Baseline Characteristics

Baseline measures were available for 61 patients (30 males, 49%). Descriptive statistics of FAM measures are displayed in Table 3.1. Patients' age ranged from 21 to 56 years old (M = 40.4, SD = 9.4), BMI from 19.6 to 48.7 (M = 29.5, SD = 6.9). Average duration of symptoms since the last episode was 194 days (SD = 191). Baseline means of leg pain (M = 5.56, SD = 2.5), back pain (M = 4.24, SD = 2.5), and functional disability (ODI) ranged from 16 to 86 (M = 43.47, SD = 15.3). All of which were typical of patients scheduled for discectomy surgery.

Fourteen patients (23%) had clinically relevant levels of catastrophizing [23] (PCS>30). According to BDI[44], 44 (72%) of the patients had no depression symptoms, 9 (15%) had mild depression (BDI = 14-19), 4 (6.6%) had moderate depression (BDI = 20-28), and 3 (5%) had severe depression (BDI>28). Ten (16.4%) patients scored above 29 on the FABQ-work subscale (previously reported cut-off [45, 46]) and 42 (68%) patients scored above 14 on the FABQ-physical activity subscale (cut-off score [47, 48]). Baseline IPAQ classified patients into three activity level groups (35 patients into low, 11 into moderate, and 12 into high activity level group). When asked to rate their expectation of surgery, the majority of patients either somewhat agreed (n = 14) or completely agreed (n = 42) that surgery would help.

Table 3.1. FAM baseline measures mean (and standard deviation)

Measure	Mean (SD)
FABQ- PA scale	17.5 (6.1)
FABQ- work scale	17.5 (11.7)
PCS	19.3 (11.0)
BDI	10.5 (7.9)

The 10-week postoperative outcomes (leg pain, back pain, and disability)

The 10-week outcome measures were available for 55 patients. Their average 10-week ODI was 14.3 (*SD* = 16.3), leg pain was 1.2 (*SD* = 1.6), and back pain was 1.7 (*SD* = 1.9). Forty patients (73%) improved by 20 points or more on ODI. Forty-three patients (78%) improved in leg pain by two points or more. Only 29 (53%) patients improved in back pain by two points or more.

Univariate associations between demographic, baseline FAM measures, and the 10-week postoperative outcomes

Associations among preoperative FAM variables are shown in Table 3.2. Baseline disability (ODI) as well as pain catastrophizing (PCS) correlated significantly with all other variables. Strongest correlations were seen between baseline ODI and leg pain (r = 0.61, P<.001), PCS and BDI (r = .55, p<.001), back pain and PCS (r = .49, p<.001), and between back pain and BDI (r = .46, p<.001). Younger age associated significantly with higher baseline back pain (r = -.43, p = .001) and with higher baseline ODI (r = -.36, p<.01). Likewise, female gender was associated with higher baseline ODI (r = -.30, p<.05) and higher baseline BDI (r = -.26, p<.05). Neither baseline BMI nor surgical

Table 3.2 Bivariate correlations of the baseline FAM measures (with the 95% CI)

	LP (NPRS)	BP (NPRS)	PCS	FABQ-W	FABQ-P	IPAQ	BDI
ODI	.62** (.40, .83)	.36** (.11, .61)	.41** (.17, .66)	.29* (.03, .55)	.34* (.09, .59)	-.26* (-.52, -.001)	.33* (08, .58)
BDI	.21 (-.05, .48)	.46** (.22, .70)	.55** (.33, .77)	.18 (-.09, .44)	.08 (-.19, .35)	-.08 (-.35, .20)	
IPAQ	.07 (-.20, .34)	-.14 (-.41, .13)	-.30* (-.56, -.05)	.10 (-.17, .36)	-.19 (-.46, .08)		
FABQ-P	.34** (.09, .59)	.06 (-.21, .33)	.34* (.09, .59)	.19 (-.08, .45)			
FABQ-W	.17 (-.10, .43)	.41** (.17, .65)	.31* (.06, .56)				
PCS	.35** (.10, .60)	.49** (.26, .72)					
BP (NPRS)	.23 (-.04, .49)						

BP: back pain
LP: leg pain
Pearson's correlation (*r*)
*$p<0.05$; **$p<0.01$

expectation showed any significant correlation with baseline FAM variables. After adjusting for age and gender, few associations have changed. ODI was no longer significantly associated with back pain, IPAQ, or with BDI.

Zero-order correlations between FAM measures and the 10-week outcomes (leg pain, back pain, and ODI) were also investigated. The strongest correlations found with the greater 10-week leg pain improvement were lower baseline BDI (r = .41, p<.01) and lower baseline FABQ-W (r = .40, p<.01). The strongest correlations with the 10-week back pain improvement were lower baseline back pain (r =.49, p<.001), lower baseline FABQ-W (r =.44, p=.001), and lower baseline BDI (r =.42, p =.001). The strongest correlations with the 10-week ODI improvement were lower baseline BDI (r =.52, p<.001), FABQ-W (r =.42, p<.01), and lower baseline back pain (r =.41, p<.01). Baseline leg pain did not show any significant correlation with the three 10-week outcomes (leg pain, back pain, and ODI).

Predictors of the 10-week postoperative leg pain, back pain, and disability

We ran three hierarchical linear regression analyses to determine the unique variance of the 10-week outcome (leg pain, back pain, and ODI) accounted for by the FAM variables and to identify significant FAM predictors. Each model was adjusted for age, gender, and patients' surgical expectations (entered in the first step).

FAM explained a significant amount of the 10-week ODI variance, *Adj.* R^2=0.37, F (11,40) = 3.71, p =.001. However, none of the FAM variables reached significance for predicting the 10-week ODI. Table 3.3 shows the predictors' standardized coefficients (β) and the change in R^2, from model 1 (adjusted variables) to model 2 (addition of FAM variables).

Table 3.3 Hierarchical multiple regression of the 10-week ODI

Step	Predictors	β (95%CI)	t	p-value	Change in R^2
Step 1	Age	.07 (-.20, .34)	.52	.60	.14
	Gender	-.14 (-.39, .12)	-1.10	.30	
	Expectation	-.13 (-.34, .11)	-1.04	.30	
Step 2	Leg pain	-.28 (-.61, .06)	-1.7	.11	**.37****
	Back pain	.04 (-.28, .35)	.23	.82	
	PCS	.30 (-.04, .61)	1.8	.09	
	FABQ-P	-.09 (-.35, .17)	-.71	.48	
	FABQ-W	.16 (-.12, .42)	1.14	.26	
	IPAQ	.22 (-.08, .49)	1.5	.15	
	ODI	.26 (-.11, .63)	1.4	.17	
	BDI	.30 (-.01, .61)	1.98	.06	

Dependent variable: 10-week postoperative ODI;
*p<.05; **p<.01

Likewise, a significant amount of the 10-week leg pain (NPRS) variance was explained by adding FAM measures to the model, *Adj.* R^2=0.21, F (11,40)=2.20, P<.05. In this analysis, both BDI and FABQ-W were significant predictors for the 10-week leg pain, (b=.07, P<.05) and (b=.04, P<.05), respectively. Table 3.4 shows the results of the hierarchical regression analysis (to predict the 10-leg pain).

Hierarchical multiple regression analysis to predict the 10-week back pain (NPRS) showed similar results. Entering FAM variables to the model explained a significant amount of the 10-week postoperative back pain variance, *Adj.* R^2=0.31, F (11,40)=3.07, P<.01. However, none of the FAM predictors reached significance. Table 3.5 shows the results of the hierarchical regression analysis (to predict the 10-back pain).

To examine which FAM variables were most influential, each of the three hierarchical regression analyses was followed by a stepwise multiple regression analysis, where we adjusted for age, gender, and surgical expectation. The BDI was the only significant predictor added to the prediction model for the 10-week ODI, (b =1.1, t (47)=4.38, p<.001). Depression (BDI) explained a significant amount of the 10-week ODI variance, *Adj.*R^2=0.34, F (4,47)=7.46, p<.001.

The BDI and FABQ-W scores were the only significant predictors for both the 10-week leg pain and 10-week back pain. These two FAM variables explained significant amounts of the 10-week postoperative leg pain and back pain variances, *Adj.*R^2=0.26, F (5,46)=4.52, p<.01 and *Adj.*R^2=0.32, F (5,46)=5.87, p<.001, respectively.

Discussion

Our results support the relationship between preoperative FAM variables and the 10-week outcomes following surgery for LDH. Moderate to strong relationships were

Table 3.4. Hierarchical multiple regression of the 10-week leg pain

Step	Predictors	β (95%CI)	t	p-value	Change in. R^2
Step 1	Age	-.16 (-.45, .15)	-.99	.33	.07
	Gender	-.13 (-.41, .16)	-.91	.37	
	Expectation	.124 (-.13, .36)	.93	.36	
Step 2	Leg pain	.20 (-.18, .56)	1.05	.30	**.31***
	Back pain	-.18 (-.53, .17)	-1.03	.31	
	PCS	.09 (-.27, .45)	.49	.62	
	FABQ-P	-.06 (-.33, .23)	-.38	.71	
	FABQ-W	**.33* (.01, .60)**	**2.08***	**.04**	
	IPAQ	.06 (-.26, .37)	.37	.72	
	ODI	-.05 (-.46, .36)	-.26	.80	
	BDI	**.36* (.02, .70)**	**2.15***	**.04**	

Dependent variable: 10-week postoperative leg pain (NPRS);
*p<.05; **p<.01

Table 3.5 Hierarchical multiple regression of the 10-week back pain

Step	Predictors	β (95%CI)	t	p-value	Change in. R^2
Step 1	Age	-.09 (-.36, .20)	-.59*	.56	.12
	Gender	-.15 (-.40, .12)	-1.05	.30	
	Expectation	.13 (-.11, .35)	1.05	.30	
Step 2	Leg pain	-.20 (-.54, .15)	-1.16	.26	**.34****
	Back pain	.21 (-.12, .53)	1.27	.21	
	PCS	.10 (-.23, .43)	.60	.55	
	FABQ-P	.12 (-.15, .38)	.90	.38	
	FABQ-W	.25 (-.04, .51)	1.70	.10	
	IPAQ	-.02 (-.31, .27)	-.13	.90	
	ODI	-.03 (-.41, .35)	-.14	.89	
	BDI	.30 (-.02, .60)	1.88	.07	

Dependent variable: 10-week postoperative back pain (NPRS)
*$p<.05$; **$p<.01$

seen between many of the preoperative FAM measures. Baseline disability and pain catastrophizing correlated significantly with all of the included FAM measures. However, some correlations were no longer statistically significant after adjustments for age and gender. Being young and female was associated with more depression at baseline and more back pain and disability both at baseline and at week 10 following surgery. This finding was supported by previous research findings that being female is associated with poorer LDH surgical outcomes [13, 49, 50].

Our main findings were that FAM variables measured preoperatively explained significant amounts of the three 10-week outcome measures (leg pain, back pain, and disability). However, many FAM measures did not reach statistical significance in these models. This might be due to statistical significant correlations and shared variance among baselines FAM measures. Especially, moderate to strong correlations between baseline depression, pain catastrophizing, and back pain might prevent the last two from reaching statistical significance to predict the postoperative outcomes. When we ran stepwise regression models, depression and work-related fear-avoidance beliefs were the only significant predictors; explaining 26% of the variance in 10-week postsurgical leg pain and 32% of the variance in 10-week postsurgical back pain. Depression was the only significant predictor for the 10-week postsurgical disability, explaining 34% of the 10-week disability variance. Previous studies supported the impact of both fear and depression on LDH surgical outcomes [6, 13, 50-53]. Our results also were similar to previous studies in LDH patients showing higher baseline back pain increased the risk of unfavorable surgical outcomes [6, 54].

A number of limitations need to be taken into account when interpreting these results. The relatively small sample size included in this analysis may question the accuracy of these results. In addition, our analysis included only one follow-up time point (i.e., 10 weeks postoperative). Therefore, we were unable to compare our results with other follow-up time points. The relative short follow-up time (10 weeks) may change the results if longer follow-up were used. Lastly, all the measures in this study were self-report measures. Although self-report measures are easier to use, response biases may distort the results. Therefore, future prospective studies with larger sample sizes, longer and multiple follow-up time points are warranted.

To our knowledge, this is the first study to use FABQ and PCS measures to predict LDH surgical outcomes. Our results supported the association between baseline FAM measures and preoperative functional disability. Our results also supported the impactfullness of both depression and work-related fear-avoidance beliefs on LDH postsurgical leg pain, back pain, and functional disability.

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CHAPTER 4

CONCLUSION AND DISCUSSION

The aim of this dissertation was to study the influence of the FAM factors (pain, pain catastrophizing, fear, avoidance, physical activity, disability, and depression) on patients with specific LBP (i.e., LDH) who were candidates for discectomy surgery. Our investigation consisted of a systematic review and a secondary analysis of a prospective study. The goal of the systematic review was to identify prospective studies that examined any FAM factors to predict LDH surgical outcomes. The secondary analysis was done to examine specific FAM measures and their prognostic value on patients undergoing discectomy surgery. The findings of both projects generally supported the hypothesis that FAM variables have similar impact on LDH patients before and after the surgery as on nonspecific LBP individuals.

We identified 13 prospective studies that met our systematic review's inclusion criteria. All of the included studies examined the predictive value of one or more FAM measures for LDH surgical outcomes. Postoperative follow-up in these studies ranged from 6 months to 7 years. Two reviewers assessed the methodological quality of the included studies and found that most of the studies, except four, had good quality. Heterogeneity was present among studies in terms of the FAM predictors studied, outcome measures, follow-up periods, and analyses used. Pain and depression were the most measured FAM factors in these studies. Pain was consistently associated with LDH surgical outcomes; however, leg pain and back pain seem to have different prognostic values and should be viewed differently. Depression was the most measured FAM factor in these studies and most studies found it to be associated with LDH surgical outcome. Fear, avoidance, anxiety, and pain coping were also negatively associated with LDH surgical outcomes. Pain catastrophizing and physical activity were the least measured

FAM factors in operative LDH patients. In conclusion, LDH surgical outcome appears to be dependent on the outcome measure used (e.g., pain, disability, quality of life, or composite outcome) and many of these measures appear to be associated with preoperative FAM factors.

In the secondary analysis, we examined the association of the preoperative Fear-Avoidance Belief Questionnaire (FABQ), the Pain Catastrophizing Scale (PCS), the International Physical Activity Questionnaire (IPAQ), and other FAM measures, with the 10-week post discectomy leg pain, back pain, and functional disability outcomes. All these measures were significantly correlated with the preoperative functional disability. FAM variables were also able to explain significant amounts of the 10-week outcomes' variances. Depression and work-related fear-avoidance beliefs were the most impactful predictors on the 10-week post discectomy outcomes. Being young and female was associated with more depression at baseline and more back pain and disability both at baseline and at week 10 following surgery. Many of the findings of this secondary analysis are supported by previous research.

There are limitations that need to be taken into account when interpreting the findings of this dissertation. All the FAM measures included in the systematic review's studies and included in the secondary analysis were self-report measures. This kind of measure may be affected by many response biases. Although objective measures are more reliable, self-report measures are more convenient and easier to use. In addition, most of the FAM measures used or mentioned in this dissertation have good reliability and validity. Another limitation of the findings of the systematic review was the heterogeneity in the studies that were analyzed. Different FAM predictors, outcome measures, and analyses were used, and follow-up periods of different duration made it difficult to pool the results and come up with effect sizes. A relatively small sample size may have influenced the accuracy of the secondary analysis findings. Future research with larger sample sizes should examine the association of many FAM measures during different follow-up time points to predict multiple LDH surgical outcomes.

This is the first systematic review to look at the impact of FAM measures on LDH surgical-outcomes. We were also the first to examine the influence of FABQ and PCS on LDH discectomy-outcomes. In general, FAM factors seem to have an important role on many LDH unfavorable outcomes. These factors should be screened for during the conservative management as well as before and after surgery. The combination of physical therapy and Cognitive Behavioral Therapy (CBT) are effective components to target chronic LBP [1]. Brox et al. (2006) has demonstrated the efficacy of CBT for patients with chronic LBP after previous LDH surgery [2]. Focusing only on the classic medical factors and continually ignoring the psychosocial factors may lead to persistence of symptoms, decline in the quality of life, and excessive health care costs [3, 4].

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