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REVIEW

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A systematic review of bio-psychosocial risk factors for an unfavourable outcome after lumbar disc surgery

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Abstract The objective of this systematic review is to summarize scientific evidence concerning the predictive value of bio-psychosocial risk factors with regard to the outcome after lumbar disc surgery. Medical and psychological databases were used to locate potentially relevant articles, which resulted in the selection of 11 studies. Each of these studies has a prospective design that examined the predictive value of preoperative variables for the outcome of lumbar disc surgery. Results indicated that socio-demographic, clinical, work-related as well as psychological factors predict lumbar disc surgery outcome. Findings showed relatively consistently that a lower level of education, a higher level of preoperative pain, less work satisfaction, a longer duration of sick leave, higher levels of psychological complaints and more passive avoidance coping function as predictors of an unfavourable outcome in terms of pain, disability, work capacity, or a combination of these outcome measures. The results of this review provide preliminary opportunities to select patients at risk for an unfavourable outcome. However, further systematic and methodologically high quality research is required, particularly for those predictors that can be positively influenced by multidisciplinary interventions.

Keywords Lumbar disc surgery · Predictor · Prospective · Bio-psychosocial · Review

Introduction

In 1934, Mixter and Barr described the close pathomorphological relation between radiation of pain in the leg and lumbar disc herniation [41]. By removing the lumbar disc material that compromised a lumbar nerve root, it was possible to relieve specific neuropathic symptoms such as segmental irradiating pain in the leg, sensory loss, and motor disturbance. Internationally, this method is the most accepted and applied treatment for persistent pain caused by lumbar disc herniation, which is not relieved by conservative treatment [3, 16]. In the Netherlands 0.5% of the population develop a lumbosacral radiculair syndrome (LRS) on an annual basis [4]. Although the majority of patients obtain functional recovery without treatment or with conservative treatment [29, 45, 57]. 20% of the patients require an operation [8, 55]. Research on the results of lumbar

disc surgery shows that success rates for the long-term outcome vary between 60–90%, depending upon which outcome measure was utilized [12, 33, 37, 53, 66] Major complaints after surgery are back or leg pain, restriction in daily activities and the loss of work capacity; i.e., the inability to work. In an attempt to predict the individual differences in the outcome of lumbar disc surgery, various prospective cohort studies investigated differing predictors for an unfavourable outcome, including socio-demographic, clinical, work related, and psychological variables.However, till now, the scientific evidence of the predictive value of different prognostic variables has not been summarised and structured through a systematic overview. By constructing such a review, this study aims to provide an insight into the most relevant prognostic factors that could contribute to the identification and selection of patients at risk, as well as the development of tailored post-operative treatment methods based on the predictive variables.

Methods

Electronic database searches of Medline, Psychinfo, CHINAL and Embase were performed for articles written in English, Dutch and German (1980–2003). To ensure that we did not exclude any relevant studies, we adopted a sensitive search strategy using the following combination of key words: lumbar, disc, herniation with surgery, discectomy or laminectomy and with prognostic, predict, risk factor, longitudinal or prospective. These extensive searches lead to 256 references. Based upon the abstracts, studies were excluded because: (1) the data was collected retrospectively; (2) the goal of the studies was different from the studying predictors for the outcome after LRS (e.g, the effect of different surgery techniques, rehabilitation programs, medication intake or non-operative treatment in comparison with operative treatment); 3. specific patient groups were examined (adolescents, patients above 70 years old, patients with rheumatoid arthritis, patients with spondylolistesis). Because operation techniques, radiological diagnostics and indications for surgery have changed in the past decades, we also decided to exclude studies initiated prior to 1980. The exclusion of citation based upon the abstract lead to a pre-selection of 22 articles. The references of all selected articles were screened for additional potentially eligible publications, further producing seven articles. The final selection of the studies was based on the following criteria:

- Involvement of a population which had undergone surgery for a lumbar herniated disc. Study designs, which included patients operated for lumbar stenosis or patients that had undergone a lumbar fusion were excluded.
- The complaints had to be based on the neuropathic symptoms caused by a herniated lumbar disc and had to be confirmed by neuroradiological assessment (MRI, CT, myelography and rhizography) or by operative findings (bulging/protrusion, prolaps and sequester).
- The design of the study had to be a prospective cohort study (considered the appropriate method for best evidence concerning prognosis [50]).
- The aim of the study was to detect predictors for pain, disability, work capacity, or a composite score.
- Inclusion of the patients had had to occur within 6 weeks prior to the date of surgery.
- The sample size at first assessment had to exceed 30 patients.
- The publication had to be a full report, letters and abstracts being excluded.

Two reviewers screened the selected studies independently. All disagreements between the reviewers were subsequently discussed during a consensus meeting. A third reviewer was consulted to achieve a final decision in the case of disagreement. The review team exists of a multidisciplinary team of researchers with a great deal of experience in the research and clinical field of chronic pain (i.e. Dr. A.W.M. Evers, psychologist, Dr. M. Munneke, physical therapist and epidemiologist and J. den Boer, Msc, research physical therapist). Totally 14 studies were excluded because (1) they included a mixed population of patients following surgery for a herniated disc, lumbar stenosis and a lumbar fusion [30, 60], (2) only a selection of patients were operated [9, 24, 61] or patients had undergone more than one back operation [1], (3) the aim of the study was to predict solely the operative or radiological findings [44, 54, 58, 59] or the diagnosis was not confirmed by radiological findings [34, 35, 38] (4) the follow-up time was less than 1 week [22] or varied largely between patients with differences more than 1 year [2, 48] or (5) the study included less than 30 patients [4]. Finally, 15 publications were selected. All studies except one included patients before surgery. One study included patients shortly after surgery (6 weeks post-operatively). From the latter study, only those factors that are not affected by the assessment point (before and after surgery) were included. Finally, 15 publications were selected [6, 7, 14, 18–21, 28, 29, 31, 32, 49, 51, 52, 64]. Four publications [18–21] were based upon the findings from the same sample, and therefore we regard these publications as one study, resulting in the inclusion of 11 studies.

For these 11 studies, predictor variables were reported only when (1) the operationalisation and statistical results of significance (*P*-value, correlations) were sufficiently described in the text and; (2) when the variables were measured in at least two studies (this because

of the large number of predictor variables, i.e. approximately 150).

Predictor variables were categorised into socio-demographic, clinical, work-related, and psychological variables. The first category, socio-demographic predictor variables, consists of the items gender, age, body weight, body length, education level and marital status. Clinical predictors used in the studies, we looked at consist of two main categories, namely pre-operative status (including pre-operative pain and disability, other complaints and duration of complaints) and clinical signs (including segmental sensory loss, straight leg raising test, radiological findings and operative findings). Work-related predictor variables entail a patient's physical work conditions, work satisfaction and duration of sick leave. Psychological predictors measured in the studies were depression, anxiety, somatisation, coping strategies, life events and social support.

As a result of the relatively small number of selected studies, the wide variation between them in terms of study design, predictor variables, outcome measures and statistical analyses as well as the lack of a widely accepted quality rating system for prospective studies [36], the methodological quality of the studies was not rated. The heterogeneity of the prognostic factors and outcome measures also precluded the statistical pooling of the results. Instead, to be sure of the basic methodological quality of the studies, relatively stringent selection criteria were formulated. These criteria were based on the frequency with which a variable was measured in different studies, and whether a significant association between this variable and the outcome was established. This resulted in the following categories for the level of evidence

Positive evidence

The number of studies which found a significant association between predictor variables and surgery outcome exceeds the number of studies with no significant association by three or more.

Preliminary positive evidence

The number of studies with a significant association exceeds the number of studies with no significant association by two.

Conflicting evidence

1. The number of studies with a significant association exceeds the number of studies with no significant association by one or less.
2. The number of studies with no significant association exceeds the number of studies with a significant association by one.

Preliminary negative evidence

The number of studies with no significant association between predictors and outcome exceeds the number of studies with a significant association by two.

Negative evidence

The number of studies with no significant association exceeds the number of studies with a significant association by three or more.

In order to compare the results of the studies, we collectively analysed the predictors for all outcome measures (pain, disability, work capacity and composite score). Subsequently, we separately examined the extent to which the predictor variables were able to predict different outcomes. Because the criteria for the composite scores differed greatly between the different studies (including a combination in the outcomes of pain, disability, work capacity, doctor visits, medical consumption, sleep disturbances, patient's opinion or clinical examination), it was not possible to separately analyse these outcomes. Due to the small number of studies with single outcome parameters of pain, disability or work capacity, no level of evidence was defined in these analyses.

Results

Table 1 displays a summary of information about the reviewed studies, including population, research design and results. All studies included more than 50 patients at first assessment, and five studies included more than 100 patients [6, 7, 18–21, 28, 31]. In all studies except one [7], the inclusion of patients took place within a week before surgery. Dropout rates in all studies were generally low with the exception of three studies [31, 52, 64] that had a follow-up loss of more than 10%. All studies except one [49] used a follow-up time of more than 6 months, with four studies including patients who had received follow-up investigations over a year after the surgery [21, 32, 51, 64]. In addition, two studies [18–21, 64] had more than one follow-up assessment [18–21]. In regard to the statistical analyses used by the different studies, six studies used multivariate regression analyses [14, 18–21, 28, 49, 51, 64], while five studies performed univariate analyses [6, 7, 31, 32, 52].

Table 2 gives an overview of the predictors for all outcome measures, and indicates whether or not these

Table 1 Prospective studies of prognostic factors for the outcome after lumbar disc surgery

Studies	First assessment	Follow-up	Outcome variables	Significant predictors[a]	Comments
Dauch et al. 1994 [6]	1 day before surgery n = 109 Age = 18–66 (M = 42) Gender = 44% female	6 months after surgery n = 105 (96%)	Pain, disability, work capacity	Socio-demographic: age Clinical: duration of complaints, other preoperative complaints Work: duration of sick leave	(a) Use of additional outcome measure. (segmental motor loss) (b) No multivariate statistics
Donceel & Du Bois 1999 [7]	6 weeks after surgery n = 177 Age = 18–69 (M = 39) Gender = 36% female	1 year after surgery n = 175 (98%)	Work capacity	Socio-demographic: gender, education level Clinical: segmental sensory loss Work: duration of sick leave Psychological: life events	(a) 1 outcome measure, work capacity (b) Exclusion of self employed workers and patients with age > 65 (c) No pre-operative assessment (d) No multivariate statistics
Fulde et al. 1995 [14]	Between admission to hospital and surgery n = 52 Age = 16–62 (M = 41) Gender = 46% female	6 months after surgery n = 48 (92%)	Composite score consisting of pain, work capacity and doctor visit	Psychological: coping strategies	(a) Use of only one outcome measure. (composite score) (b) n < 50 at follow up
Graver et al. 1992 [18]	Before surgery n = 122 Age = 18–66 (M = 41)	1 year after surgery n = 122 (100%)	Composite score consisting of pain, disability, clinical examination and medication	Clinical: fibronilytical hyperactivity	Use of only one outcome measure. (composite score)
Graver et al. 1995 [19]	Gender = 46% female		Pain, disability, composite score consisting of pain, disability, clinical examination and medication	Psychological: anxiety, somatisation, coping strategies	Use of additional outcome measure: (use of analgesics)
Graver et al. 1998 [20]			Composite score consisting of pain, disability, clinical examination and medication, work capacity	Socio-demographic: gender, body weight, body length Work: work conditions (physical), duration of sick leave	
Graver et al. 1999 [21]		7 years after surgery n = 114 (93%)	Pain, composite score consisting of pain, disability, clinical examination and medication	Socio-demographic: gender Clinical: fibronilytical hyperactivity, operative findings Psychological: somatisation	
Hurme and Alaranta 1985 [28]	1–4 weeks before surgery n = 220 Age = 16–54 (M = 39) Gender = 46% female	6 months after surgery n = 215 (98%)	Pain, disability, composite score consisting of pain and work capacity	Socio-demographic: age, body weight, education level, marital status Clinical: preoperative pain and disability, duration of complaints Work: work conditions (physical), work satisfaction Psychological: somatisation	Exclusion of patients with age > 55
Junge et al. 1995 [31]	Between admission to hospital and surgery n = 381 Age = 18–69 (M = 45) Gender = 40% female	1 year after surgery n = 328 (86%)	Composite score consisting of pain, work capacity and doctor visit	Socio-demographic: education level Clinical: preoperative pain and disability, duration of complaints, other complaints, radiological findings Work: work satisfaction, duration of sick leave Psychological: coping strategies	(a) use of only one outcome measure. (composite score) (b) exclusion of patients with age > 55 (c) no multivariate statistics
Kjellby et al. 1999 [32]	Before surgery n = 50 Age = 21–68 (M = 40) Gender = 28% female	2 years after surgery n = 47 (94%)	Composite score consisting of pain and patient's opinion	Clinical: preoperative pain Psychological: depression, anxiety	(a) use of only one outcome measure. (patients opinion) (b) n < 50 at follow-up (c) no multivariate analyses
Rosenstiel and Gross 1986 [49]	1 day before surgery n = 50 Age = 18–66 (M = 42) Gender = 44% female	6 weeks after surgery n = 47 (94%)	Pain, composite score consisting pain and patients opinion	Clinical: operative findings Psychological: coping strategies	(a) n < 50 at follow up (b) use of two additional outcome measures. (sleep disturbance and depression)

Table 1 (Contd.)

Studies	First assessment	Follow-up	Outcome variables	Significant predictors[a]	Comments
Schade et al. 1999 [42]	Before surgery $n = 46$ Age = 20–50 Gender = 26% female	2 years after surgery $n = 42$ (91%)	Pain, disability, work capacity, composite score consisting pain, disability, work and medication	Clinical: preoperative pain and disability, radiological findings Work: work satisfaction Psychological: depression, anxiety, social support	(a) exclusion of non employed patients and patients with age > 50 (b) $n < 50$ at follow up
Sorensen et al. 1987 [52]	Before surgery $n = 57$ Age = not described Gender = 49% female	6 months after surgery $n = 49$ (85%)	Composite score consisting of pain and patient's opinion	Socio-demographic: gender Clinical: preoperative pain, duration of complaints Work: duration of sick leave Psychological: depression, anxiety, somatisation	(a) use of only one outcome measure. (composite score) (b) $n < 50$ at follow up (c) no multivariate analyses
Woertgen et al. 1999a [64]	Before surgery $n = 121$ Age = 15–70 ($M = 43$) Gender = 30% female	1 year after surgery $n = 98$ (80%)	Composite score consisting of pain, disability, work capacity, medical consumption	Socio-demographic: level of education Clinical: straight leg raising	(a) use of only one outcome measure. (composite score)
Woertgen et al. 1999b [64]		28 months after surgery $n = 98$ (80%)		Clinical: segmental sensor loss, straight leg raising test	

[a]Predictors are significant for at least one outcome variable of pain, disability, work capacity or composite score.

predictors are significant, as well as delineating their level of evidence. All main categories; i.e. socio-demographic, clinical, work-related, and psychological factors, contained at least one variable that was classified as positive evidence. In regard to socio-demographic variables, positive evidence was found for a lower level of education. In the category clinical variables, higher levels of preoperative pain were significantly predictive in terms of positive evidence, while in terms of work-related variables, less work satisfaction and a longer duration of sick leave were predictors for an unfavourable outcome. Regarding psychological variables, three predictors with positive evidence were found: anxiety, somatisation, and passive avoidance coping. In contrast to anxiety and somatisation, which were both measured by relatively corresponding scales, the assessment of coping strategies differed in that various cognitive and behavioural coping strategies were either measured in regard to stress or pain, or by assessing pain behaviour. Irrespective of these varying assessment methods, there was a tendency towards the fact that passive avoidance coping strategies relatively consistently predicted an unfavourable outcome in three [7, 14, 19] of the five studies.

Preliminary positive evidence was further found in both clinical and work-related variables. In regard to the former, high levels of pre-operative disability, other pre-operative complaints, a longer duration of complaints and segmental sensory loss were classified as preliminary positive evidence. Additionally, radiological findings (especially the type of disc herniation) were significantly associated with the outcome of the surgery, which indicates that a bulging or protruded disc predict an unfavourable outcome [31, 51]. In terms of the work-related variables, preliminary positive evidence was found for a patient's physical work condition.

Conversely, the studies examined here consistently found that a number of predictors did not affect the outcome after lumbar disc surgery. Preliminary negative evidence was found for the socio-demographic variable marital status as well as the clinical variable straight leg raising. Moreover, negative evidence was found for the socio-demographic variables age and smoking. In fact, smoking was the only variable that showed a consistently negative association with all three outcomes in more than one study [51, 64].

Table 3 shows an overview of the predictors for the outcomes of pain, disability and work capacity. The first outcome, pain, was measured in five studies [6, 19, 21, 28, 49, 51] through the use of validated pain scales. Three studies [6, 19, 21, 49] used the VAS [46], one study the Pain Index [38], and one study [51] used a composite score of the VAS [46] and the McGill Pain Questionnaire [40]. Variables that most consistently predicted pain were the operative findings (significant in two out of three studies) and coping (consistently significant in two

Table 2 Overview of significant predictors for at least one outcome measure (pain, disability, work capacity and composite score)

Predictor ↓	Outcome →			
	Outcome (pain, disability, work and composite score)		Positive findings/*n* study (%)	Level of evidence[a]
	Sign	Not sign		
Socio-demographic				
Gender (female)	B, D, J	A, F, K, I	3/7 (42.8%)	3
Age	A, E	B, K, D, I, F, J	2/8 (25%)	5
Body weight	D, E	B*, I	2/4 (50%)	3
Body length	D	B*, I	1/3 (33%)	3
Education level	E, B, F, L, K	J	5/6 (84%)	1
Marital status	E	J, I, B	1/4 (25%)	4
Clinical				
Preoperative status				
Preoperative pain	E, F, G, I, J	A, H	5/7 (71.4%)	1
Preoperative disability	E, F, I	H	3/4 (75%)	2
Other preoperative complaints	A, F		2/2 (100%)	2
Duration of complaints	A, E, I, J, F	D, B, K	5/8 (62.5%)	2
Clinical signs				
Segmental sensory loss	B, K		2/2 (100%)	2
Straight leg raising test	K	E, F, I	1/4 (25%)	4
Radiological findings	F, I		2/2 (100%)	2
Operative findings	D, H	E	2/3 (66.6%)	3
Work				
Work conditions (physical)	D, E	B, J	2/4 (50%)	2
Work satisfaction	E, I, F		3/3 (100%)	1
Duration of sick leave	A, B, D, F, J	I, K	5/7 (71.4%)	1
Psychological				
Depression	G, I, J	C, D, E, F	3/7 (42%)	3
Anxiety	D, G, I, J	E	4/5 (80%)	1
Somatisation	D, E, J	H	3/4 (75%)	1
Coping	C, D, F, H		4/4 (100%)	1
Live events	B	J	1/2 (50%)	3
Social support	I	J	1/2 (50%)	3

A = Dauch et al. (1994) [6]
B = Donceel and Du Bois (1999) [7]
C = Fulde et al. (1995) [14]
D = Graver et al. (1992) [18–21]
E = Hurme and Alaranta (1987) [28]
F = Junge et al. (1995) [31]
G = Kjelby et al. (1999) [32]
H = Rosenstiel and Gross (1986) [32]
I = Schade et al. (1999) [51]
J = Sorensen et al. (1987) [52]
K = Woertgen et al. (1999) [64]
*Trend ($P = 0.1$)
[a]1 = Positive evidence
2 = Preliminary positive evidence
3 = Conflicting evidence
4 = Preliminary negative evidence
5 = Negative evidence

studies). Disability was measured in four studies [6, 18, 21, 38, 51] using the validated disability scales for lower back pain: the Disability index [28] and the Roland disability scale [47]. Variables that best predicted disability were preoperative disability, less work satisfaction, and somatisation (all were consistently significant in two studies). Work capacity was measured in four different studies [6, 7, 20, 51] by assessing the difference in the number of paid working hours before the operation and during the follow-up assessment. The variable that best predicted work capacity was depression (consistently significant in two studies).

Table 3 Overview of predictors for the outcome pain, disability and work capacity separately*

Predictor↓	Outcome →					
	Pain		Disability		Work capacity	
	Sign	Not sign	Sign	Not sign	Sign	Not sign
Socio-demographic						
Gender (female)	D	A, I		A, I	B, D	A, I
Age	A	E, I	E	A, I	A	B, I
Body Length						B, D, I
Body weight		E, I	E	I	D	B, I
Marital status	E	I		E, I		B, I
Clinical						
Preoperative pain	E, I	A, H		A, E, I	I	A
Preoperative disability		E, H, I	E, I			
Duration of complaints	A	E, I	E	A, I	I	A, B, D
Straight leg raising test		E, I		E, I		
Operative findings	D, H	E				
Work						
Work conditions (physical)					D	B
Work satisfaction	E	I	E, I			
Duration of sick leave	A	I		A, I	B, D	A, I
Psychological						
Depression	I	D, E	I	D, E	D	
Anxiety	D	E, I	D	E, I		
Somatisation	D	E, H	D, E			
Coping	D, H			D, I		I

A = Dauch et al. (1994) [6]
B = Donceel and Dubois (1999) [7]
D = Graver et al. (1992) [18–21]
E = Hurme and Alaranta (1987) [28]
H = Rosenstiel and Gross (1986) [49]
I = Schade et al. (1999) [51]
The following predictors were not measured in relation to pain, disability or work capacity separately: educational level, other preoperative complaints, segmental sensor loss, radiolological findings, life events, social support.

Discussion

Results of this systematic review indicate that the outcome after lumbar disc surgery is determined by a multiple set of bio-psychosocial variables. Preliminary evidence indicates that a lower level of education, a higher level of pre-operative pain, less work satisfaction, a longer duration of sick leave, passive avoidance coping strategies and higher levels of anxiety and somatisation relatively consistently predicted an unfavourable outcome after lumbar disc surgery in terms of pain, disability, work capacity, or a composite score.

Because of its findings, this study offers preliminary opportunities to select patients at risk for an unfavourable outcome and will be useful in developing tailored treatment after operation. However, due to the differences in predictor variables and outcome assessments, as well as the methodological shortcomings of the studies, more systematic research is required regarding specific prognostic factors for specific outcomes.

When considering the socio-demographic variables, positive evidence was found that a lower level of education predicts an unfavourable outcome. This is in line with the findings of the research conducted among other chronic pain populations, proving that a lower social economic status is a risk factor for various chronic pain conditions [10, 13, 25]. The specific nature of this relationship is not entirely clear though, and could be caused by various factors, such as physical work conditions, less access to health services, and/or less healthy behaviours [10]. In contrast, all other socio-demographic variables (gender, age, body length, body weight and marital status) showed only conflicting or negative evidence in regard to the outcome after lumbar disc surgery. For instance, although younger patients have frequently been assumed to recover more quickly following lumbar disc surgery (due to a better physical condition), six of eight studies were unable to find a significant association between age and the follow-up outcome.

In regard to the clinical predictors, there is either positive or preliminary positive evidence for the variables pre-operative pain and disability, other complaints, and duration of pain, indicating that the severity

and duration of complaints prior to surgery predict an unfavourable outcome. In addition, the loss of the neurological function ''segmental sensory'' was predictive for the outcome after lumbar disc surgery. Recent studies suggest that this segmental sensory loss could be a reflection of disturbances of sensory input in the central nervous system which lead to hypersensitivity for pain through a sensitisation of the dorsal horn (central neuro-plasticity) [23, 27, 63, 65].

Regarding the work-related variables, the duration of sick leave was a consistent predictor, suggesting that a long pain history accompanied by (partial) disability and work difficulties, has unfavourable effects on the outcome of lumbar disc surgery. In line with studies conducted among chronic pain populations [5, 15, 17, 26, 62], our review also found positive evidence that a lack of work satisfaction functions as a predictor for an unfavourable outcome, suggesting that psychosocial aspects of work are important for the outcome of the surgery thus requiring further research.

Finally, regarding the psychological variables, positive evidence was found for anxiety, somatisation and passive avoidance coping strategies. The predictive value of anxiety and somatisation is in accordance with previous research [36, 39, 43], revealing that higher levels of physical and psychological complaints are predictive for an unfavourable outcome in various chronic pain populations. Furthermore, the role of passive avoidance coping strategies as a risk factor also corresponds to the research findings in other pain populations [11, 42, 56]. Consequently, multidisciplinary treatment options that focus on passive avoidance coping and have been successfully applied in chronic pain population [11, 42, 56], could also be effective in enhancing the recovery of risk patients after lumbar disc surgery.

Although all the studies were prospective, and the inclusion of the articles was based on strict selection criteria, results have to be interpreted with caution and it is imperative that several methodological shortcomings of the studies are mentioned. This study is based on few trials with relatively small patient samples. An overestimation of the true effects of predictors can therefore not be excluded. The majority of the studies used a composite score as outcome measure and did not present the results for specific outcomes. As a result, findings of predictors for separate outcomes seem to be largely determined by the limited number of predictors used in these studies, which implies that more systematic research of specific predictors for different outcomes of pain, disability and work capacity is required. In addition, no study controlled for pain medication or post-operative treatment (e.g. physical therapy). Predictor assessments also vary widely between studies, especially for work-related variables and coping strategies. Statistical methods used in the studies were frequently univariate and only one study [51] took the pre-operative level of pain and disability into account in multivariate analyses. Because of these and other methodological shortcomings of the studies, it was not possible to either evaluate the methodological quality of the studies using a proper rating scale, or to statistically pool the results of the studies. Instead, comprehensive selection criteria for the studies of this review and a preliminary, best possible definition of the level of evidence were used. Future research requires more systematic and methodologically sound studies for the prediction of the outcome of lumbar disc surgery.

Conclusion

This review has found an evidence that socio-demographic, clinical, work-related, and psychological factors function as predictors for the outcome after lumbar disc surgery. The results of this review provide opportunities to select those patients that are at risk for an unfavourable outcome and who may benefit from multidisciplinary treatment after lumbar disc surgery. However, in order to develop tailored intervention after lumbar disc surgery for patients at risk, further systematic and methodologically high quality research is required, particularly for those predictors that can be positively influenced by specific (multidisciplinary) interventions.

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