Psychosocial factors in patients with lumbar disc herniation: Enhancing postoperative outcome by the identification of predictive factors and optimised physiotherapy
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ABSTRACT

Johansson, A-C (2008). Psychosocial factors have been advanced as an explanation for the development of chronic disability in 20 to 30% of patients treated by lumbar disc surgery.

Aims: The overall aim of this thesis was to study the role of psychosocial factors in patients undergoing first-time lumbar disc surgery in relation to the outcome of both surgery and subsequent physiotherapy.

Methods: Sixty-nine patients with lumbar disc herniation undergoing first-time disc surgery participated in the studies; in addition, Study I included 162 knee patients for comparison. Psychosocial factors were assessed preoperatively, as was the activation of the physiological stress response system. Pain, disability and quality of life were assessed before, and 3 and 12 months after surgery. Coping and kinesiophobia were analysed before and one year after surgery. The results of two different postoperative training programmes were compared.

Results: There were no differences between disc and knee patients regarding the presence of psychosocial stress factors preoperatively (Study I). Disc patients with low diurnal cortisol variability had lower physical function, perceived fewer possibilities to influence their pain and were more prone to catastrophise than patients with high diurnal cortisol variability (Study II). The results of clinic-based physiotherapy and home training did not differ regarding postoperative disability and pain 3 months after surgery. The home-based group had less pain and higher quality of life in comparison to the clinic-based group 12 months after surgery (Study III). Patients’ expectations of returning to work could best predict pain, disability, quality of life and sick leave one year after surgery (Study IV). Psychosocial factors were only weakly associated to pain, disability, quality of life and sick leave preoperatively. However, these associations were stronger in patients with residual pain one year after surgery.

Conclusion: Psychosocial factors and, in particular, patients’ expectations regarding outcome are associated with the results of lumbar disc surgery. Assessing psychosocial factors preoperatively and developing an active home training programme after surgery could create options leading to better results for these patients.

Keywords: Lumbar disc herniation, surgery, psychosocial factors, physiotherapy, expectations
PUBLICATIONS


III Ann-Christin Johansson, Steven J Linton, Leif Bergkvist, Olle Nilsson, Michael Cornefjord Clinic-based training in comparison to home-based training after first-time lumbar disc surgery: a randomized controlled trial. In press

ABBREVIATIONS

ACTH  Adrenocorticotrophic Hormone
ADL   Activities of Daily Living
AUC   Area under the response curve
CHAMP The Centre for Health and Medical Psychology
CKF   Centre for Clinical Research
CRH   Corticotrophine-Releasing Hormone
CSQ   Coping Strategies Questionnaire
CT    Computer Tomography
EuroQol European Quality of life questionnaire
EuroQol5D The five dimensional scale of the EuroQol
EuroQolVAS EuroQol visual analogue scale
HPA   Hypothalamic-Pituitary-Adrenal
LiSat-9 Life Satisfaction Scale 9
MRI   Magnetic Resonance Imaging
ODI   Oswestry Disability Index
OR    Odds Ratio
QWC   Quality-Work-Competence
RCT   Randomised Controlled Trial
SF-36 Medical Outcomes Study Short Form Health Survey 36
SPSS  Statistical Package for the Social Sciences
SRSS  Social Readjustment Scale
TSK   Tampa Scale for Kinesiophobia
VAS   Visual Analogue Scale
PREFACE
Since ancient Greece, the term *sciatica* has been used to describe pain arising from around the hip and thigh. According to Hippocrates (460-370 BC), “ischiatic” pain mainly affected men between 40 to 60 years of age and lasted usually for 40 days in younger men. However, the term was not used for pain following the distribution of the sciatic nerve until modern times.

Since the beginning of the 20th century, recommending rest was traditionally the key orthopaedic treatment of low back pain. This also applied for sciatica, based on the idea that it, as well as low back pain, was due to a traumatic inflammation which needed to be allowed to heal in order to avoid the development of chronic back pain.

On July 30th 1932, in a corridor of the old Bullfinch Building of the Massachusetts General Hospital, the neurosurgeon William J Mixter and the orthopaedist Joseph S Barr met to discuss a surgical case from the previous day. From this interdisciplinary meeting the work started which identified the prolapsed intervertebral disc as a cause of sciatica. Six months later, the first patient with a preoperative diagnosis of a “ruptured intervertebral disc” entered the operating theatre of the Massachusetts General Hospital. The resulting original paper from 1936 described that disc herniation could cause neurological deficits, and surgical treatment was proposed.

Over the last few decades, diagnostic tools, surgical techniques and postoperative rehabilitation programmes have developed dramatically. The treatment principle of rest has gradually changed into a more active approach. Today it is widely accepted that the key to a well-functioning back is activity, and treatment principles involving early activation for back patients are well established.

Activity patterns are one aspect of behaviour and are therefore affected by beliefs and attitudes. This insight has opened up new perspectives for the postoperative care of back patients. Even though lumbar disc herniation is a precise and well-defined diagnosis, the resulting pain is a multidimensional phenomenon influenced by sensory, emotional and cognitive factors; therefore, understanding pain requires a broad perspective.
BACKGROUND

Some patients with lumbar disc herniation will have an excellent and others a poor outcome after the same type of surgical procedure, despite identical pre-operative clinical and magnetic resonance imaging (MRI) findings. The reasons for this are still largely unknown. Identifying and possibly eliminating or treating factors leading to a poor postoperative outcome is a challenge for all caregivers.

The intervertebral disc and disc herniation

The intervertebral disc connects the vertebrae to a functional unit. Its role is mechanical, acting as an absorber of load forces and as a joint allowing motion in all planes. The outer part, annulus fibrosus consists of lamellae rich in collagen which are structurally and functionally different from the inner part nucleus pulposus which is gelatinous in texture and rich in proteoglycan. The latter provides the disc with its osmotic properties and its ability to resist compressive loads [207].

A disc herniation was first described by Mixter and Barr [158] as a rupture of the annulus fibrosus with leakage of the nucleus pulposus into the intervertebral space. Today, herniation is categorised as a protrusion without perforation of the posterior longitudinal ligament (contained), an extrusion with perforation of the posterior longitudinal ligament (complete/non-contained) or an extrusion with free disc material within the spinal canal (sequestered/non-contained) [104]. This phenomenon usually occurs dorsally or dorsolaterally in the back, between the fourth and fifth lumbar vertebrae, or between the fifth vertebra and the sacrum. Herniation can cause compression and deformation of adjacent nerve structures and result in sciatic and/or back pain [223] (Figure 1).
Aetiology
Among several factors which can contribute to disc herniation, degenerative changes are most common [10, 63]. Disc degeneration is regarded as a weakening, complex multifactorial disease determined by the interplay between genes and the environment [28]. The morbidity curve for disc herniation, however, does not follow the corresponding curve for degeneration. While disc degeneration proceeds with time and is most pronounced in the aging spine, symptoms of lumbar disc herniation are most common in middle age [10, 120].

Genetic disposition, mechanical compression, e.g. heavy torque strain [9, 10, 110] and vigorous physical activity, low frequency vibrations, trauma, obesity and psychosocial stress are all factors which have been referred to as promoters of disc degeneration and subsequent herniation [96, 172].

Research from the last decade has resulted in a shift from heavy physical loading to genetic disposition being considered the main risk factor in the aetiology of disc degeneration [9, 183, 188]. Still, the degenerative progression may be influenced by environmental factors [10].

Pathogenesis
Symptoms of disc herniation may be induced by mechanical compression of the nerve root/s, but the pathogenesis also involves inflammatory and immunological components [67, 68]. Biochemical irritants from the nuclear tissues include an activation of the proinflammatory cytokines [67, 187]. The cytokines excite nociceptors either directly or indirectly via prostaglandin
In particular, the cytokine TNF-alpha [167] and interleukines [69] have been related to the onset of sciatic pain. Other clinical signs of this phenomenon are sensory deficits and/or muscle weakness [34, 168]. The different types of disc herniation have different inflammatory properties; inflammatory cells are more common in sequestered than in extruded discs without a sequester [215]. Moreover, the inflammatory response is influenced by genetic factors [69, 163].

**Prevalence**
The lifetime prevalence of disc herniation is 1-2% [64, 90, 213]. Men are more often affected than women (1.5-1.0) [220].

According to MRI analysis, the occurrence of disc herniation among symptom-free individuals is 20-30% (volunteers, aged 20-80 years) [13, 99]. In comparison, the corresponding proportion is 76% in symptomatic individuals matched for age, sex and work-related factors. The only highly significant difference between individuals with and without symptoms was shown to be the extent of nerve root compression [15].

Disc herniation is most common between 40 and 50 years of age [195] but can occur in all age groups [63, 195].

**Symptoms**
Radiating sciatic pain and back pain are the main symptoms of lumbar disc herniation [183, 223]. The distribution of leg pain usually follows the affected nerve root leaving the spinal canal one vertebral level caudal to the herniation [47]. Lumbar pain and neurological deficits with motor weakness and/or sensory and reflex disturbances specific for the nerve root distribution are other common symptoms [47, 183]. The pain is usually elicited by increased abdominal pressure like coughing and strain, and a pain-induced scoliosis can often be observed [96]. A herniation located centrally in the spinal canal may affect the nerve roots two levels below or nerve roots that exit several levels below. In the cauda equina syndrome, which is an emergency condition, the sacral roots are affected, usually with incontinence, and peroneal sensory loss in addition to bilateral sciatica [1, 41, 47].

**Treatment**
Since most disc herniations will regress with time [35, 101], a conservative treatment approach is usually the first choice. Physiotherapy and/or medical
treatment is frequently recommended to reduce the disabling symptoms. If no progress is observed within six to eight weeks surgery may be considered. The frequency for surgical treatment varies both in the western world and within Sweden [198]: according to Deyo, approximately 5-10% of patients with symptomatic lumbar disc herniation require surgery [46].

Surgery aims to reduce the nerve root irritation caused by compression, thereby relieving pain and improving function [197]. Recovery of adjacent non-compressed nerve roots after surgery may be due to less production of proinflammatory mediators when the disc material is removed [165].

Open discectomy, performed by macrotechnique with or without microscope, is the most common surgical procedure [96].

Indications for surgery are severe disabling leg pain radiating below the knee, a positive nerve tension test (positive Lasègue’s sign at an elevation of less than 30°) with or without neurological symptoms corresponding to the affected nerve root, no improvement despite six to eight weeks of conservative treatment and a positive MRI or computer tomography (CT) examination corresponding well to clinical findings [86]. Acute surgery may be required if a cauda equina syndrome with compromised bladder function develops [74].

It was reported from the Swedish national spine register that 1.7 to 2.1 per 10 000 inhabitants were treated by surgery between 1998 and 2003, 55% men and 45% women. The mean age of these patients was 43 years [197]. The number of surgically treated patients has been almost constant since the mid-1950’s [96].

Systematic reviews on the outcome of disc surgery report a success rate of 65-90% for sciatic pain and disability [6, 73]. According to the Swedish national spine register, 76% of 2796 operations succeeded in reducing sciatic pain [197]. The rate of reherniation after discectomy is low (1%) within the first postoperative year [213]. A large Finnish long-term study found 12% repeated surgery, corresponding to a cumulative risk of 19% in the 9-year follow-up [111].

In the long run, differences between surgical and conservative treatment tend to level out [4, 52, 221]. The long-term results of surgery are difficult to evaluate, however, as the degenerative process is a lifelong progressive disease [176].

The most common residual symptom after disc surgery is low back pain [227].
**Factors associated to the outcome of disc surgery**

Several factors may influence the outcome of disc surgery. Mannion and Elfering emphasised that interactions between several risk factors make the identification of unequivocal predictive factors extremely difficult [144].

Individual patient characteristics are crucial, but assessing outcome is also a matter of defining success. In general, functions related to medical variables (e.g. pain duration, previous spine operations) are best predicted by pain and symptom-specific impairment, whereas disability, general well-being and return to work are better predicted by psychosocial variables [145].

Positively associated with a favourable outcome of disc surgery are factors such as sciatic pain duration of less than one year, a short period of preoperative sick leave [181], disc herniation not being caused by an occupational injury [144], high socioeconomic status and minimal psychosocial stress [105].

Conversely an extremely heavy work load is negatively associated to outcome [12, 137]. This also applies to factors such as smoking [143], low physical activity levels [56], short preoperative walking distance [97], overweight [144], joint-related comorbid conditions, systemic disease (e.g. inflammatory disease) [24, 224], a low educational level [224] and depression [23, 105, 109, 206].

The severity of pathology based on preoperative MRI findings, e.g. characteristics of the herniated disc [24, 103] and the extent of nerve compression [189], have also been referred to as predictors of a poor outcome. Some authors have argued, however, that a preoperative neurological deficit is predictive of a good outcome after surgical treatment [105, 118]. Halldin came to the conclusion that morphologic characteristics of the herniation such as its position in the spinal canal, its direction and size, are of no importance for the postoperative clinical results [84].

**Psychosocial factors associated to the outcome of lumbar disc surgery**

Psychosocial factors can be described as individual characteristics, such as psychological, cognitive or behavioural aspects, but they can also be related to social circumstances in the individual’s life, including work and family issues [210]. These factors are often interrelated, influencing and modulating pain perception and, thereby, perceived health.
Psychological key dimensions are distress, anxiety and depression, all of which have been reported to have a negative influence on the outcome of disc surgery [87, 105, 118, 206]. Cognitive components are represented by attitudes, beliefs and cognitions concerning pain, disability and perceived health. It is well known that these factors play an important role in the development of non-specific low back pain [37, 62, 153, 175, 202], but cognitive aspects also predict pain and disability after disc surgery [42, 43].

Expectations, which are one aspect of cognition, have also been studied in patients with lumbar disc herniation [42, 43, 139, 172]. Ostelo et al. found that a favourable prognosis after surgery was best predicted by high treatment expectancy [172]. In accordance with this den Boer et al. [43] as well as Lutz et al. [139] found that positive expectations before disc surgery could anticipate a favourable treatment result. Moreover, Elfering concluded in his review that a low expectation of treatment success regarding early return to work is strongly linked to a poor work prognosis in patients with spinal disorders [55]. In patients with non-specific low back and neck pain, expectancy, pain-related fear and function are strongly interrelated [14, 77].

Behavioural activity patterns are also referred to as psychosocial factors. A passive attitude towards pain and avoidant and non-verbal pain behaviour can promote negative development of symptoms related to lumbar disc herniation [87].

Psychosocial aspects of work may also play an important role in the perpetuation of back pain in patients with disc herniation. In a case-control study by Seidler et al. it was concluded that psychological strain at work, and time pressure in particular, is more common in cases with symptomatic disc herniation than in healthy controls [191].

It has been suggested that pronounced family problems play a role in the modulation of pain, but the empirical support for this assumption is insufficient [121]. Social support from the spouse in terms of overprotection [189], a search for social support (as a pain behaviour) [105] and family reinforcement of pain [12] have all been associated with a negative outcome after spine surgery.

The impact of demanding life events on the development and onset of low back pain is not yet fully understood. Originally, the instrument for its measurement was studied in cardiovascular diseases, but it has since been used in musculoskeletal research [107, 205]. Adverse life events also appear to be
associated with the development of chronic idiopathic low back pain [116, 121]. To the author’s knowledge, the question of whether stressful life events are more common among patients with disc herniation and radicular pain than in others has not previously been studied.

A large number of studies have demonstrated an association between psychosocial factors and musculoskeletal disorders [5, 13, 65, 99, 121]. These factors may also contribute to an explanation for why discectomy is not universally successful even if the morphological problem is correctly addressed by surgery.

Coping
Applying cognitive and behavioural efforts to manage and adjust stress is defined as coping [123]. Pain causes stress for the individual, with pain coping being defined as an effort to manage or minimise the negative impact of pain.

Coping is the general plan, conscious or unconscious, that we have for dealing with pain. It is believed to be critical for understanding patient behaviour and may also serve as an important part of any treatment that is offered [134].

Problem-focused strategies aimed at altering person-environment relationships are called active coping, in comparison to passive/emotion-focused coping aimed at regulating emotional distress [60, 123]. With regards to pain, an active coping strategy means to try to control pain or continue activity in spite of it. Passive or maladaptive pain coping means negative thoughts, the assignment of the responsibility for pain to others and feelings of helplessness [21]. Catastrophising is defined as an exaggerated negative orientation towards pain [201], whereas kinesiophobia is the fear of physical movement and activity [119].

Passive pain coping and negative expectancies predict residual pain and disability after lumbar disc surgery independent of other biomedical factors such as the extent of disc degeneration and muscular instability [42]. Passive pain coping has also been suggested to contribute to the transition from acute to chronic pain [124, 132, 131]. Burton et al. observed that patients who were prone to catastrophise contributed to 47% of the variation predicting the development of chronic pain after an episode of acute low back pain [22].
Fear avoidance beliefs and the fear-avoidance model

Fear is a normal reaction to acute pain. However, if the pain is prolonged, fear and a belief that activity will cause injury and thereby exacerbate pain can result in avoidance of activity [219]. The fear-avoidance model was first introduced by Lethem [127] and later refined by Vlaeyen et al. [218]. It is a cognitive and behavioural framework explaining how pain-related fear can develop into persistent disability [219]. According to Vlaeyen and Linton, “confrontation and avoidance are postulated as the two extreme responses to this fear, of which the former leads to a reduction of fear over time” [219]. The model includes factors which contribute to deconditioning and in turn reinforce further pain experience, negative expectancies and avoidance. The concept is that fear of pain and (re)injury may be more disabling than the pain itself. Negative pain beliefs, fear and catastrophic misinterpretations, in particular, can lead to a vicious circle of exacerbated fear, avoidance of movements and activities, disuse, distress and disability [219]. According to the model, the anticipation of pain or the harm and (re)injury the pain might imply leads to avoidance of activity rather than the response to pain itself. On the other hand, confrontation strategies increase activity and thereby promote recovery [219].

Research supports the relationship between fear avoidance beliefs and disability both in acute, subacute and chronic phases of musculoskeletal pain [44, 79, 124]. Pain-related fear has been shown to be a salient predictor of pain in a chronic pain population, even more than biomedical status and pain intensity [218].

Studies on the consequences of fear of movement among patients treated by disc surgery are contradictory. Ostelo et al. found that fear of movement is not associated to recovery after disc surgery [172], whereas den Boer et al. concluded that it is predictive of pain and disability [42] as well as work capacity [43] six weeks and six months after disc surgery. There are still few studies available in which the consequences of fear and avoidant behaviour have been analysed in back patients after surgery.

The interplay between psychosocial factors, impairment and disability

In clinical practice, impairment, such as a disc herniation with nerve affection and disability are closely connected. Impairment is defined as a limitation of body functions and structures, causing disability. Both impairment and
disability can be associated with pain, but the direct relationship between pain and disability is weak [20, 135, 210].

There is a dynamic interaction between the two concepts in which disability incorporates cognitive, emotional and behavioural components [210]. Disability is lack of ability, which concerns physiological aspects but also how an individual cope with the impairment. Lack of ability is also a matter of psychological resources, reflected by the efforts an individual is capable of making. Consequently, disability is dependent on the interplay between impairment and psychosocial factors [20, 210]. This interplay differs both between the various stages of the pain process and between individuals. Mannion et al. have emphasized that for patients treated by disc surgery are disability, general well being and return to work after surgery best predicted by psychosocial variables [145].

The physiological stress response system
The physiological stress response system can be defined as a general, non-specific alarm system which alters the homeostatic balance, occurring whenever there is a discrepancy between what is expected or “normal” and what is actually happening. The alarm level depends on the expectancy of the outcome of the threat and the specific available coping responses [209].

The ability to respond to changes and challenges with a general alarm response are an essential element of the overall adaptive and self-regulating system of the organism [128]. The stress response is therefore a normal, healthy and necessary alarm system [208], through which psychological resources are mobilised to improve performance. However, a sustained response may increase the risk of illness or disease [209].

When exposed to stress, a first rapid wave of the stress hormones adrenaline and noradrenalin is released from the adrenal glands [151]. A second hormone wave is initiated if the stress becomes more prolonged and involves activation of the hypothalamic-pituitary-adrenal (HPA) axis. The HPA axis comprises a chain of hormonal reactions with increased production of corticotrophine-releasing hormone (CRH) from the hypothalamus, stimulating the pituitary gland to release adrenocorticotropic hormone (ACTH), which in turn activates the adrenal gland to release cortisol [54].

A stimulus that triggers the stress response is known as a stressor; the most potent stimulus for triggering the HPA axis is psychological stress [148].
Stress hormone activity is dependent not only on the nature of the stressor, but also on an individual’s assessment of available coping resources [113].

The release of cortisol normally follows a pulsatile circadian rhythm with levels peaking in the morning after awakening and than gradually decreasing throughout the day [113]. Cortisol is released and inhibited in an on-off fashion via a negative feedback loop. This loop can be influenced by a stressor, which initially increases cortisol levels. Prolonged stress, however, results in exhaustion with a decreased morning peak as well as a flattened cortisol profile throughout the day [80, 178].

The way cortisol levels change during the day is a potentially important indicator of the function of the HPA axis [194]. In clinical populations, a flattening of the diurnal cortisol rhythm is seen among patients with depression [25], fibromyalgia [36], chronic fatigue syndrome [140] rheumatoid arthritis [162] and patients with residual pain after lumbar disc surgery [70].

Cortisol in human saliva, non-invasively measured in small samples, highly correlates with free cortisol concentrations in the blood [113]. The morning increase is approximately 50-160% of the awakening level, peaking about 30 minutes after awakening [31, 53, 85, 113, 180, 225]. The circadian rhythm in an individual is believed to be relatively stable over time [31, 53, 225]. When measured repeatedly and with reference to awakening, the morning response is considered to be a reliable biological measure of adrenocortical activity [180, 225].

The biochemical process associated with disc herniation involves an inflammatory reaction with activation of proinflammatory cytokines [17, 187]. These are potent stimulators of the HPA axis [8, 70], leading to an enhanced release of cortisol from the adrenal cortex [30, 161]. Cortisol plays a central role in the regulation of the inflammatory response to infection and injury inhibiting the release of cytokines [154]. The function of the HPA axis is one potential pathway through which stress could influence surgical outcome [69].

Furthermore, there are associations between behaviour and the function of the HPA axis. An active way of coping is associated with high cortisol levels, while a more passive one is linked to a low morning cortisol [16]. Low levels of salivary cortisol in the morning and high levels in the evening are also associated to the development of chronic widespread pain [16]. However, there remains a lack of knowledge regarding the causal directions of this possible link between body and mind.
Deconditioning after surgery
Deconditioning refers to a progressive process of worsening physical fitness as a result of reduced muscle activity [219]. Dependent on the duration and severity of symptoms, most patients already experience some degree of deconditioning when they present for disc surgery [91, 150].

Postoperatively, loss of back and abdominal muscle strength and endurance plays a significant role [40, 94]. Structural changes in the spine and spinal muscles are inevitable and are exacerbated by surgery [71, 149, 204]. Atrophy of both type 1 and type 2 fibres and alterations in the connective tissue of multifidus muscles have been observed [125, 174, 228, 230]. This might be the result of disuse, reflex inhibition [92] and/or nerve root impairment [93, 228]. The loss of strength and endurance has been shown to correlate well with activity limitations [40]. Furthermore, postural control, lumbar proprioception [126] and mobility [82, 149] are decreased after disc surgery.

According to Rantanen et al., who explored the structural changes in the multifidus muscles five years after disc surgery, these correlate well with the long-term outcome. There was less recovery of type 2 fibres among those with a negative outcome after surgery than in patients with a positive outcome. The authors suggested that these changes could be minimised by adequate surgical and physiotherapeutic treatment [182].

Rehabilitation after surgical treatment for lumbar disc herniation
Return to normal activity after surgery is dependent on the surgical success but also on the patients’ physical recovery. Postoperative rehabilitation could be important for minimising complaints and deconditioning. Disc degeneration is a continuous process which can be accelerated by lack of physical activity [56], which might also be predictive of repeated spine surgery [108]. A Cochrane review confirmed that intensive postoperative exercises lead to an improved functional outcome [169].

There is a wide variety of post-disc surgery rehabilitation programmes in Sweden. An active treatment approach dominates, however, and most training programmes include exercises which aim to increase back stability, strength, endurance and mobility; recommendations of general future activity and ergonomic advice are also common. However, there is no official consensus and many patients still receive little or no formal rehabilitation after disc surgery.
Treatment models and graded activity

Two treatment models are commonly used in the management of patients with back pain: the medical and the biopsychosocial model.

The medical model implies that an interaction between the patient and a disease leads to an illness complex. It suggests recognising symptoms, identifying and treating the underlying disease and expecting the patient to recover [222]. In an orthopaedic setting this model needs to be in focus, but problems may occur when pain and perceived disability are influenced by psychosocial factors. Therefore, extended knowledge about these factors is needed [211].

According to the biopsychosocial model, pain is an interaction between biological, psychological and social phenomena. Consequently, it incorporates psychosocial variables into treatment programmes, e.g. kinesiophobia, passive pain coping, anxiety and lack of control [27, 45, 219]. This treatment model has favourably been applied to patients with non-specific low back pain [88, 129, 130, 134, 164, 173, 196] and has recently also attracted attention for the management of post-lumbar disc surgery patients.

Operant treatment, which is based on the biopsychosocial model, was first presented by Skinner [193] and introduced to the field of pain management by Fordyce [61]. Principles from learning theories have been employed, e.g. that behaviours are influenced by their consequences. Positive reinforcement of healthy behaviour, withdrawal of attention towards pain behaviour and the inclusion of a time instead of a pain contingent are important elements [61]. Cognitive and behavioural treatment approaches include intervention strategies such as self-instruction, relaxation, developing coping strategies, increasing assertiveness, minimising negative or self-defeating goals, changing mal-adaptive thoughts about pain and goal setting [133, 141].

Graded activity, which is one application of operant treatment, is a submaximal, gradually increasing exercise programme. Its essence is the development of individually graded exercises to teach the patient that it is safe to move while increasing the activity level. The therapist acts as a coach, and sets together with the patient exercise quotas to be performed at each treatment session. These quotas are systematically increased towards preset goals [171].
Previous research on rehabilitation after surgical treatment for lumbar disc herniation

A Cochrane review from 2002 [169] on rehabilitation after lumbar disc surgery concluded: “There is no evidence that patients need to have activity restrictions after first-time lumbar disc surgery. There is strong evidence that intensive exercise programmes starting four to six weeks post-surgery are more effective on functional status and faster return to work (short-term follow-up) as compared to mild exercise programmes. There is also strong evidence that at long-term follow-up there is no difference between intensive and mild exercise programmes with regard to overall improvement.” Furthermore, it was concluded that it was unclear as to what the exact content of post-surgery rehabilitation should be.

Thirteen studies were included in this review of which six were of high quality. The studies were very heterogeneous regarding the type of exercise programmes; timing, duration of the intervention and long-term follow-up were to a large extent lacking. Two main future research topics were addressed in this review:

- Is a minimal care programme that incorporates a message about the importance of activity sufficient for patients with minimal complaints after surgery?
- Psychosocial factors should be taken into account in future research designs.

Since that review, ten randomised controlled studies [29, 50, 57, 59, 83, 114, 115, 170, 190, 226] and one prospective, controlled study [156] have been published on this topic. These add further support to early and active programmes which include trunk muscle strengthening and stabilising exercises. These exercises have above all been shown to be beneficial at short-term follow-up when compared with no postoperative training or a more conservative approach [57, 59, 115].

In long-term follow-ups (12 months or longer), the differences between various training programmes tend to level out [29, 50, 95, 114]. From this perspective, home training seems to be as effective as clinic-based training [29, 57, 59, 102].

In a prospective controlled (non-randomised) study by Millisdotter and Strömqvist, however, a specific stabilising programme which started two weeks after surgery and was employed twice weekly during four weeks
improved disability more than routine care which was less focused on stabilising training [156]. This difference persisted at the 12-month follow-up.

Neural mobilisation has been evaluated in one study in which patients with spinal fusions or laminectomy were also included, but the results indicated that this treatment did not provide any additional benefit in comparison to standard postoperative care for spine surgery patients [190].

Donceel et al. [51] compared a return to work-oriented rehabilitation with routine care which resulted in fewer patients being on sick leave one year after surgery (10% after work-oriented rehabilitation in comparison to 18% after routine care).

Behaviourally-oriented treatment principles have only been evaluated in one study of post-lumbar disc surgery patients where graded activity was applied [170]. It was concluded that these treatment principles did not offer any additional advantages to these patients. However, both Manniche et al. [142]. and Kjellby-Wendt et al. [115] suggested that the intensive and active training approach most benefited the active pain coping patterns the patients adopted, thus implying a positive behavioural effect.

*Home training versus clinic-based training*

According to earlier studies, home-based training can be a feasible treatment arrangement after arthroscopic orthopaedic surgery [39, 185], for patients with acute orthopaedic injuries [7] and with non-specific low back pain [160].

In a number of studies from the previous decade, home-based training was compared to clinic-based and supervised training after disc surgery [29, 38, 50, 57, 59, 83, 102, 142, 226]. Only one of these studies [226] found supervised training to be significantly more effective than home training, but the study sample was small (14 patients in each treatment group). All these studies except the one by Ostelo et al. [170] primarily aimed to evaluate physiotherapy which was entirely physical. Conventional physiotherapy with additional behavioural features has rarely been evaluated.

To conclude, early and active training is beneficial for patients after disc surgery, as well as training programmes including exercises which aim to regain back muscle activity and trunk stability. Furthermore, a passive attitude towards pain seems to be an obstacle for recovery. Previous studies add support to physiotherapist-led training in the short term, but the positive effects tend to equalise within the first postoperative year. Studies which have
evaluated behaviourally oriented physiotherapy are rare. In clinical practice it remains unclear whether minimal instructions regarding training and activity are sufficient, or if an additional comprehensive programme led by a physiotherapist is more appropriate.

**Background summary**

Symptoms related to disc herniation can be induced both by mechanical compression of nerve roots and by biochemical irritants from the disc tissues. It is still unknown if patients with symptomatic disc herniation already have more psychosocial stress than others when they present for surgery and which psychosocial factors most powerfully predict surgical outcome. Psychosocial stress is connected to the physiological stress response system, reflected in the function of the hypothalamic-pituitary-adrenal (HPA) axis. This in turn has an influence on the inflammatory reaction and is also associated to an individual’s cognitive and behavioural stress response. The activation of the HPA axis in patients with disc herniation has only been estimated in a few studies. Therefore, it needs to be further explored to understand possible pathways between psychosocial stress, the physiological stress response, perceived pain and disability. Advantages of early and active training aiming to restore back muscle activity and trunk stability have previously been emphasised in rehabilitation studies. A passive attitude towards pain seems to be an obstacle for recovery. Previous studies add support for physiotherapist-led training in the short term, but the positive effects tend to equalise within the first postoperative year. Studies which have evaluated behaviourally oriented physiotherapy are rare. In clinical practice it remains unclear whether minimal instructions regarding training and activity are sufficient, or if an additional comprehensive programme led by a physiotherapist is more appropriate.
AIMS
The overall aim of this thesis is to study the role of psychosocial factors in patients undergoing first-time lumbar disc surgery in relation to the outcome of both surgery and subsequent physiotherapy. Furthermore, links between the physiological stress response system, psychosocial factors and subjective complaints are studied.

The specific aims of the individual studies are:

- To analyse preoperative psychosocial factors (e.g. work-related stress, life satisfaction and demanding life events) in patients with lumbar disc herniation in comparison with knee patients (Study I).

- To explore the associations between pain, disability, quality of life and psychosocial factors in relation to the diurnal cortisol variability (Study II).

- To compare clinic-based physiotherapy with a behavioural approach to a home-based training programme regarding disability, behavioural aspects, pain and global health measures (Study III).

- To analyse the predictive value of cognitive behavioural factors in relation to pain, disability and quality of life one year after lumbar disc surgery (Study IV).

- To analyse the associations between cognitive behavioural factors and pain, disability and quality of life preoperatively and 12 months after lumbar disc surgery (Study IV).
METHODS

Study design

The study designs of studies I-IV are presented in Table 1.

Table 1. Studies and their design, number of patients, data collection and main outcome measures.

<table>
<thead>
<tr>
<th>Study</th>
<th>Type of Study</th>
<th>Number of patients</th>
<th>Data collection</th>
<th>Main outcome measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Cross-sectional</td>
<td>69 disc patients</td>
<td>Questionnaire</td>
<td>Work-related stress, Life satisfaction, Life events, Sick leave</td>
</tr>
<tr>
<td></td>
<td></td>
<td>162 knee patients</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>Cross-sectional</td>
<td>42 disc patients</td>
<td>Questionnaire</td>
<td>Pain, Disability, Work-related stress, Quality of life, Coping, Fear avoidance beliefs, Diurnal cortisol variability</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Salivary cortisol</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>Randomised controlled trial</td>
<td>59 disc patients</td>
<td>Questionnaire</td>
<td>Disability, Pain, Activity level, Fear avoidance beliefs, Coping, Quality of life, Patient satisfaction, Compliance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Interview</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>Prospective cohort study</td>
<td>59 disc patients</td>
<td>Questionnaire</td>
<td>Pain, Disability, Quality of life, Sick leave, Coping, Fear avoidance beliefs, Expectations</td>
</tr>
</tbody>
</table>

Study populations

The studies included in this thesis are based on a sample of 69 lumbar disc patients from the Departments of Orthopaedics at Uppsala University Hospital and at the Central Hospital in Västerås. Additionally, a sample of 162 knee patients from the same two orthopaedic clinics was included in Study I. All patients were scheduled for first-time lumbar disc surgery between March 2003 and May 2005.
The knee patients in Study I were planned for arthroscopic knee surgery for a suspected meniscus tear during the same time period. For an overview of participating patients see Figures 2 and 3.

**Inclusion and exclusion criteria**

Inclusion criteria for all four studies were patient age between 18 and 60 years, no previous spine or knee (Study I) surgery and disc herniation as main indication for decompression surgery. Exclusion criteria were acute surgery, comorbidity influencing daily activities or working capacity and not being fluent in the Swedish language. Steroid treatment was an exclusion criterion in Study II.

Overall, 253 patients with lumbar disc herniation underwent surgery in the two participating orthopaedic clinics during the study period. Spine surgery was acute or repeated in 97 patients who could therefore not be included in the studies. Thus, a total of 156 disc patients were checked for eligibility of which 69 patients were allocated to Study I. Forty two of these patients were also included in Study II and 59 in Studies III and IV. For an overview of participating patients and reasons for exclusion see Figures 2 and 3.

Additionally, 232 knee patients were contacted, all agreeing to participate in Study I; 162 of these returned the completed questionnaire within the requested time limits.
Number of patients with lumbar disc herniation operated during the study period, $n=253$

Number of acute or reoperated patients, $n=97$

Number of patients excluded, $n=87$
- 55 patients did not meet the inclusion criteria;
- 33 patients with age $<18$ or $>60$
- 20 patients with comorbidity
- 2 patients not Swedish speaking
- 27 patients excluded for other reasons;
- 15 patients for geographical reasons
- 4 patients planned for day surgery
- 8 patients could not be traced
- 5 patients refused to participate

Number of patients checked for eligibility, $n=156$

Informed consent

Baseline measurements, $n=69$ patients in Study I

42 patients eligible for participation in Study II

59 patients participating in Studies III and IV, randomisation

Additional 10 patients excluded for geographical reasons

Allocated to the clinic-based training group, $n=29$
(all received clinic-based training)

Post-treatment measures at three months, $n=29$

Post-treatment measures at 12 months, $n=28$
1 patient did not return questionnaire

Allocated to the home-based training group, $n=30$
(all received home-based training)

Post-treatment measures at three months, $n=30$

Post-treatment measures at 12 months, $n=29$
1 patient did not return questionnaire

42 patients eligible for participation in Study II

59 patients participating in Studies III and IV, randomisation

Additional 10 patients excluded for geographical reasons

Allocated to the clinic-based training group, $n=29$
(all received clinic-based training)

Post-treatment measures at three months, $n=29$

Post-treatment measures at 12 months, $n=28$
1 patient did not return questionnaire

Allocated to the home-based training group, $n=30$
(all received home-based training)

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Post-treatment measures at 12 months, $n=29$
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Post-treatment measures at 12 months, $n=29$
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(all received clinic-based training)

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Post-treatment measures at 12 months, $n=28$
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(all received home-based training)

Post-treatment measures at three months, $n=30$

Post-treatment measures at 12 months, $n=29$
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59 patients participating in Studies III and IV, randomisation

Additional 10 patients excluded for geographical reasons

Allocated to the clinic-based training group, $n=29$
(all received clinic-based training)

Post-treatment measures at three months, $n=29$

Post-treatment measures at 12 months, $n=28$
1 patient did not return questionnaire

Allocated to the home-based training group, $n=30$
(all received home-based training)

Post-treatment measures at three months, $n=30$

Post-treatment measures at 12 months, $n=29$
1 patient did not return questionnaire

Figure 2. Flow chart of inclusion and exclusion, allocation to Studies I-IV and post-treatment measurements for patients operated for lumbar disc herniation.
69 patients with lumbar disc herniation

162 knee patients

Study I
69 patients with lumbar disc herniation
162 knee patients

Study II
42 patients

Study III
59 patients

Study IV
59 patients

Figure 3. Numbers of patients participating in Studies I-IV

**Measures**

*A. Assessment questionnaires*

All lumbar disc herniation patients received a questionnaire at enrolment one to four weeks before surgery at their respective clinic. The completed questionnaire was returned the day before surgery.

Two follow-up questionnaires were sent by mail 3 and 12 months after surgery.

The knee patients in Study I were similarly sent a questionnaire which they returned by mail one to four weeks before planned arthroscopic knee surgery. For an overview of measurements see Table 1 and Figure 4.

The questionnaire to be answered preoperatively and 3 and 12 months after surgery included questions regarding:

**Demographics (Studies I, II, III and IV)**

Background variables, including age, sex, diagnosis, occupation, work load, sick leave (preoperatively and at 12-month follow-up), physical activity level, and preoperative duration of current back and leg pain.

**Psychosocial stress at work (Studies I and II)**

Work-related stress was measured by a short form of the Quality-Work-Competence (QWC) questionnaire. Its scales have been developed in a series of studies based on samples comprising approximately 100 000 employees overall. It has acceptable validity and reliability [3]. The questionnaire
contains three items on job satisfaction, concerning the current, previous and coming years. The subsequent indices cover areas such as mental energy, work climate, work tempo, performance management, participatory management, skills development, organisational efficacy and leadership. Each area consists of one to five items with standard Likert check-off scales. The scores on the enhancement indices range from 0 to 100.

**Life satisfaction (Study I)**
Life satisfaction was assessed using a modified Life Satisfaction Scale 9 (LiSat-9), a nine-item self-administered checklist, both regarding life as a whole (one item) and domain-specific (eight items) [152]. Its items have an acceptable test-retest reliability, specificity and sensitivity [19, 76]. We omitted one question on sex life and added one question on sleep satisfaction. The domains were vocation, personal finances, spare time, contact with friends, relationship with partner, family life, sleep and activities of daily living.

Levels of life satisfaction were reported on a six-grade scale ranging from very dissatisfied (1) to very satisfied (6).

Additionally, a dichotomy was used in the analysis with grades 5-6 classified as satisfied and grades 1-4 as not satisfied.

**Life events (Study I)**
A modification of the Social Readjustment Scale (SRSS) [121] was used to retrospectively assess stressful life events of the two years preceding surgery. This scale measures a number of events requiring life adjustment covering, for example, changes in family constellation, marriage, group and peer relations, occupation, economics, residence and health. It contains 18 questions with the response alternatives “Yes” or “No”. A given number of points per item are multiplied with the factors 0 (no) or 1 (yes) and the total life events score is than obtained by addition of all points.

**Disability (Studies II, III and IV)**
Disability was assessed using the Oswestry Disability Index [58] with a possible score distribution from 0 (no disability) to 100 (maximal disability). The Swedish version of the ODI has a proven validity and a high degree of responsiveness [81].
Pain (Studies I-IV)
Back and leg pain intensity during activity in the previous week was assessed by visual analogue scales (VAS) [177].

In addition, the patients reported orally whether their leg pain was better, unchanged or worse three weeks after compared with before surgery.

Quality of life (Studies II, III and IV)
Generic health-related quality of life was measured by Medical Outcomes Study Short Form Health Survey 36 (SF-36) [199, 212], which has an acceptable reliability, validity and responsiveness [229]. Quality of life was also measured by the five dimensional scale of the European Quality of life questionnaire (EuroQol 5D) (Study III and IV) and European Quality of life visual analogue scale (EuroQoLVAS) (Study III) [18].

Coping (Studies II, III and IV)
The coping self-statement and catastrophising subscales of the Coping Strategies Questionnaire (CSQ) were used. Each of the two dimensions contains six questions and has a possible score ranging from 0 to 36. A higher score indicates higher coping self-statement and higher catastrophising, respectively [122, 186]. Reliability coefficients for each of the subscales range from 0.71 to 0.85 [186], with a value of 0.83 for the Swedish version [98].

Fear avoidance beliefs (Studies II, III and IV)
A modification of the Tampa Scale for Kinesiophobia (TSK) with a possible score distribution from 12 to 48 [155] was included. Low scores indicate no fear avoidance and high scores the opposite. Five questions of the TSK scale dealing with attitudes towards pain were omitted as they refer to pain not being caused by a serious condition. Most psychometric research has been done with the Dutch version which has a reliability of $\beta=0.77$ and an acceptable validity in acute and chronic low back pain populations [119, 155, 216]. The Swedish version has also been shown to have an acceptable reliability and validity in patients with chronic back pain [138].

Patient satisfaction (Study III)
Patient satisfaction regarding physiotherapy care was measured by two separate questions three months after surgery. The first question was “In your own view, did you receive enough help from the physiotherapist after your back operation?”. Possible answers were “No, I received too little help” or “Yes, I
received enough help”. The second question was “Would you recommend the physiotherapy you received to a friend who is going to be treated by disc surgery?” Possible answers were “Yes” or “No”.

**Therapies given by other caregivers (Study III)**
Some separate questions were included at 3-month follow-up to ascertain whether patients had sought treatment by other caregivers during the study period. The first question was “Have you been treated by any caregiver/s other than those at the hospital since you had your back operation?” Possible answers were “Yes” or “No”. For those patients who answered positively there was an attendant question regarding which caregiver they had visited and how many times.

**Physical training habits (Study III)**
Three separate questions assessed patients level of physical training and possible walking distance: whether the individual was regularly physically active (“Yes” or “No”) and, if yes, in which way, how often they were regularly physically active (from occasionally to five times or more per week) [214] and how often they performed back exercises (from never to several times per day).

**Expected outcome (Study IV)**
A patient’s own perception of his or her likeliness to recover was preoperatively measured with one item: “In your estimation, what are the chances that you will be back at work in three months?” This question was rated on a scale of 0 (no chance) to 10 (very high chance). This question is one item of the Örebro Screening Questionnaire [136].

**Salivary cortisol measures (Study II)**
Salivary cortisol levels were analysed in all patients in Study II. Four salivary samples were obtained from each patient three days before surgery using Salivates (Sarstedt, Nümbrecht, Germany). The patients collected the salivary samples at home, keeping the saliva test tubes in their refrigerator and bringing them, when presenting for surgery.

Salivary cortisol levels were analysed with a commercial radioimmunoassay (Spectria, Orion Diagnostica Oy, Espoo, Finland).
The salivary samples were collected at four time points:
- directly upon awakening
• 30 minutes after awakening
• before the evening meal
• at bedtime

Three different estimates on the reactivity of the diurnal cortisol levels were used:

• The diurnal cortisol variability, i.e. the difference between morning peak and last evening salivary cortisol value [192].
• The total area under the response curve including all four cortisol measures (AUCG1) [179].
• The total area under the response curve including only the two morning values (AUCG2).

Since the diurnal cortisol variability showed the highest association to pain and disability (calculations done using Spearman’s rank correlation coefficient), this difference was used in the subsequent analysis in Study II. The patients were dichotomised into the low cortisol variability group (salivary differences of median 14.87 nmol/l or less than median) or the high cortisol variability group (difference between morning and evening salivary measures higher than median 14.87 nmol/l). These two groups were compared in the analysis in Study II.

Telephone interview (Study III)
Patients who were allocated to the home training group in Study III were followed up three months after surgery with a structured telephone interview regarding compliance with the training programme. The patients were asked if they had trained frequently (“Yes” or “No”), how frequently they had trained the first three months after surgery and if they thought the training instructions they had received were sufficient.
Treatment
For an overview of the measurement time points and the treatment patients received see Figure 4.

![Timeline of measures and interventions for disc patients participating in Studies I-IV.](image)

Surgery
All patients were operated with a standard lumbar discectomy using microsurgical technique with magnifying glasses but without microscope.

Physiotherapy

**Initial physiotherapy 0-3 weeks after surgery**
All patients received oral and written information about postoperative training from a physiotherapist in the ward. Exercise started the first day after surgery and comprised stabilisation of the trunk by activation of the deep abdominal muscles [166], activation of the back, abdominal and buttock muscles, back and hip mobility and instructions about how to best get out of bed. Additionally, the patients received a written exercise programme which they were instructed to follow at least once a day. No sitting restrictions were given; daily walks and a gradual increase of daily activities were encouraged.

The same physiotherapist followed up all patients three weeks after surgery. For those patients in Study III who were allocated to the home-based training group this was the only physiotherapy visit they experienced. At this follow-up visit all patients were clinically examined and given a new training programme which they were recommended to follow daily. The importance of physical
activity for the healing process was emphasised. The new programme comprised back and hip mobility, trunk stability, strengthening of back, abdominal and leg muscles, and stretching of back, hamstring, quadriceps femoris and calf muscles. The patients were recommended to continue, and gradually extend, their daily walks and return to their work and normal daily routines as soon as possible. They were given no restrictions apart from heavy lifting during the first three months after surgery.

After this visit, the patients followed one of the two treatment groups (Study III), the clinic-based or the home-based training group.

The clinic-based training group
Patients who were randomised to the clinic-based training group visited the physiotherapy department once a week for eight weeks, starting at the first follow-up visit three weeks after surgery and continuing until ten weeks after surgery. They worked on their exercises under supervision by the same physiotherapist in addition to their daily home programme and were recommended to gradually resume normal daily activities. All patients were treated by the same physiotherapist (ACJ). The physiotherapy was influenced by a behavioural operant approach including graded activity with positive reinforcement of healthy behaviour, aiming to reduce fear and avoidant behaviour [61, 72, 129, 130, 170, 217]. The exercise programme comprised back and hip mobility, trunk stability, and strengthening of back, abdominal and leg muscles. Exercises with weight resistance were gradually added and increased. The programme also comprised general condition training by treadmill walking, stretching of back, hamstring, quadriceps femoris and calf muscles as well as a short relaxation. The patients also had the opportunity to discuss questions and thoughts about their condition at every visit. Active coping styles were encouraged; patients with residual pain were recommended to continue with their daily walks and home programme regardless. If a patient showed signs of passive pain coping, barriers to activity were identified and discussed and alternatives to painful exercises were given. The importance of future regular physical training was continuously emphasised and the patients were requested to establish goals for future regular weekly physical activity.

The home-based training group
Patients randomised to the home-based training group were informed and instructed at the above described occasion three weeks after surgery. No
additional instructions were given to this group. They were recommended to gradually increase the number of repetitions of the exercises and their daily walks as well as to resume normal daily activities. Future regular physical activity was encouraged. After this visit, the patients continued to train on their own. They had the possibility of contacting the physiotherapist if they had any questions concerning their training programme.

**Statistical methods**

*Power analyses*

**Study I**
It was determined that a total of 70 disc patients and 70 knee patients was needed to detect a mean score difference of 15 points on the QWC subscale of work-related stress with a 80% power at a 5% significance level. As we had access to 162 eligible knee patients, we included all these patients, to ensure high power.

**Study III**
According to the power analysis performed prior to the study, a total of 50 patients, 25 in each group, was needed to detect a clinically significant mean score difference of eight points in the ODI (SD=10) with 80% power and a significance level of 5%. To allow for possible drop-outs we decided to include 30 patients in each of the two groups.

No power analyses were made for Studies II and IV since they had an exploratory nature and were based on available patients.

*Analysis methods*

In this thesis most data were ordinal or not normally distributed and were therefore analysed mainly with nonparametric methods.

Median values were used as a measure of location and the interquartile range (q₁–q₃) as a measure of dispersion (Studies I-IV) means and standard deviation were correspondingly used for interval data (Studies II and IV).

Independent comparisons between groups were analysed using the Mann-Whitney rank sum test (Studies I-IV).
Changes within groups over time were studied using the Wilcoxon signed rank test (paired variable test) (Studies III and IV).
Differences in proportions were analysed by chi-square statistics and Fisher’s exact test (Studies I-IV) and changes in proportions over time by McNemar’s test (Study III).

The Spearman correlation coefficient (r_s) was applied when calculating correlations (Studies II and IV).

Analysis of interaction (Study I):
Since the variable representing job satisfaction in Study I was not normally distributed, a nonparametric test for interactions, based on aligned ranks (program written in FORTRAN) [231] was also applied. Briefly, the test is based on the joint ranking of all observations after removing the effect of the group affiliation (disc or knee patient). Suitably normalised, the weighted sum of squared differences between the two subcategories’ mean rank (each combination of group affiliation and sick leave status) and the total mean rank will be approximately F-distributed. If the null hypothesis was rejected, a Kruskal-Wallis test was performed with each combination of group affiliation (disc herniation and controls) and sick leave status constituting a separate subcategory. A two-sided p-value of less than 0.05 was considered to be significant in all the analyses of main effects, while a significant p-value when testing for the presence of interactions had to be less than 0.1.

In Study IV, multiple backward stepwise logistic regression analysis was performed to study the contribution of the behavioural/cognitive factors (coping, fear avoidance beliefs and assessed chance to return to work within three months) to pain, disability and quality of life 12 months after surgery. To check the possible multicollinearity of predictor variables (i.e. insufficient unique variance of different predictors due to high intercorrelation) we calculated correlation coefficients for all studied variables with each other. Only those variables with a correlation coefficient r<0.40 were included in the regression model (e.g. the coping variables were omitted since their correlation to the variable “chance to return to work within three months” was too high). A regression model including independent variables which fulfilled the multicollinearity restrictions and had a p-value <0.10 was used. The variables were divided into high or low scores based on median values. The variables age, sex, work load, duration of leg pain preoperatively, and the behavioural variables coping catastrophising, fear avoidance beliefs and expectations of chance to return to work within three months after surgery were included in the final regression model. Furthermore, the two rehabilitation groups were
controlled for in the regression analysis. To check for possible influence of the type of rehabilitation received we investigated this variable’s effect on the relationship between the independent and the dependent variables. No significant effects were found. The influence of the independent variables on dependent variables was presented by odds ratios and 95% confidence intervals. The explanation value of the regression model was calculated using Nagelkerke $R^2$.

**Intention to treat principle (Study III):**
According to the intention-to-treat principle, the two patients who underwent repeated surgery during the first postoperative period were included in the data analysis. We performed a separate analysis without these two patients and found only minor differences concerning group median values; moreover, these differences did not influence any of the outcome variables.

The chosen level of significance was $p<0.05$, two-tailed.

**Ethics**
All studies were approved by the Research Ethics Committee of Uppsala University (No 02-115 and 02-116) and performed in accordance with the principles of the Helsinki Declaration (World Medical Association Declaration of Helsinki: Ethical principles for medical research involving human subjects. Adopted by the 18th WMA General Assembly, Helsinki June 1964. Revised in Tokyo, 2004).
RESULTS

Presence of psychosocial factors preoperatively (Study I)
Sick leave was considerably more common in the disc patients: 62% had been on sick leave for a mean of almost eight months, while only 14% of the knee patients had been on sick leave for a mean of four months.

There were no significant differences between the two groups regarding work-related stress measured by the Quality-Work-Competence (QWC) questionnaire which includes aspects of work such as work-related exhaustion, work climate, work tempo, performance management, participatory management, skills development, organisational efficacy and leadership.

The overall satisfaction of disc patients with their present work situation (one item of the QWC questionnaire) was lower (median score 50) than in knee patients (median score 70). Being on sick leave had significantly negative impact on job satisfaction in disc patients (median score 35 versus 70). This pattern was not seen in knee patients. Consequently, there was an interaction between the variables of group affiliation (disc or knee patient), sick leave and current job satisfaction.

Both disc patients on sick leave and knee patients on sick leave expected significantly higher job satisfaction the following year than they currently experienced. The expected improvement was significantly larger in disc patients than in knee patients (45 versus 10).

Less work satisfaction in the disc patient group in comparison to the knee patient group was also reflected in the results of the LiSat-9 questionnaire. There was also a significant difference between the two groups regarding leisure time, activities of daily living and sleep. Satisfaction with life overall, with personal finances, contacts with partner or friends, and family life, was similar between the two groups (Figure 5).
Life as a whole

Figure 5. Life satisfaction. Proportions (%) of disc and knee patients, respectively who were satisfied or very satisfied (grade 5 or 6) according to LiSat-9 questionnaire.
*Denotes $p<0.05$.

Self-reported occurrence of demanding life events during the two years before planned disc surgery was also similar in both groups (mean 3.0 for disc and 2.9 for knee patients).

**The diurnal cortisol variability in relation to pain disability, quality of life and coping (Study II)**
No significant differences in background variables between the high and the low cortisol group were found.

Scores for pain, disability, coping fear avoidance beliefs and quality of life are presented in Table 2. Leg and back pain intensity varied markedly but did not differ between the two groups. The low cortisol group was more disabled according to the Oswestry Disability Index than the high cortisol group.
Health-related quality of life, estimated with the SF-36 dimension physical function, was poorer in the low cortisol group than in the high cortisol group. Fear avoidance beliefs were comparable in both groups.

Patients in the low cortisol group had lower coping self-statement scores than the high cortisol group but higher pain catastrophising scores.

There were only small and negligible differences between the two groups regarding work-related stress.

Table 2. Median score (interquartile range) for pain, disability and coping in the low and high cortisol group, respectively. *P*-values for the comparison between both groups.

<table>
<thead>
<tr>
<th></th>
<th>Low cortisol group median (interquartile range)</th>
<th>High cortisol group median (interquartile range)</th>
<th>Difference between groups <em>p</em>-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg pain intensity, VAS range 0-100</td>
<td>79 (52-92)</td>
<td>68 (39-77)</td>
<td>0.10</td>
</tr>
<tr>
<td>Back pain intensity, VAS range 0-100</td>
<td>70 (42-80)</td>
<td>68 (61-78)</td>
<td>0.83</td>
</tr>
<tr>
<td>Oswestry Disability Index range 0-100</td>
<td>40 (34-51)</td>
<td>30 (26-45)</td>
<td>0.03</td>
</tr>
<tr>
<td>Coping self-statement range 0-36</td>
<td>18 (15-21)</td>
<td>23 (18-28)</td>
<td>0.01</td>
</tr>
<tr>
<td>Coping catastrophising range 0-36</td>
<td>15 (12-18)</td>
<td>10 (4-17)</td>
<td>0.04</td>
</tr>
<tr>
<td>Fear avoidance beliefs (TSK) range 12-48</td>
<td>33 (27-36)</td>
<td>31 (27-38)</td>
<td>0.74</td>
</tr>
<tr>
<td><strong>SF-36:</strong> (range 0-100)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>physical function</td>
<td>45 (28-53)</td>
<td>60 (45-68)</td>
<td>0.02</td>
</tr>
<tr>
<td>role physical</td>
<td>0</td>
<td>0</td>
<td>0.53</td>
</tr>
<tr>
<td>bodily pain</td>
<td>31 (17-41)</td>
<td>31 (22-41)</td>
<td>0.56</td>
</tr>
<tr>
<td>general health</td>
<td>67 (56-87)</td>
<td>77 (51-87)</td>
<td>0.43</td>
</tr>
<tr>
<td>vitality</td>
<td>33 (25-48)</td>
<td>40 (28-50)</td>
<td>0.42</td>
</tr>
<tr>
<td>social function</td>
<td>63 (38-88)</td>
<td>75 (44-81)</td>
<td>0.94</td>
</tr>
<tr>
<td>role emotional</td>
<td>66 (0-100)</td>
<td>33 (0-100)</td>
<td>0.94</td>
</tr>
<tr>
<td>mental health</td>
<td>68 (46-76)</td>
<td>68 (50-78)</td>
<td>0.68</td>
</tr>
</tbody>
</table>
Clinic-based training in comparison to home-based training after first-time lumbar disc surgery (Study III)

Three months after surgery there were no significant differences between the two groups regarding ODI, level of physical training, maximum walking distance, kinesiophobia, coping, pain or quality of life. Compliance to prescribed training was high in both groups.

The home-based training group had the opportunity to contact the physiotherapist during the eight weeks of home training. Six patients (20%) used this opportunity; a total of 13 telephone calls. They all had questions and concerns about residual leg or back pain.

Comparisons of differences between the two groups at baseline and the different time points are presented in Table 3. Most patients in the home-based training group (86%) thought they had got on well with their exercises at home, while four patients were dissatisfied. Three patients had not undertaken the home programme at all.

Three months after surgery, significantly more patients in the clinic-based training group than in the home-based training group (28 versus 20) reported that they had received sufficient help from the physiotherapist. In line with this finding, significantly more patients in the clinic-based than in the home-based training group was willing to recommend their treatment to other patients (27 versus 21).

At 12-month follow-up there were no significant differences between the two treatment groups regarding disability, kinesiophobia or coping (Table 3). Back pain was, however, significantly more reduced in the home-based than the clinic-based training group. Reduction of leg pain showed the same pattern, but this difference was not statistically significant (Table 3).

Quality of life as measured by EuroQol VAS increased significantly more in the home-based training group than in the clinic-based training group at 12-month follow-up (Table 3). This difference was also reflected in the dimensions physical function, bodily pain and vitality of the SF-36 questionnaire.

All patients in the clinic-based training group but only 23 patients (79%) in the home-based training group reported that they trained regularly.
Table 3.
Median preoperative values for the two treatment groups. Medians of outcome scores and medians and interquartile range for differences between the two treatment groups at the different time points. *P*-values for comparisons of differences between the two treatment groups 3 and 12 months after disc surgery.

<table>
<thead>
<tr>
<th></th>
<th>Preoperative value</th>
<th>3 months post intervention</th>
<th>12 months post intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Clinic-based</td>
<td>Home-based</td>
<td>Clinic-based</td>
</tr>
<tr>
<td></td>
<td>training group</td>
<td>training group</td>
<td>training group</td>
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<tr>
<td></td>
<td>p-value</td>
<td>p-value</td>
<td>p-value</td>
</tr>
<tr>
<td>ODI¹ (0-100) median</td>
<td>38</td>
<td>39</td>
<td>16</td>
</tr>
<tr>
<td>median for difference</td>
<td></td>
<td></td>
<td>(-20)</td>
</tr>
<tr>
<td>Back pain VAS² (0-100) median</td>
<td>70</td>
<td>70</td>
<td>23</td>
</tr>
<tr>
<td>median for difference</td>
<td>(-31)</td>
<td>(-42)</td>
<td>(-23)</td>
</tr>
<tr>
<td>Leg pain VAS² (0-100) median</td>
<td>75</td>
<td>70</td>
<td>18</td>
</tr>
<tr>
<td>median for difference</td>
<td>(-32)</td>
<td>(-53)</td>
<td>(-23)</td>
</tr>
<tr>
<td>TSK³ (12-48) median</td>
<td>31</td>
<td>33</td>
<td>20</td>
</tr>
<tr>
<td>median for difference</td>
<td>(-10)</td>
<td>(-9)</td>
<td>(-23)</td>
</tr>
<tr>
<td>CSQ⁴ Self-statement (0-36) median</td>
<td>19</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>median for difference</td>
<td>(-4)</td>
<td>(-6)</td>
<td>(-2)</td>
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<tr>
<td>CSQ⁴ Catastrophising (0-36) median</td>
<td>15</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>median for difference</td>
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<td>(-9)</td>
<td>(-2)</td>
</tr>
<tr>
<td>EuroQol⁵ 5D (0.594-1) median</td>
<td>0.19</td>
<td>0.33</td>
<td>0.76</td>
</tr>
<tr>
<td>median for difference</td>
<td>(0.06)</td>
<td>(0.76)</td>
<td>(0.11)</td>
</tr>
<tr>
<td>EuroQol⁵ VAS (0-100) median</td>
<td>50</td>
<td>49</td>
<td>80</td>
</tr>
<tr>
<td>median for difference</td>
<td>(10,43)</td>
<td>(12,49)</td>
<td>(8,33)</td>
</tr>
</tbody>
</table>

ODI¹ = Oswestry Disability Index, VAS² = Visual Analogue Scale, TSK³ = Tampa Scale for Kinesiophobia, CSQ⁴ = Coping Strategy Questionnaire, EuroQol⁵ = Quality of Life
Cognitive and behaviour variables as predictors of pain, disability and quality of life one year after surgery (Study IV)

A low score on the item “In your estimation, what are the chances that you will be working in three months?” was significantly predictive of all outcome variables, with the highest odds ratio for being on sick leave 12 months after surgery (OR=19.5).

Of the 13 patients who preoperatively had assessed their chance of returning to work within three months as low, six patients were still on sick leave 12 months after surgery.

The strongest predictor for low quality of life 12 months after surgery was a high score of fear avoidance beliefs (OR=6.6). Being a woman was also predictive of low quality of life 12 months after surgery (OR=6.0).

The regression model explained 26-40% of the variation in the outcome variables pain (leg pain 26%, back pain 24%), disability (26%), quality of life (35%) and sick leave (40%), as measured by Nagelkerke R². Almost 40% of the variation in sick leave 12 months after surgery could be explained by low preoperative scores on the item “In your estimation, what are the chances that you will be working in three months?”

Associations between cognitive behavioural factors and pain disability and quality of life (Study IV)

Preoperatively

Associations between behavioural variables and pain, disability and quality of life were generally weak before surgery. High coping self-statement was positively associated to high quality of life, \( r_s=0.4 \), whereas there was an inverse association between coping catastrophising and quality of life, \( r_s=-0.4 \). A high score on the item “In your estimation, what are the chances that you will be working in three months?” was associated with low scores on back pain \( r_s=0.3 \).

One year after surgery

Generally, the associations between behavioural variables and pain, disability, quality of life and being on sick leave were stronger among patients with residual pain after 12 months \( n=35 \) compared to corresponding associations before surgery based on all patients \( n=59 \).
Coping catastrophising was highly related to residual leg pain ($r_s=0.6$), back pain ($r_s=0.7$) and disability ($r_s=0.8$) 12 months after surgery.

Fear avoidance beliefs were also highly significantly associated to residual leg pain ($r_s=0.5$), back pain ($r_s=0.6$) and disability ($r_s=0.5$).
GENERAL DISCUSSION
The overall aim of this thesis was to study the role of psychosocial factors in the outcome of surgical and physiotherapeutic treatment for patients undergoing first-time lumbar disc surgery.

Psychosocial factors were explored preoperatively, their predictive value for outcome was assessed and links between the biological stress response system, psychosocial factors and subjective complaints were analysed. Furthermore, two different rehabilitation programmes were compared, both of which aimed at increasing activity and decreasing disability and pain after surgery.

Briefly, our results suggest that psychosocial factors such as work-related stress, life satisfaction and life events were not more common preoperatively in patients with disc herniation than in knee patients. The patients’ own expectancy of their postoperative return to work was the strongest predictor of pain, disability and quality of life one year after surgery. Furthermore, patients with low diurnal cortisol variability preoperatively had worse physical function, perceived less ability to influence their pain and were more prone to catastrophising than patients with high diurnal cortisol variability. When active pain coping was encouraged together with careful training instructions, home-based training was a feasible treatment arrangement after surgery.

Study population
It is important to note that, even though lumbar disc herniation is a clearly defined diagnosis, the patient group undergoing surgery is very heterogeneous regarding the intensity of pain and dysfunction both pre- and postoperatively [106]. The results of this thesis derive from a selected group of Swedish speaking patients between 18 and 60 years of age and without comorbidity who underwent planned first-time spine surgery. It must be emphasised that the results can only be valid for this patient group, which constituted approximately 44% of all patients who underwent disc surgery at the two Swedish hospitals between 2003 and 2005. The most frequent reasons for exclusion were age over 60 years and comorbidity. It is possible that psychosocial factors in general would have been more pronounced if patients with comorbidity had been included since it influences most aspects of life [75]. The age limitations might also have affected the results as the clinical presentation in older patients is somewhat different [106]. Walking capacity, for example, can be expected to be more limited and the accomplishment of
the prescribed training more difficult. Additionally, comorbidity should be more common among older patients. One year after surgery, our study group had somewhat lower pain scores compared with corresponding values of the Swedish National Spine Register [197]. This may further emphasise that our results are based on a strictly selected study group.

**Psychosocial factors preoperatively and one year after surgery**

*Psychosocial factors in patients with lumbar discs herniation in comparison to knee patients*

In Study I our aim was to investigate if the presence of psychosocial stress in general was common already preoperatively among patients with disc herniation. The psychosocial factors we explored were limited to work-related stress and life satisfaction which covered areas such as family life, contacts with acquaintances, relationship with a partner, personal finances and stressful life events that had occurred during the previous two years. When disc patients were compared with knee patients, these factors did not differ. One could have expected work-related stress to be more common in disc patients since Boos et al. had described higher occupational and mental stress and less job satisfaction in symptomatic disc patients compared with asymptomatic controls [15]. This discrepancy could either be due to differences in those patients chosen as controls or different methods of measuring work stress.

As expected, sick leave was more common among patients with disc herniation. The patients with disc herniation on sick leave had higher expectations regarding future work satisfaction than knee patients on sick leave. This probably reflects the fact that patients with disc herniation are more compromised regarding their work than knee patients. Furthermore, disc patients expected that the planned surgical treatment would increase their reduced work capacity. They also expected higher work satisfaction for the coming year than that they had experienced during the previous year; this could partly be explained by their longer preoperative sick leave (mean duration eight months). The shorter preoperative sick leave of knee patients (mean duration four months) might imply that most of them had been able to accomplish their work the previous year, leading to better work satisfaction. Expectations of better postoperative work satisfaction in patients with disc herniation were irrespective of sick leave. This might indicate that their symptoms affected work capacity even if they were not on sick leave preoperatively.
Coping
In Study IV, associations between coping (self-statement and catastrophising) and pain, disability and quality of life preoperatively were assessed. These associations were generally weak. The strongest link was between high scores on the coping dimension self-statement and a high quality of life \( (r_s = 0.4) \), indicating that strategies for pain control will have a positive impact on quality of life, even if pain is severe. An inverse association was seen between coping catastrophising and quality of life.

One year after surgery, coping was analysed in 35 patients with residual pain (Study IV). Here, the association between the coping dimension catastrophising and pain was much stronger than in the overall study group before surgery. Patients are often able to muster resources to cope with pain reasonably successfully if the duration of pain is short [141]. Prolonged pain, however, requires a much wider range of coping skills, and residual pain despite surgery might be a source of anxiety and fear of future persistent pain. This in turn can set the stage for behavioural changes towards a more pronounced passive pain coping. According to Main et al. [141], pain patients are concerned about the cause of their pain, its likelihood to respond to treatment, and what they can expect in the future. High levels of residual pain despite surgery might for some patients trigger an anxiety of persistent and treatment-resistant pain. This can intensify pain perception and initiate a self-perpetuating vicious cycle of anxiety, increased pain, catastrophising and possibly also avoidant behaviour.

Fear avoidance beliefs
Associations between fear avoidance beliefs and pain, disability and quality of life preoperatively followed the same pattern as coping and were generally weak (Study IV). Corresponding associations 12 months after surgery were stronger in patients with residual pain.

Pain despite surgery might give rise to fear and avoidant behaviour since these patients must have experienced that their attempts to increase activity had worsened pain. A belief that treatment-resistant pain and disability are best handled by avoiding activity might be linked to this experience.

In unspecific low back pain, evidence suggests that fear avoidance beliefs [62, 117] and passive pain coping [26, 78, 153] are present at a very early stage and can be significantly predictive of future disability. Studies on the consequences
of fear of movement in patients treated by disc surgery are, however, sparse. Ostelo et al. found that fear of movement is not associated to recovery after disc surgery [172], while den Boer et al. came to the conclusion that it predicts pain, disability and work capacity six weeks and six months postoperatively [43]. In Study IV, high preoperative scores of fear avoidance beliefs were predictive of a reduced quality of life one year after surgery (OR=6.6), but not of pain or disability.

**Expectations**

The patients’ own preoperative perception of early return to work (as measured by a screening questionnaire) was significantly predictive of the outcome variables pain, disability, quality of life and sick leave (Study IV). Scoring low on this item had an odds ratio of 19.5 for still being on sick leave 12 months after surgery. This finding is in accordance with several other studies [33, 42, 43, 89, 147, 159] in which positive recovery expectations have been pointed out as an important predictor of outcome.

Different mechanisms can explain how expectations, which are one aspect of cognition, can affect outcome; examples are the triggering of physiological responses which help motivate patients to achieve better results and psychologically condition them to perceive certain symptoms and ignore others. The expectation itself can thus be directly self-confirming [112]. Feelings and perceptions may also influence biological processes in diseases through behavioural and non-behavioural mechanisms [32]. It has been suggested that expectations, beliefs and affect should be seen as interrelated components of pain-related anxiety [14], which in turn may be driven by pain experience and, for surgical patients, by unexpected residual pain after surgery. It is possible that this process also interacts with more individual vulnerability factors in general [157].

Expectations of future work disability might additionally reflect aspects which were not directly explored in this study, such as how firmly patients are established at work, their beliefs about how their work might influence their future prognosis, or their psychological well-being. Expectations are also linked to an individual’s view of what is possible and what he or she can manage regarding work demands [11]. Assessing patients’ beliefs about future work capacity might help in identifying those who are at risk for unfavourable outcome after surgery.
Preoperative expectations seem to have a strong influence on outcome after surgery. It would be interesting to evaluate expectations in relation to outcome in future studies on treatment effects.

Taken together, the results of the present studies indicate that the presence of psychosocial stress is not more common in patients scheduled for lumbar disc surgery than in knee patients. For the prediction of residual disability and pain one year after surgery, the patients’ own perception of future return to work is the most important variable. Fear avoidance beliefs are the most significant predictor of quality of life one year after surgery. The associations between behavioural and cognitive variables and pain, disability and quality of life preoperatively are generally weak. They are, however, stronger in patients with residual pain and disability one year after surgery.

**The physiological stress response in relation to pain, disability and cognitive and behavioural variables**

The release of hypothalamic-pituitary-adrenal axis hormones as a physiological response to psychosocial stress is a well-established phenomenon [48]. This and the subsequent release of glucocorticoids from the adrenal cortex are important components of psychobiological processes to maintain or regain the homeostatic equilibrium under stress [66].

The diurnal salivary cortisol variability as an estimate for the preoperative function of the stress response system was analysed in Study II. The patients with low diurnal cortisol variability had more disability and catastrophising, but lower coping self-statement scores than patients with high diurnal cortisol variability. These findings are in line with the studies of Geiss et al. who found that patients with residual pain despite lumbar disc surgery had an attenuated cortisol increase after awakening. These patients were also more depressed, had more work-related strains and were more prone to maladaptive coping strategies than patients with less residual pain [70]. Further Geiss et al. reported that reduced preoperative cortisol levels could predict the failure of disc surgery. A decreased cortisol secretion might promote the postoperative production of proinflammatory cytokines; this was suggested to serve as an explanation for the higher risk of a poor surgical outcome in chronically stressed patients [69].
Reduced cortisol levels are associated to a passive coping style [16] and could have two possible effects on disc patients: an altered immune function with synthesis of proinflammatory cytokines resulting in increased pain and a reduced ability to cope with it. Our results show that neither pain duration nor work-related stress differed between the groups with high and low cortisol levels, respectively, whereas the ability to cope with pain did. The causal direction is still unclear and is comparable to the “chicken or egg” dilemma. One possible explanation is that patients who tend to catastrophise pain develop an altered HPA axis function due to the stress involved in this cognitive and behavioural pattern. On the other hand, the severe pain these patients experience could be a potent stressor which might affect the function of the HPA axis, resulting in less effective coping skills. Both models are plausible and interrelated, and might be true in either direction [2].

The results of Study II, however, indicate that the stress response in patients with lumbar disc herniation might be a link between the physiological stress response system and psychosocial stress factors.

**Physiotherapy after surgery**

The results of Study III suggest that instructions for subsequent home training are a feasible arrangement after lumbar disc surgery given the possibility for patients to contact the physiotherapist, if they need further advice. Back pain reduction and quality of life were significantly higher in the home-based training group one year after surgery than in the clinic-based training group. The compliance to prescribed training was high in both treatment groups, indicating that patients were motivated to manage their training on their own.

All patients received the same information regarding the importance of general activity and were encouraged to gradually resume their normal daily activities. The similarity of the treatment approaches might explain why the outcome of the groups was equal. According to den Boer et al. [42, 43], passive pain coping is the most important obstacle for recovery after disc surgery. In both groups of Study III, active pain coping was encouraged; most patients seem to have followed this advice as training compliance was high. This encouragement might have been the most important treatment aspect and was similar in both training programmes. Furthermore, patients in the home-based training group had the possibility to call the physiotherapist if questions arise during rehabilitation. Six patients did so (20%) and obtained further
advice on how to cope with residual pain. This support was probably an important option for patients in this group and might have attenuated fear and anxiety, further reducing the differences between the two groups.

Manniche et al. suggested one important effect of an intensive training programme to be the confrontation with fears and insecurities and the reduction of pain-related anxiety [142]. Similarly, Kjellby-Wendt et al. emphasised that the benefit of their active treatment approach derived from the active pain coping patterns the patients adopted [115]. Doland et al. presumed that the physiotherapist was probably able to increase the patients’ confidence in their ability to exercise and to become more active in daily life after disc surgery, thereby reducing anxiety and fear [49]. Moreover, active 3-month therapies have previously shown positive effects on psychological variables (i.e. fear avoidance beliefs and psychological distress) in chronic low back pain patients, even though none of them involved psychological or cognitive-behavioural interventions [146]. These studies imply that active treatment approaches have a positive behavioural effect, which might be the most important essence in of physiotherapy after disc surgery. The additional behavioural support of the clinic-based training group did not further improve outcome one year after surgery, which is in line with results reported by Ostelo et al. [170].

In earlier studies that evaluated treatments aiming to minimise psychosocial barriers to the rehabilitation progress, it was concluded that the behavioural intervention was most effective in patients who had pronounced kinesiophobia and passive pain coping strategies [72, 200]. Thus, programmes with behaviour-oriented principles might be of advantage for selected patients with pronounced kinesiophobia and passive pain coping after surgery, but not necessarily for all patients. Identifying patients at risk and developing effective treatment programmes for these patients are challenging future research tasks.

Three months after surgery there were no significant differences between the two treatment groups regarding pain and disability. The home-based training group had, however, significantly higher back pain reduction and quality of life than the clinic-based training group at 1-year follow-up. This difference actually developed after the physiotherapy intervention was finished. It is unlikely that the intervention itself is responsible for the differences seen after 12 months. This result might possibly indicate that a confounder was unevenly distributed in the two treatment groups.
The clinic-based training group was significantly more regularly physically active at 1-year follow-up than the home-based training group. Should this difference persist, in the long term it might positively affect outcome for the clinic-based training group, since lack of physical activity is an independent predictor of repeated surgery [108]. To answer this question, however, lies beyond the scope of this thesis.

Methodological considerations
The knee patients used as a comparison group in Study I represented a sample within which psychosocial factors were not expected to be more pronounced than in the general population. To the author’s knowledge, there are no studies that have examined psychosocial factors in a comparable group, which does not necessarily imply that such factors are absent in these patients. A different study approach would have been to choose controls from the general population, but this might on the other hand have increased the risk of a higher number of drop-outs. The reason for choosing knee patients as a control group was that they also experience pain and disability, which for most individuals are stress factors.

The use of the Tampa Scale for Kinesiophobia (TSK) and the Coping Strategies Questionnaire (CSQ) in Studies II, III and IV also deserves consideration. Both the TSK and the CSQ were developed for patients with chronic non-specific musculoskeletal pain and its relationship to behavioural performance. However, all patients in the present studies had the exact diagnosis of a MRI-verified lumbar disc herniation, and the validity of the questionnaires for this patient group is therefore uncertain. The five questions which were excluded from the TSK all referred to pain not being caused by a serious disease. This might have impaired the validity of the TSK scale and makes it difficult to compare the scores of the included patients with those of other populations. Another question is whether the fears and beliefs the TSK scale captures reflect the patients’ general fear of pain or the fear and beliefs concerning the individual diagnosis. At present, there are no scales available for the evaluation of comparable variables in surgically treated back patients; a further adaptation of the TSK to this specific patient group is therefore needed. To keep the number of items in the questionnaires within reasonable limits, we only used two of the six subscales of the CSQ, coping self-statement and coping catastrophising. The subscales of the CSQ are, however, always
reported separately, as it was suggested that the scores of the CSQ’s individual scales may be more useful than composite scores for the identification of different coping strategies [100].

In general, the sample sizes in the present studies were small, which must be considered in the interpretation of the results. The patients included in Study II needed careful instructions on how to obtain and store their salivary samples. It was important that the samples were taken at the right time. All these were complicating circumstances for inclusion. The relatively small sample size in Study III increased the risk for uncontrolled confounders; a larger sample size would have reduced this risk. The small sample size in Study IV resulted in wide confidence intervals for prediction, indicating that the precision of the odds ratio estimates is uncertain.

Emotions, such as depression, are additional psychosocial factors which can have had an impact on the variables measured in the present studies. It might have been of value if depression had been measured, however, the number of items of the questionnaires needed to be limited to make their use reasonable.
CONCLUSIONS

- Psychosocial factors such as work-related stress and demanding life events were not more common preoperatively in patients with lumbar disc herniation than in knee patients. Patients with disc herniation were, however, less satisfied with their work situation preoperatively and had higher expectations of improved work satisfaction after surgery, in comparison with knee patients.

- Patients with disc herniation and a low diurnal cortisol variability had more disability, perceived fewer possibilities of influencing their pain and were more prone to catastrophising than patients with a high diurnal cortisol variability.

- Clinic-based physiotherapy with a behavioural approach did not differ from home-based physiotherapy regarding pain, disability and quality of life three months after surgery. Twelve months after surgery, back pain and quality of life were significantly more improved in the home-based than in the clinic-based training group.

- Patients who completed the regular clinic-based physiotherapy programme were more satisfied with physiotherapy care three months after surgery and were more motivated to continue regular physical activity twelve months after surgery.

- Patients’ expectations of returning to work within three months after surgery could predict pain, disability, quality of life and sick leave one year after surgery. Fear avoidance beliefs and being a woman were predictive of a low quality of life one year after surgery.

- Cognitive and behavioural factors were only weakly associated to pain, disability, quality of life and sick leave preoperatively, however, corresponding associations were stronger in patients with residual pain 12 months after surgery.

- Eliciting patients’ expectations about returning to work after surgery might be a helpful tool in the early identification of those individuals who run the risk of developing long-term disability and sick leave after first-time lumbar disc surgery.
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